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- All-new courses for 2013 include:
  - Fiber Lasers and their Applications
  - 3D Imaging Laser Radar
  - IR Atmospheric Propagation for Sensor Systems
  - Coherent Mid-Infrared Sources and Applications
  - Fundamentals of Three-Dimensional Optical Microscopy
  - Applications and Performance of High Power Lasers in the Battlefield
  - Laser Lab Design - Laser Safety and Practicality
  - Mounting of Optical Components
  - Basic Laser Technology
- Course attendees receive CEUs to fulfill continuing education requirements.

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AUTHORIZED IACET PROVIDER

Continuing Education Units

SPIE has been approved as an authorized provider of CEUs by IACET, The International Association for Continuing Education and Training (Provider #1002091). In obtaining this approval, SPIE has demonstrated that it complies with the ANSI/IACET Standards which are widely recognized as standards of good practice.

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STUDENTS

Don't miss the valuable skill-building workshops on research proposals, job search strategies, and technical presentations.
See pp. 63–64 for more details.

New Courses for 2013

SC1105 **Fiber Lasers and their Applications** *(Samson, Dong)*
SC1103 **3D Imaging Laser Radar** *(Kamerman)*
SC1107 **IR Atmospheric Propagation for Sensor Systems** *(Thomas)*
SC1012 **Coherent Mid-Infrared Sources and Applications** *(Zodopyanov)*
SC979 **Fundamentals of Three-Dimensional Optical Microscopy** *(Javidi)*
SC1104 **Applications and Performance of High Power Lasers in the Battlefield** *(Kalisky)*
SC1106 **Laser Lab Design - Laser Safety and Practicality** *(Barat)*
SC1019 **Mounting of Optical Components** *(Kasunic)*
SC972 **Basic Laser Technology** *(Sukuta)*
SC755 **Infrared Optics and Zoom Lenses** *(Mann)*
SC547 **Terahertz Wave Technology and Applications** *(Zhang)*

IR Sensors and Systems

SC713 Mon **Engineering Approach to Imaging System Design** *(Holst)* 8:30 am to 5:30 pm, $565 / $660 15
SC278 Mon **Infrared Detectors** *(Dereniak)*8:30 am to 12:30 pm, $495 / $545 12
SC1107 Mon **IR Atmospheric Propagation for Sensor Systems** *(Thomas)*8:30 am to 5:30 pm, $685 / $780 10
SC1073 Mon **Radiometry and its Practical Applications** *(Grant)* 8:30 am to 5:30 pm, $625 / $720 18
SC1071 Mon **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645 19
SC152 Mon **Infrared Focal Plane Arrays** *(Dereniak, Hubbs)* 1:30 pm to 5:30 pm, $295 / $345 15
SC1068 Mon **Introduction to Night Vision** *(Browne)*1:30 pm to 5:30 pm, $295 / $345 18
SC180 Tue **Imaging Polarimetry** *(Dereniak, Miles, Sabatke)* 8:30 am to 12:30 pm, $295 / $345 18
SC950 Tue **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 / $610 14
SC214 Tue **Infrared Window and Dome Materials** *(Harris)* 8:30 am to 5:30 pm, $580 / $680 12
SC900 Tue **Uncooled Thermal Imaging Detectors and Systems** *(Hanson)* 8:30 am to 5:30 pm, $555 / $650. 13
SC194 Tue **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 pm to 5:30 pm, $375 / $425 17
SC1109 Wed Infrared Radiometric Calibration *(Yoon, Eppeldauer, Kaplan, Johnson)* 1:30 to 5:30 pm, $295 / $345 10
SC1076 Wed **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345 11
SC835 Wed-Thu **Infrared Systems - Technology & Design** *(Daniels)* 8:30 am to 5:30 pm, $925 / $1,145 13
SC1000 Wed **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 8:30 am to 12:30 pm, $330 / $380 . . . 14
SC789 Wed **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610 17
SC181 Wed **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)*8:30 am to 5:30 pm, $570 / $665 15
SC1012 Wed **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)*1:30 pm to 5:30 pm, $295 / $345. 11
SC755 Thu **Infrared Optics and Zoom Lenses** *(Mann)* 8:30 am to 12:30 pm, $295 / $345 12
SC067 Thu **Testing and Evaluation of E-O Imaging Systems** *(Holst)* 8:30 am to 5:30 pm, $595 / $690 16
SC154 Fri **Electro-Optical Imaging System Performance** *(Holst)* 8:30 am to 5:30 pm, $595 / $690 16

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Optical and Optomechanical Engineering

SC156 Mon **Basic Optics for Engineers** *(Boreman)* 8:30 am to 5:30 pm, $555 / $650 . . . 20
SC1073 Mon **Radiometry and its Practical Applications** *(Grant)* 8:30 am to 5:30 pm, $625 / $720 . . . 22
SC1071 Mon **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645 . . . 22
SC950 Tue **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 / $610 . . . 23
SC214 Tue **Infrared Window and Dome Materials** *(Harris)* 8:30 am to 5:30 pm, $580 / $680 . . . 24
SC1019 Tue **Mounting of Optical Components** *(Kasunic)* 8:30 am to 5:30 pm, $595 / $690 . . . 21
SC1109 Wed Infrared Radiometric Calibration *(Yoon, Eppeldauer, Kaplan, Johnson)* 1:30 to 5:30 pm, $295 / $345 . . . 19
SC254 Wed **Integrated Opto-Mechanical Analysis** *(Genberg, Doyle)* 8:30 am to 5:30 pm, $565 / $660 . . . 21
SC1000 Wed **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)*8:30 am to 12:30 pm, $330 / $380 . . . 23
SC014 **Introduction to Optomechanical Design** *(Vukobratovich)* Wed-Thu 8:30 am to 5:30 pm, $890 / $1,110 . . . 21
SC755 **Infrared Optics and Zoom Lenses** *(Mann)* Thu 8:30 am to 12:30 pm, $295 / $345 . . . 24
SC1052 Thu **Optical Systems Engineering** *(Kasunic)* 8:30 am to 5:30 pm, $515 / $610 . . . 20
WS609 Tue **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 pm to 4:00 pm, $100 / $150 . . . 24

Defense, Homeland Security, and Law Enforcement

SC1107 Mon **IR Atmospheric Propagation for Sensor Systems** *(Thomas)* 8:30 am to 5:30 pm, $685 / $780 . . . 28
SC1068 Mon **Introduction to Night Vision** *(Browne)* 1:30 pm to 5:30 pm, $295 / $345 . . . 26
SC952 Tue **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 . . . 25
SC789 Wed **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610 . . . 27
SC1075 Wed **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345 . . . 27
SC1012 Wed **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)* 1:30 pm to 5:30 pm, $295 / $345 . . . 25
SC995 Thu **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610 . . . 27
SC547 Thu **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $515 / $610 . . . 26

Imaging and Sensing

SC713 Mon **Engineering Approach to Imaging System Design** *(Holst)* 8:30 am to 5:30 pm, $565 / $660 . . . 33
SC1107 Mon **IR Atmospheric Propagation for Sensor Systems** *(Thomas)*8:30 am to 5:30 pm, $685 / $780 . . . 37
SC1077 Mon **Ocean Sensing and Monitoring** *(Hou)* 8:30 am to 12:30 pm, $295 / $345 . . . 32
SC1073 Mon **Radiometry and its Practical Applications** *(Grant)* 8:30 am to 5:30 pm, $625 / $720 . . . 35
SC1071 Mon **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645 . . . 37
SC952 Tue **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 . . . 36
SC180 Tue **Imaging Polarimetry** *(Dereniak, Miles, Sabatke)* 8:30 am to 12:30 pm, $295 / $345 . . . 30
SC950 Tue **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 / $610 . . . 35
SC157 Tue **MTF in Optical and Electro-Optical Systems** *(Boreman)* 8:30 am to 5:30 pm, $555 / $650 . . . 31
SC194 Tue **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 pm to 5:30 pm, $375 / $425 . . . 31
SC1109 Wed Infrared Radiometric Calibration *(Yoon, Eppeldauer, Kaplan, Johnson)* 1:30 to 5:30 pm, $295 / $345 . . . 28
SC1076 Wed **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345 . . . 34
SC1069 Wed **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345 . . . 30
SC967 Wed **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $560 / $655 . . . 30
SC1000 Wed **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 8:30 am to 12:30 pm, $330 / $380 . . . 34
SC789 Wed **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610 . . . 32
SC995 Thu **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610 . . . 36
SC067 Thu **Testing and Evaluation of E-O Imaging Systems** *(Holst)* 8:30 am to 5:30 pm, $5 95 / $690 . . . 33
SC547 Thu **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345 . . . 29
SC154 Fri **Electro-Optical Imaging System Performance** *(Holst)* 8:30 am to 5:30 pm, $595 / $690 . . . 33

Sensing for Industry, Environment, and Health

SC1107 Mon **IR Atmospheric Propagation for Sensor Systems** *(Thomas)* 8:30 am to 5:30 pm, $685 / $780 . . . 41
SC1077 Mon **Ocean Sensing and Monitoring** *(Hou)* 8:30 am to 12:30 pm, $295 / $345 . . . 39
SC1106 Mon **Laser Lab Design - Laser Safety and Practicality** *(Barat)* 1:30 pm to 5:30 pm, $295 / $345 . . . 42
SC952 Tue **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 . . . 40
SC180 Tue **Imaging Polarimetry** *(Dereniak, Miles, Sabatke)* 8:30 am to 12:30 pm, $295 / $345 . . . 43
SC1109 Wed Infrared Radiometric Calibration *(Yoon, Eppeldauer, Kaplan, Johnson)* 1:30 to 5:30 pm, $295 / $345 . . . 37
SC789 Wed **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610 . . . 38
SC1075 Wed **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345 . . . 43
SC1012 Wed **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)* 1:30 pm to 5:30 pm, $295 / $345 . . . 41
SC1105 Thu **Fiber Lasers and their Applications** *(Samson, Dong)* 8:30 am to 5:30 pm, $515 / $610 . . . 42
SC995 Thu **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610 . . . 40
SC547 Thu **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345 . . . 44
SC972 Fri **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345 . . . 43

Emerging Technologies

SC1071 Mon **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645 . . . 45
SC1076 Wed **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345 . . . 44
SC1075 Wed **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345 . . . 43
SC547 Thu **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345 . . . 44

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Laser Sensors and Systems

SC1104 Mon **Applications and Performance of High Power Lasers in the Battlefield** *(Kalisky)* 8:30 am to 12:30 pm, $295 / $345 45
SC1032 Mon **Direct Detection Laser Radar Systems for Imaging Applications** *(Richmond)* 8:30 am to 5:30 pm, $555 / $650 . . 48
SC1107 Mon **IR Atmospheric Propagation for Sensor Systems** *(Thomas)* 8:30 am to 5:30 pm, $685 / $780 49
SC160 Mon **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 / $610. 49
SC1071 Mon **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645 50
SC1103 Mon **3D Imaging Laser Radar** *(Kamerman)*1:30 pm to 5:30 pm, $295 / $345 45
SC1106 Mon **Laser Lab Design - Laser Safety and Practicality** *(Barat)* 1:30 pm to 5:30 pm, $295 / $345 46
SC789 Wed **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610 48
SC1012 Wed **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)* 1:30 pm to 5:30 pm, $295 / $345. 47
SC1105 Thu **Fiber Lasers and their Applications** *(Samson, Dong)* 8:30 am to 5:30 pm, $515 / $610 46
SC997 Thu **High Power Laser Beam Quality** *(Ross)* 8:30 am to 12:30 pm, $340 / $390 47
SC972 Fri **Basic Laser Technology** *(Sukuta)*8:30 am to 12:30 pm, $295 / $345 47

Displays for Innovative Applications

SC1071 Mon **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645 52
SC1068 Mon **Introduction to Night Vision** *(Browne)* 1:30 pm to 5:30 pm, $295 / $345 51
SC159 Tue **Head-Mounted Displays: Design and Applications** *(Melzer, Browne)* 8:30 am to 5:30 pm, $550 / $645 50
SC979 Wed **Fundamentals of Three-Dimensional Optical Microscopy** *(Javidi, Martinez-Corral)* 8:30 am to 5:30 pm, $515 / $610. . . . 51
SC1069 Wed **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345 52
SC967 Wed **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)*8:30 am to 5:30 pm, $560 / $655 52

Unmanned, Robotic, and Layered Systems

SC1077 Mon **Ocean Sensing and Monitoring** *(Hou)* 8:30 am to 12:30 pm, $295 / $345 54
SC1068 Mon **Introduction to Night Vision** *(Browne)* 1:30 pm to 5:30 pm, $295 / $345 53
SC952 Tue **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 54
SC1075 Wed **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)*8:30 am to 12:30 pm, $295 / $345 53

Sensor Data and Information Exploitation

SC160 Mon **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 / $610. 55
SC1106 Mon **Laser Lab Design - Laser Safety and Practicality** *(Barat)* 1:30 pm to 5:30 pm, $295 / $345 57
SC994 Tue **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680 56
SC194 Tue **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 pm to 5:30 pm, $375 / $425 56
SC1076 Wed **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345 57
SC1069 Wed **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345 57
SC181 Wed **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)*8:30 am to 5:30 pm, $570 / $665 55
SC995 Thu **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610. 55
SC972 Fri **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345 58

Signal, Image, and Neural Net Processing

SC066 Mon **Fundamentals of Electronic Image Processing** *(Weeks)* 8:30 am to 5:30 pm, $585 / $680 58
SC952 Tue **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 59
SC994 Tue **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680 59
SC1076 Wed **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345 58
SC1069 Wed **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345 60
SC995 Thu **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610 60

Information Systems and Networks: Processing, Fusion, and Knowledge Generation

SC952 Tue **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 61
SC994 Tue **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)*8:30 am to 5:30 pm, $585 / $680 61
SC1069 Wed **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345 62

Industry Workshops

Business + Professional Development

SC972 Fri **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345 64
WS609 Tue **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 pm to 4:00 pm, $100 / $150 63
WS951 Wed **Leading Successful Product Innovation** *(Carrano)* 8:30 am to 12:30 pm, $295 / $345 63
WS933 Wed **Complying with the ITAR: A Case Study** *(Scarlott)* 1:30 pm to 5:30 pm, $295 / $345 63
WS1108 Wed **Just Outgoing Enough: Public Speaking, Networking, and Getting What You Want for Scientists and Engineers** *(McGovern)* 1:30 pm to 5:00 pm, $50 / $100 64
WS846 Thu **Essential Skills for Engineering Project Leaders** *(Hinkle)* 1:30 pm to 5:30 pm, $295 / $345 62

Course Daily Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
IR Sensors and Systems				
SC713 **Engineering Approach to Imaging System Design** *(Holst)*8:30 am to 5:30 pm, $565 / $660	SC180 **Imaging Polarimetry** *(Dereniak, Miles, Sabatke)*8:30 am to 12:30 pm, $295 / $345	SC1076 **Analog-to-Digital Converters for Digital ROICs** *(Veeder)*8:30 am to 12:30 pm, $295 / $345	SC755 **Infrared Optics and Zoom Lenses** *(Mann)*8:30 am to 12:30 pm, $295 / $345	SC154 **Electro-Optical Imaging System Performance** *(Holst)*8:30 am to 5:30 pm, $595 / $690
SC278 **Infrared Detectors** *(Dereniak)*8:30 am to 12:30 pm, $495 / $545	SC950 **Infrared Imaging Radiometry** *(Richards)*8:30 am to 5:30 pm, $515 / $610	SC835 **Infrared Systems - Technology & Design** *(Daniels)*8:30 am to 5:30 pm, $925 / $1,145		
SC1107 **IR Atmospheric Propagation for Sensor Systems** *(Thomas)*8:30 am to 5:30 pm, $685 / $780	SC214 **Infrared Window and Dome Materials** *(Harris)*8:30 am to 5:30 pm, $580 / $680	SC1000 **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)*8:30 am to 12:30 pm, $330 / $380	SC067 **Testing and Evaluation of E-O Imaging Systems** *(Holst)*8:30 am to 5:30 pm, $595 / $690	
SC1073 **Radiometry and its Practical Applications** *(Grant)*8:30 am to 5:30 pm, $625 / $720, p.159	SC900 **Uncooled Thermal Imaging Detectors and Systems** *(Hanson)*8:30 am to 5:30 pm, $555 / $650	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)*8:30 am to 5:30 pm, $515 / $610		
SC1071 **Understanding Diffractive Optics** *(Soskind)*8:30 am to 5:30 pm, $550 / $645	SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)*1:30 pm to 5:30 pm, $375 / $425	SC181 **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)* :30 am to 5:30 pm, $570 / $665		
SC152 **Infrared Focal Plane Arrays** *(Dereniak, Hubbs)*1:30 pm to 5:30 pm, $295 / $345		SC1012 **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)*1:30 pm to 5:30 pm, $295 / $345		
SC1068 **Introduction to Night Vision** *(Browne)*1:30 pm to 5:30 pm, $295 / $345		SC1109 **Infrared Radiometric Calibration** *(Yoon, Eppeldauer, Kaplan, Johnson)* Wed 1:30 to 5:30 pm, $295 / $345		

Course Daily Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Optical and Optomechanical Engineering				
SC156 **Basic Optics for Engineers** *(Boreman)* 8:30 am to 5:30 pm, $555 / $650	SC950 **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 / $610	SC254 **Integrated Opto-Mechanical Analysis** *(Genberg, Doyle)* 8:30 am to 5:30 pm, $565 / $660	SC755 **Infrared Optics and Zoom Lenses** *(Mann)* 8:30 am to 12:30 pm, $295 / $345	
SC1073 **Radiometry and its Practical Applications** *(Grant)* 8:30 am to 5:30 pm, $625 / $720	SC214 **Infrared Window and Dome Materials** *(Harris)* 8:30 am to 5:30 pm, $580 / $680	SC1000 **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 8:30 am to 12:30 pm, $330 / $380	SC1052 **Optical Systems Engineering** *(Kasunic)* 8:30 am to 5:30 pm, $515 / $610	
SC1071 **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645	SC1019 **Mounting of Optical Components** *(Kasunic)* 8:30 am to 5:30 pm, $595 / $690	SC014 **Introduction to Optomechanical Design** *(Vukobratovich)* 8:30 am to 5:30 pm, $890 / $1,110		
	WS609 **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 pm to 4:00 pm, $100 / $150	SC1109 **Infrared Radiometric Calibration** *(Yoon, Eppeldauer, Kaplan, Johnson)* Wed 1:30 to 5:30 pm, $295 / $345		
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SC1068 **Introduction to Night Vision** *(Browne)* 1:30 pm to 5:30 pm, $295 / $345		SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345	SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345	
		SC1012 **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)* 1:30 pm to 5:30 pm, $295 / $345		

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SC1107 **IR Atmospheric Propagation for Sensor Systems** *(Thomas)* 8:30 am to 5:30 pm, $685 / $780	SC180 **Imaging Polarimetry** *(Dereniak, Miles, Sabatke)* 8:30 am to 12:30 pm, $295 / $345	SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345	SC067 **Testing and Evaluation of E-O Imaging Systems** *(Holst)* 8:30 am to 5:30 pm, $595 / $690	
SC1077 **Ocean Sensing and Monitoring** *(Hou)* 8:30 am to 12:30 pm, $295 / $345	SC950 **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 / $610	SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $560 / $655	SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345	
SC1073 **Radiometry and its Practical Applications** *(Grant)* 8:30 am to 5:30 pm, $625 / $720	SC157 **MTF in Optical and Electro-Optical Systems** *(Boreman)* 8:30 am to 5:30 pm, $555 / $650	SC1000 **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 8:30 am to 12:30 pm, $330 / $380		
SC1071 **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645	SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 pm to 5:30 pm, $375 / $425	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610		
		SC1109 **Infrared Radiometric Calibration** *(Yoon, Eppeldauer, Kaplan, Johnson)* Wed 1:30 to 5:30 pm, $295 / $345		
Sensing for Industry, Environment, and Health				
SC1107 **IR Atmospheric Propagation for Sensor Systems** *(Thomas)* 8:30 am to 5:30 pm, $685 / $780	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610	SC1105 **Fiber Lasers and their Applications** *(Samson, Dong)* 8:30 am to 5:30 pm, $515 / $610	SC972 **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345
SC1077 **Ocean Sensing and Monitoring** *(Hou)* 8:30 am to 12:30 pm, $295 / $345	SC180 **Imaging Polarimetry** *(Dereniak, Miles, Sabatke)* 8:30 am to 12:30 pm, $295 / $345	SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345	SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610	
SC1106 **Laser Lab Design - Laser Safety and Practicality** *(Barat)* 1:30 pm to 5:30 pm, $295 / $345		SC1012 **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)* 1:30 pm to 5:30 pm, $295 / $345	SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345	
		SC1109 **Infrared Radiometric Calibration** *(Yoon, Eppeldauer, Kaplan, Johnson)* Wed 1:30 to 5:30 pm, $295 / $345		

Course Daily Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Emerging Technologies				
SC1071 **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645		SC1076 **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345	SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 1:30 pm to 5:30 pm, $295 / $345	
		SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345		
Laser Sensors and Systems				
SC1104 **Applications and Performance of High Power Lasers in the Battlefield** *(Kalisky)*8:30 am to 12:30 pm, $295 / $345		SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 / $610	SC1105 **Fiber Lasers and their Applications** *(Samson, Dong)* 8:30 am to 5:30 pm, $515 / $610	SC972 **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345
SC1032 **Direct Detection Laser Radar Systems for Imaging Applications** *(Richmond)*8:30 am to 5:30 pm, $555 / $650		SC1012 **Coherent Mid-Infrared Sources and Applications** *(Vodopyanov)* 1:30 pm to 5:30 pm, $295 / $345	SC997 **High Power Laser Beam Quality** *(Ross)* 8:30 am to 12:30 pm, $340 / $390	
SC1107 **IR Atmospheric Propagation for Sensor Systems** *(Thomas)*8:30 am to 5:30 pm, $685 / $780				
SC160 **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 / $610				
SC1071 **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645				
SC1103 **3D Imaging Laser Radar** *(Kamerman)* 1:30 pm to 5:30 pm, $295 / $345				
SC1106 **Laser Lab Design - Laser Safety and Practicality** *(Barat)* 1:30 pm to 5:30 pm, $295 / $345				

Course Daily Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Displays for Innovative Applications				
SC1071 **Understanding Diffractive Optics** *(Soskind)* 8:30 am to 5:30 pm, $550 / $645	SC159 **Head-Mounted Displays: Design and Applications** *(Melzer, Browne)* 8:30 am to 5:30 pm, $550 / $645	SC979 **Fundamentals of Three-Dimensional Optical Microscopy** *(Javidi, Martinez-Corral)* 8:30 am to 5:30 pm, $515 / $610		
SC1068 **Introduction to Night Vision** *(Browne)* 1:30 pm to 5:30 pm, $295 / $345		SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345		
		SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $560 / $655		
Unmanned, Robotic, and Layered Systems				
SC1077 **Ocean Sensing and Monitoring** *(Hou)* 8:30 am to 12:30 pm, $295 / $345	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610	SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 8:30 am to 12:30 pm, $295 / $345		
SC1068 **Introduction to Night Vision** *(Browne)* 1:30 pm to 5:30 pm, $295 / $345				
Sensor Data and Information Exploitation				
SC160 **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 / $610	SC994 **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680	SC1076 **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345	SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610	SC972 **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345
SC1106 **Laser Lab Design - Laser Safety and Practicality** *(Barat)* 1:30 pm to 5:30 pm, $295 / $345	SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 pm to 5:30 pm, $375 / $425	SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345		
		SC181 **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)* 8:30 am to 5:30 pm, $570 / $665		

Course Daily Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Signal, Image, and Neural Net Processing				
SC066 **Fundamentals of Electronic Image Processing** *(Weeks)* 8:30 am to 5:30 pm, $585 / $680	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610	SC1076 **Analog-to-Digital Converters for Digital ROICs** *(Veeder)* 8:30 am to 12:30 pm, $295 / $345	SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610	
	SC994 **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680	SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345		
Information Systems and Networks: Processing, Fusion, and Knowledge Generation				
	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610	SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to 12:30 pm, $295 / $345		
	SC994 **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680			
Business + Professional Development Workshops				
	WS609 **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 pm to 4:00 pm, $100 / $150	WS951 **Leading Successful Product Innovation** *(Carrano)* 8:30 am to 12:30 pm, $295 / $345	WS846 **Essential Skills for Engineering Project Leaders** *(Hinkle)* 1:30 pm to 5:30 pm, $295 / $345	SC972 **Basic Laser Technology** *(Sukuta)* 8:30 am to 12:30 pm, $295 / $345
		WS933 **Complying with the ITAR: A Case Study** *(Scarlott)* 1:30 pm to 5:30 pm, $295 / $345		
		WS1108 **Just Outgoing Enough: Public Speaking, Networking, and Getting What You Want for Scientists and Engineers** *(McGovern)* 1:30 pm to 5:00 pm, $50 / $100		

IR Sensors and Systems

Infrared Radiometric Calibration

SC1109 New

Course level: Intermediate
CEU .35 $295 Members | $345 Non-Members
Wednesday 1:30 to 5:30 pm

This course describes the radiometric calibration techniques used for SI-traceable measurements of sources, detectors and material properties in the infrared wavelength region. The main goal is to enable understanding of infrared measurements with quantified uncertainties so that full uncertainty budgets can be established for the final quantities. Examples from NIST calibrations of sources, detectors and materials will be described.

The properties and measurements of various different blackbody and lamp sources will be discussed. Detector calibrations using both thermal and quantum detectors with monochromators and Fourier-transform spectrometers will be covered. Also, infrared reflectance measurements using Fourier-transform spectrometers will be explained. Examples of NIST-developed infrared transfer and working standard radiometers in field deployments will be utilized to illustrate the above concepts.

LEARNING OUTCOMES

This course will enable you to:

- choose the optimal sources for the measurement needs from the different sources available in the field
- list the procedures for selecting and calibrating infrared detectors and their associated uncertainties
- describe the uncertainty propagation principles in both source and detector calibrations
- utilize techniques for infrared material reflectance measurements and their uncertainty propagation
- characterize a radiation thermometer according to ASTM standards

INTENDED AUDIENCE

This course is designed for technical staff involved in radiometric calibrations of sources, detectors and radiometers.

INSTRUCTORS

Howard Yoon graduated with a B.S. Physics and Chemistry degree from Swarthmore College and earned his M.S. and Ph.D. Physics degrees from the University of Illinois at Urbana-Champaign. He has worked for Bell Communications Research and Dartmouth College. He currently serves as the US Representative to the Consultative Committee on Thermometry and is a member of the IEC TC65/SC65B/WG5 committee. While at NIST, he has received the Allen V. Astin Award and the DOC Silver Award. Currently at NIST he is a physicist working on several projects related to advancing spectroradiometry for improvements in fundamental and disseminated standards of spectral radiance, spectral irradiance, and radiance temperature.

George Eppeldauer received his M.E. and Ph.D. Electronics Engineering degrees from the Technical University of Budapest. Previously, he has worked at the Research Institute for Technical Physics at the Hungarian Academy of Sciences. He won the Best Paper Award at the NCSLI Conference in 2004, and he chairs the CIE TC2-48 Technical Committee (TC) on Spectral Responsivity Calibrations and the CIE TC2-29 TC on Detector Linearity. He is an electronics engineer with research areas in detector metrology developing transfer and working standard optical radiometers, photometers, and colorimeters and realizing detector responsivity based scales. The standards he has developed have been utilized to improve the two NIST SI units, the candela and kelvin, the illuminance responsivity scale, the tristimulus color scale, the spectral power, irradiance, and radiance responsivity reference-scales, and the spectral irradiance scale. He was one of the three pioneers who developed the SIRCUS reference responsivity-calibration facility.

Simon Kaplan received a B.A. Physics degree from Oberlin College and Ph.D. Physics degree from Cornell University. Prior to joining NIST, he has worked at the University of Maryland, College Park. He is a physicist with research interests in spectrophotometry and radiometry. He has worked on the characterization of optical materials and components in support of UV photolithography and infrared remote sensing applications. Currently he is leading the Low Background Infrared (LBIR) facility for absolute detector-based irradiance and radiance calibrations in support of missile defense as well as climate monitoring technology.

Carol Johnson earned a B.S. Engineering Physics degree from the University of Colorado and M.A. and Ph.D. in Astronomy from Harvard University, where she also worked before joining NIST. At NIST, she has earned the NIST Bronze Medal and DOC Silver and Gold Medals, as well as the Arthur S. Flemming and Edward Bennett Rosa Awards. Currently she is a physicist developing methods for improved radiometric characterization and calibration of instruments, transferring this knowledge to the user community, and improving the metrology of radiometry in remote sensing global climate change research. She serves on instrument design and calibration and validation peer reviews for NASA and NOAA sensors, participates in the Working Group on Calibration and Validation (WGCV) for the Committee on Earth Observation Satellites (CEOS), and collaborates with ocean color calibration scientists.

ADDITIONAL COMMENTS: This course has been designed to complement and build upon the content presented in SC1073, Radiometry and its Practical Applications. Attendees will benefit maximally from attending both courses.

IR Atmospheric Propagation for Sensor Systems

SC1107 New

Course Level: Intermediate
CEU: 0.65 $685 Members | $780 Non-Members USD
Monday 8:30 am to 5:30 pm

This course reviews the fundamental principles and applications concerning absorption and scattering phenomena in the atmosphere that impact infrared sensor performance. Topics include an introduction to atmospheric structure, a background reviewing the basic formulas concerning the complex index of refraction, a survey of molecular absorption bands and continuum absorption, the HITRAN database, atmospheric refractivity, molecular Rayleigh scattering, particle distribution functions, Mie scattering and anomalous diffraction approximation. This background is applied to atmospheric transmittance, path radiance and path fluctuations with examples from computer codes such as MODTRAN and FASCODE. These topics are further reinforced by practical examples on atmospheric optics whenever possible. A set of contemporary references is provided.

LEARNING OUTCOMES

This course will enable you to:

- summarize the basics of absorption, refraction and scatter in the atmosphere
- distinguish between the optical properties of gases and condensed matter
- identify the structure of the atmosphere
- compute atmospheric transmittance
- compute atmospheric scattering
- relate course concepts to observable phenomena in the atmosphere

INTENDED AUDIENCE

The course is intended for engineers and scientists working with EO/IR systems in the atmosphere of earth. The material is beneficial to experimentalists and modelers. The course material is presented at an intermediate level, suitable for those with some experience in optical propagation in the atmosphere. Working knowledge of undergraduate electromagnetic theory as applied to optical frequencies is desired.

INSTRUCTOR

Michael Thomas is currently a Principal Staff Engineer at the Applied Physics Laboratory, and a Research Professor in the Department of Electrical and Computer Engineering at Johns Hopkins University. He has been at APL since 1979, and is currently in the EO/IR Systems and Technologies Group at APL. Dr. Thomas holds a Ph.D. in electrical engineering from The Ohio State University. Dr. Thomas is a specialist in electromagnetic theory, optical propagation, and quantum electronics with research interests in measurement and theoretical modeling of atmospheric propagation and remote sensing, optical properties of solids and high pressure gases. He has over 190 journal type publications in these areas. Dr. Thomas is a Fellow of the Optical Society of America, a senior member of IEEE and also holds membership in SPIE, Sigma Xi and Tau Beta Pi.

COURSE PRICE INCLUDES THE text *Optical Propagation in Linear Media* (Oxford University Press , 2006) by M. E. Thomas.

Coherent Mid-Infrared Sources and Applications

SC1012

New

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 1:30 pm to 5:30 pm

This course explains why the mid-IR spectral range is so important for molecular spectroscopy, standoff sensing, and trace molecular detection. We will regard different approaches for generating coherent light in the mid-IR including solid state lasers, fiber lasers, semiconductor (including quantum cascade) lasers, and laser sources based on nonlinear optical methods. The course will discuss several applications of mid-IR coherent light: spectral recognition of molecules, trace gas sensing, standoff detection, and frequency comb Fourier transform spectroscopy.

LEARNING OUTCOMES

This course will enable you to:

- define the “molecular fingerprint” region
- identify existing direct laser sources of mid-IR coherent radiation, including solid state lasers, fiber lasers, semiconductor heterojunction and quantum cascade lasers
- identify laser sources based on nonlinear optical methods, including difference Frequency generators and optical parametric oscillators and generators
- describe the principles of trace gas sensing and standoff detection
- explain mid-IR frequency combs and how they can be used for advanced spectroscopic detection

INTENDED AUDIENCE

Students, academics, researchers and engineers in various disciplines who require a broad introduction to the subject and would like to learn more about the state-of-the-art and upcoming trends in mid-infrared coherent source development and applications. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Konstantin Vodopyanov is a world expert in mid-IR solid state lasers, nonlinear optics and laser spectroscopy. He has both industrial and academic experience, has > 300 technical publications and he is a co-author, with I.T. Sorokina, of the book Solid-State Mid-Infrared Laser Sources (Springer, 2003). He is a member of program committees for several major laser conferences including CLEO (most recent, General Chair in 2010) and Photonics West (LA106 Conference Chair). Currently he teaches and does scientific research at Stanford University and his research interests include mid-IR and terahertz-wave generation using micro-and nano-structured materials, nano-IR spectroscopy, generation of mid-infrared frequency combs and their applications. Dr. Vodopyanov has delivered numerous invited talks and tutorials at scientific meetings on the subject of mid-IR technology.

Analog-to-Digital Converters for Digital ROICs

SC1076

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course surveys structure and operation of analog-to-digital converters (ADCs) implemented on digital readout integrated circuits (ROICs) and digital image sensors. Attendees will learn how to evaluate ADC architectures using basic figures of merit for use in different sensor formats. We will cover a wide range of cutting edge architectures and see published examples without delving into transistor level theory. We will survey both academia and industrial ADC architectures. From this survey attendees will discover the industrial design evolution convergence down to a few workhorse architectures and what lessons it imparts to the image sensor community. If you are interested in the digital ROIC revolution or if you ever interface with designers or evaluate digital ROIC proposals, then you will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify analog-to-digital architectures used for creating digital ROICs and image sensors
- calculate ADC architecture figures of merit important to image sensors
- evaluate ADC architecture compatibility with image sensor format and requirements
- infer the direction in which state-of-the-art digital image sensors are headed
- name the top ADC architectures used by commercial industry and explain how this knowledge benefits the image sensor industry
- stimulate your own creativity and help you develop new ideas and applications for digital ROICs and digital image sensors

INTENDED AUDIENCE

This course is intended for engineers and physicists with a background in basic electrical theory (electrical stimuli, resistors, capacitors and block diagramming) who wish to learn about analog-to-digital converter architectures and how they are applied to digital ROICs and digital image sensors. An undergraduate degree in science or engineering is assumed, and basic knowledge of electrical engineering will be particularly helpful.

INSTRUCTOR

Kenton Veeder is a ROIC design engineer, systems engineer, and part time detector physicist. He has been in the defense and commercial image sensor field for over 12 years and is the president of Senseeker Engineering Inc. in Santa Barbara, California. He has nine patents and several publications, one of which earned the MSS Detectors best paper award in 2006. While working for Raytheon he was awarded recognition as Raytheon’s ‘Father of the Digital Focal Plane Array’ and he and his team were given the company wide ‘Excellence In Technology’ award. Kenton earned his M.S. in electrical engineering from the Analog-and-Mixed Signal Center at Texas A&M University. Kenton is a member of SPIE and IEEE.

Infrared Window and Dome Materials

SC214

Course Level: Advanced
CEU: 0.65 $580 Members | $680 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course presents an overview of the optical, thermal and mechanical characteristics of infrared-transmitting window and dome materials. Other topics include thermal shock response, rain and particle erosion, protective coatings, antireflection coatings, electromagnetic shielding, proof testing, and fabrication of optical ceramics. The course concludes with a brief discussion of sapphire and diamond as infrared materials.

LEARNING OUTCOMES

This course will enable you to:
- identify the optical, thermal and mechanical characteristics of a window material that are critical to its selection for a particular application
- predict optical, thermal and mechanical performance of window materials under a range of conditions, based on tabulated data
- compare the strengths and weaknesses of different materials and different coatings for a given application
- describe the principal methods by which optical ceramics are manufactured

INTENDED AUDIENCE

The course is directed at engineers, scientists, managers and marketing personnel who need an introduction to properties, performance, and manufacture of windows and domes. A basic degree in engineering or science is the expected background, but care will be taken to provide introductory background information for each topic.

INSTRUCTOR

Daniel Harris is a Senior Scientist at the Naval Air Warfare Center, China Lake, California, where he directs programs in optical materials.

COURSE PRICE INCLUDES the text *Materials for Infrared Windows and Domes* (SPIE Press, 1999) by Daniel Harris. **Attendees should bring a calculator to this course.**

Infrared Optics and Zoom Lenses

SC755

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Thursday 8:30 am to 12:30 pm

This course describes the fundamental properties of the infrared region of the spectrum and explains the techniques involved in the design and analysis of representative infrared zoom lenses. The use of computer optimization is discussed with examples to illustrate the step-by-step development of any optical system and zoom lenses in particular. It gives attendees an insight into zoom lens characteristics in general and the design and analysis process involved in developing an infrared zoom lens system. Civil and military applications are discussed which match the optics with infrared detectors and sensors. Recent trends include the advent of focal plane arrays and the shift to the near infrared spectral region. 32 refractive zoom lens systems and 9 representative reflective zoom systems are presented, along with many new diagrams.

LEARNING OUTCOMES

After completing this course, attendees will be able to:
- describe the fundamental properties of zoom lenses as to whether they are mechanically or optically compensated and with regard to positive or negative moving groups
- describe the relevant issues that are unique to the infrared region of the spectrum, including sources, detectors, CCD arrays, optical materials, athermalization, narcissus, and coatings
- gain an insight into the optical design techniques utilized in the design of infrared zoom lenses, including achieving high magnification ratios, achromatization, aberration control, the use of aspherics and diffractive optical elements, compactness techniques, computer optimization, global search, scaling, and tolerances
- classify infrared zoom lenses according to their application: scanning telescopes, target simulators, surveillance systems, target recognition, battlefield detection, imaging systems, solar observatories, laser beam expanders, and cell phone cameras
- establish requirements for your particular application
- decide whether a given zoom lens optical system meets your requirements and matches the capabilities of the detector

INTENDED AUDIENCE

This course is for engineers and scientists interested in learning more about the infrared region of the spectrum and about infrared zoom lenses and their applications.

INSTRUCTOR

Allen Mann has over forty years' experience in the design and analysis of optical systems, including visual and infrared zoom lenses. Mr. Mann has written several papers on the subject of infrared zoom lenses and is the editor for the SPIE Milestone Volume on Zoom Lenses. He was chairman of SPIE Zoom Lens Conference I and co-chair of Zoom Lens Conference II. He is retired from Hughes Aircraft Company and is now an independent consultant. Mr. Mann has been elected to be a Fellow of SPIE.

COURSE PRICE INCLUDES the text *Infrared Optics and Zoom Lenses, Second Edition* (SPIE, 2009) by Allen Mann.

Infrared Detectors

SC278

Course Level: Introductory
CEU: 0.35 $495 Members | $545 Non-Members USD
Monday 8:30 am to 12:30 pm

This course will provide a broad and useful background on optical detectors, both photon and thermal, with a special emphasis placed on the infrared detectors. Discussion of optical detection will be stressed. The fundamentals of responsivity (Rl), noise equivalent power (NEPl) and specific detectivity (D*) will be discussed. These figures of merit will be extended to photon noise limited performance and Johnson noise limitations (RA product). Discussion of optical detector fundamentals will be stressed. To aid the attendee in selecting the proper detector choice, the detailed behavior of the more important IR detector materials will be described in detail. Newer technologies such as quantum well infrared photodetectors and blocked impurity bands as well as IR detectors will be covered briefly.

LEARNING OUTCOMES

This course will enable you to:
- describe optical radiation detection processes
- explain noise mechanisms related to optical detectors
- derive figures of merit for optical detectors
- compare BLIP condition to RA product performance
- evaluate and discuss HgCdTe detectors' unique features
- explain why room temperature thermal detectors are so important
- derive the wavelength dependence of detectors

INTENDED AUDIENCE

This class is directed at people who need to learn more about optical detectors from a user point of view. It will give the student insight into the optical detection process as well as what is available to application engineers, advantages, shortcomings, and pitfalls.

INSTRUCTOR

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the Univ. of Arizona, Tucson, Arizona. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

COURSE PRICE INCLUDES the text *Infrared Detectors and Systems* (Wiley, 1996) by E. L. Dereniak and G. D. Boreman.

Infrared Systems - Technology & Design

SC835

Course Level: Advanced
CEU: 1.3 $925 Members | $1,145 Non-Members USD
Wednesday - Thursday 8:30 am to 5:30 pm

This course covers the range of topics necessary to understand the theoretical principles of modern infrared-technology. It combines numerous engineering disciplines necessary for the development of infrared systems. Practical engineering calculations are highlighted, with examples of trade studies illustrating the interrelationships among the various hardware characteristics.

This course is comprised of four sections:

Section 1	introduces the geometrical optics concepts including image formation, stops and pupils, thick lenses and lens combinations, image quality, and the properties of infrared materials.
Section 2	covers the essentials of radiometry necessary for the quantitative understanding of infrared signatures and flux transfer. These concepts are then developed and applied to flux-transfer calculations for blackbody, graybody, and selective radiator sources. Remote temperature calibrations and measurements are then used as an illustration of these radiometric principles.
Section 3	is devoted to fundamental background issues for optical detection-processes. It compares the characteristics of cooled and uncooled detectors with an emphasis on spectral and blackbody responsivity, detectivity (D*), as well as the noise mechanisms related to optical detection. The detector parameters and capabilities of single detectors and third generation focal plane arrays (FPAs) are analyzed.

With this acquired background, Section 4 considers the systems-design aspects of infrared imagers. The impact of scan format on signal-to-noise ratio is described, and the engineering tradeoffs inherent in the development of infrared search and track (IRST) systems are explained. Figures of merit such as MTF, NETD, and MRTD of staring arrays are examined for the performance metrics of thermal sensitivity and spatial resolution of thermal imaging systems (TIS). Contrast threshold functions based on Johnson and visible cycles (often denoted as N- and V-cycles) are specified. The interrelationships among the design parameters are identified through trade-study examples.

LEARNING OUTCOMES

This course will enable you to:

- learn the principles and fundamentals of infrared optical design
- choose the proper infrared materials suite for your applications
- quickly execute flux-transfer calculations
- calibrate infrared sources and target signatures
- recognize the importance of background in thermal signatures
- have an appreciation for the capacity of infrared systems and learn the interaction of its critical components (optics, detectors, and electronics) in the production of a final infrared image
- assess the influence of noise mechanisms related to optical detection
- comprehend the fundamental response mechanisms and differences between cooled and uncooled single detectors as well as focal plane arrays (FPAs)
- comprehend the central theory behind third generation infrared imagers
- define and use common descriptors for detector and system performance (R, D*, NEP, NEI, MTF, NETD, and MRTD)
- estimate system performance given subsystem and component specifications
- apply design tradeoffs in both infrared search and track systems (IRST) and thermal-imaging systems (TIS)
- carry out the preliminary design of infrared systems for different thermal applications

INTENDED AUDIENCE

This course is directed to the practicing engineers and/or scientists who require both theoretical and effective practical technical information to design, build, and/or test infrared systems in a wide variety of thermal applications. A background at the bachelor's level in engineering is highly recommended. The participant should also have ample understanding of Fourier analysis and random processes.

INSTRUCTOR

Arnold Daniels is a senior lead engineer with extensive experience in the conceptual definition of advance infrared, optical, and electro-optical systems. His background consists of technical contributions to applications for infrared search & track, thermal imaging, and ISR systems. Other technical expertise include infrared radiometry (testing and measurements), infrared test systems (i.e., MTF, NETD, and MRTD), thermographic nondestructive testing (TNDT), optical design, precision optical alignment, stray light analysis, adaptive optics, Fourier analysis, image processing, and data acquisition systems. He earned an M.S. in Electrical Engineering from the University of Tel-Aviv and a doctorate in Electro-Optics from the School of Optics (CREOL) at the University of Central Florida. In 1995 he received the Rudolf Kingslake medal and prize for the most noteworthy original paper to appear in SPIE's Journal of Optical Engineering. He is presently developing direct energy laser weapon systems for defense applications.

COURSE PRICE INCLUDES the *Field Guide to Infrared Systems, Detectors, and FPAs, 2nd Edition* by Arnold Daniels (SPIE, 2010) and *Infrared Detectors and Systems* (Wiley, 1996) by Eustace L. Dereniak and Glenn D. Boreman.

Uncooled Thermal Imaging Detectors and Systems

SC900

Course Level: Intermediate
CEU: 0.65 $555 Members | $650 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The success of uncooled infrared imaging in commercial and military markets has greatly increased the number of participants in the field, and, consequently, the variety of products available and in development. The intent of this course is to provide attendees a broad view of the field as well as an in-depth look at important technologies. The course describes the fundamentals of uncooled IR imaging arrays, emphasizing resistive bolometric and ferroelectric/pyroelectric detectors, but also including a number of innovative technologies such as thermally activated cantilevers, thin films with temperature-dependent optical transmission properties, and thermal-capacitive detectors. Students will learn the fundamentals of uncooled IR sensors, how the various technologies operate, the merits and deficiencies of the different technologies, quantitative metrics for evaluating and comparing performance, and how key factors influence those metrics. The course also explores the limits of performance of uncooled IR imaging, as well as trends to be expected in future products.

LEARNING OUTCOMES

This course will enable you to:

- describe the operation of uncooled IR detectors and basic readout circuits
- evaluate performance in terms of responsivity, noise, noise equivalent temperature difference, minimum resolvable temperature, and response time
- gauge the fundamental limits to their performance, including temperature-fluctuation noise and background fluctuation noise
- compare theory with measured performance of the uncooled arrays

- evaluate practical issues and limitations of current technology
- ascertain the state of development of new IR technologies by asking the right questions
- differentiate well-developed concepts from ill-conceived notional concepts
- identify the uncooled IR technology best suited to your needs
- assess the performance potential of novel IR imaging technologies
- evaluate quantitatively the performance of a wide variety of uncooled IR detectors
- summarize construction details from the technical literature.

INTENDED AUDIENCE

This material is intended for engineers, scientists, and managers who need a background knowledge of uncooled IR technologies, for those who need to be able to evaluate those technologies for usefulness in particular applications, and for those working in the field who wish to deepen their knowledge and understanding. Anyone concerned with current and future directions in thermal imaging or involved in the development of IR detector technology or advanced uncooled IR system concepts will find this course valuable. The course has a significant mathematical content designed to illustrate the origin of the principles involved, but knowledge of the mathematics is not required to understand the concepts and results.

INSTRUCTOR

Charles Hanson has a Ph.D. in theoretical solid-state physics and, after retiring as CTO of L-3 Infrared Products, is an independent consultant in the fields of electro-optics and thermal imaging, with particular specialty in uncooled thermal imaging. He has held government and industrial positions in infrared imaging for more than 40 years. He is a past chairman of Military Sensing Symposia (MSS) Passive Sensors and is presently co-chair of the SPIE Infrared Technology and Applications conference.

COURSE PRICE INCLUDES the text *Uncooled Thermal Imaging Arrays, Systems, and Applications* (SPIE Press, 2001) by Paul Kruse.

Infrared Imaging Radiometry

SC950

Course Level: Advanced
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course will enable the user to understand how an infrared camera system can be calibrated to measure radiance and/or temperature and how the digital data is converted into radiometric data. The user will learn how to perform their own external, “by hand” calibrations on a science-grade infrared camera system using area or cavity blackbodies and an Excel spreadsheet provided by the instructor. The influences of lenses, ND and bandpass filters, windows, emissivity, reflections and atmospheric absorption on the system calibration will be covered. The instructor will use software to illustrate these concepts and will show how to measure emissivity using an infrared camera and how to predict system performance outside the calibration range.

LEARNING OUTCOMES

This course will enable you to:

- classify the measurement units of radiometry and thermography
- describe infrared camera transfer functions - electrical signal output versus radiance signal input
- determine which cameras, lenses and both cold and warm filters to select for your application
- assess effects of ND filters and bandpass filters on calibrations, and calculate which ND warm filter you need for a given temperature range of target
- perform radiometric calibration of camera systems using cavity and area blackbodies
- convert raw data to radiometric data, and convert radiometric data to temperatures
- measure target emissivity and calibrate emissivity into the system
- gauge and account for reflections and atmospheric effects on measurements

INTENDED AUDIENCE

This material is intended for engineers, scientists, graduate students and range technicians that are working with science-grade infrared cameras in the lab, on military test ranges, or similar situations.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Commercial Vision Systems in Santa Barbara, and has specialized in scientific applications of infrared imaging technology for over 9 years. He holds a Ph.D. in astrophysics from UC Berkeley and is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* .

Introduction to Infrared and Ultraviolet Imaging Technology

SC1000

Course Level: Introductory
CEU: 0.35 $330 Members | $380 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The words infrared and ultraviolet are coming into much more widespread use, as ideas about the technology penetrates the public’s awareness and becomes part of popular culture through TV and film. In industry and academia, applications for infrared and ultraviolet cameras are multiplying rapidly, because both of the continued reduction in system cost as the technology penetrates the commercial marketplace, and the forward march of technology. At the same time, there is a fairly limited body of information about applications for these cameras. This is because camera manufacturers tend focus on the products themselves, not applications, and because most textbooks on IR and UV technology are outdated and tend to emphasize the basics of radiometry and detection by single detectors, not imaging applications. This course gives a non-technical overview of commercial infrared and ultraviolet camera systems, the “taxonomy” of infrared and ultraviolet wavebands, and the wide variety of applications for these wavebands. The course relies heavily on interesting imagery captured by the presenter over the last ten years and uses a SPIE monograph written by the author as a supplementary textbook.

LEARNING OUTCOMES

This course will enable you to:

- identify the different wavebands of the infrared and ultraviolet spectrum and describe their differences
- gain familiarity with the different types of cameras, sensors and optics used for imaging in the infrared and ultraviolet wavebands
- describe some of the key imaging applications for different wavebands of the infrared and ultraviolet

INTENDED AUDIENCE

The course is suitable both for technology professionals and non-technical persons that are new to infrared and ultraviolet imaging and want a very basic, qualitative overview of the fields with minimal mathematics. Little to no mathematic background is required.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Systems in Santa Barbara, CA. He holds a PhD in Astrophysics from UC Berkeley, and has worked in the commercial infrared industry for over 10 years. He is also the CTO of Oculus Photonics, a small company devoted to near-ultraviolet imaging systems manufacturing, sales and support. Richards is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* and an adjunct professor at the Brooks Institute of Photography in Santa Barbara.

COURSE PRICE INCLUDES the text *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* (SPIE Press, 2001) by Austin A. Richards.

Infrared Focal Plane Arrays

SC152

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

The course presents a fundamental understanding of two-dimensional arrays applied to detecting the infrared spectrum. The physics and electronics associated with 2-D infrared detection are stressed with special emphasis on the hybrid architecture unique to two-dimensional infrared arrays.

LEARNING OUTCOMES

This course will enable you to:

- develop the building blocks of 2-D arrays
- explain charge transfer concepts of various architectures
- describe various input electronics circuits
- discuss testing techniques used in the IR for 2-D arrays
- provide an overview of current technologies
- demonstrate aliasing effects
- review room temperature arrays
- discuss dual band arrays

INTENDED AUDIENCE

This material is intended for engineers, scientists and project managers who need to learn more about two-dimensional IR arrays from a user's point of view. It gives the student insight into the optical detection process, as well as what is available to application engineers, advantages, characteristics and performance.

INSTRUCTOR

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the University of Arizona, Tucson, AZ. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

John Hubbs is an engineer with Ball Aerospace and Technologies.

Predicting Target Acquisition Performance of Electro-Optical Imagers

SC181

Course Level: Advanced
CEU: 0.65 $570 Members | $665 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course describes how to predict and evaluate electro-optical (EO) imager performance. Metrics that quantify imager resolution are described. The detection, recognition, and identification tasks are discussed, and the meaning of acquisition probabilities is explained. The basic theory of operation of thermal imagers, image intensifiers, and video cameras is presented. This course describes how to quantify the resolution and noise characteristics of an EO imager. The theory and analysis of sampled imagers is emphasized. Image quality metrics are described, and the relationship between image quality and target acquisition performance is explained. The course provides a complete overview of how to analyze and evaluate the performance of EO imagers.

LEARNING OUTCOMES

This course will enable you to:

- describe what a target acquisition model does
- describe the operation of thermal sensors, video cameras and other EO imagers
- analyze the impact of sampling on targeting performance
- evaluate the targeting performance of an EO imager

INTENDED AUDIENCE

This course is intended for the design engineer or system analyst who is interested in quantifying the performance of EO imagers. Some background in linear systems analysis is helpful but not mandatory.

INSTRUCTOR

Richard Vollmerhausen recently retired from the Army's Night Vision and Electronic Sensors Directorate. He is currently consulting. Mr. Vollmerhausen is the developer of the current generation of target acquisition models used by the Army.

COURSE PRICE INCLUDES the text *Analysis and Evaluation of Sampled Imaging Systems* (SPIE Press, 2010) by Richard H. Vollmerhausen, Ronald G. Driggers, and Don Reago.

Engineering Approach to Imaging System Design

SC713

Course Level: Intermediate
CEU: 0.65 $565 Members | $660 Non-Members USD
Monday 8:30 am to 5:30 pm

This course discusses the three popular approaches to electro-optical imaging system design: spatial resolution, sensitivity (signal-to-noise ratio), and modulation transfer function (MTF) analysis. While often evaluated individually, all three must be considered to optimize system design. Usually, the dominant MTFs in machine vision devices are image motion (including random vibration of the sensor), optics (including aberrations), and the detector. For man-in-the-loop operation, the display and the eye are of concern and, in many situations, these limit the overall system performance.

Equally important, but often neglected is sampling; an inherent feature of all electronic imaging systems. Sampling, which creates blocky images are particularly bothersome with periodic targets such as test targets and bar codes. An engineering approach is taken. This course will provide numerous practical design examples (case studies) to illustrate the interplay between subsystem MTFs, resolution, sensitivity, and sampling.

LEARNING OUTCOMES

This course will enable you to:

- use approximations; often called 'rules-of-thumb,' or 'back-of-the-envelope' analysis
- identify the subsystem components that affect resolution and sensitivity
- determine if your system is resolution or sensitivity limited
- equivalently determine if your system is detector-limited or optics-limited
- determine which subsystem limits system performance and why
- understand sampling artifacts (Nyquist frequency limit, aliasing, Moiré patterns, and variations in object edge location and width)
- use MTFs, resolution, sensitivity, and sampling concepts for system optimization
- understand the trade-off between MTF and aliasing

INTENDED AUDIENCE

The course is for managers, system designers, test engineers, machine vision specialists, and camera users who want the best performance from their systems. It is helpful if the students are familiar with linear system theory (MTF analysis).

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference *Infrared Imaging Systems: Design, Analysis, Modeling and Testing* since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and IEEE and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Holst's Practical Guide to Electro-Optical Systems* (JCD Publishing, 2003) by Gerald C. Holst.

Testing and Evaluation of E-O Imaging Systems

SC067

Course Level: Advanced
CEU: 0.65 $595 Members | $690 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course describes all the quantitative and qualitative metrics that are used to characterize imaging system performance. While this course highlights thermal imaging systems, the concepts are generic and can be applied to all imaging systems (CCDs, intensified CCDs, CMOS, and near IR cameras). Data analysis techniques are independent of the sensor selected (i.e., wavelength independent). The difference lies in the input variable name (watts, lumens, or delta-T) and the output variable name (volts, lumens, or observer response). Slightly different test methodologies are used for visible and thermal imaging systems. Performance parameters discussed include resolution, responsivity, aperiodic transfer function, slit response function, random noise, uniformity, fixed pattern noise, modulation transfer function (MTF), contrast transfer function (CTF), minimum resolvable temperature (MRT), and the minimum resolvable contrast (MRC). The eye's spatial and temporal integration allows perception of images whose signal-to-noise ratio (SNR) is less than unity. Since all imaging system spatially sample the scene, sampling artifacts occur in all imagery and therefore affects all measurements. Sampling can significantly affect MRT and MTF tests. Low SNR and sampling effects are interactively demonstrated. This course describes the most common testing techniques. Equally important is identifying those parameters that adversely affect results.

LEARNING OUTCOMES

This course will enable you to:

- write concise test procedures with unambiguous system specifications
- identify all appropriate test parameters
- describe the radiometric relationship between delta-T and spectral radiance
- differentiate between observer variability and system response during MRC and MRT testing
- describe the difference between the CTF and the MTF
- learn about the latest MTF measurement techniques
- discern the difference between poor system performance, peculiarities of the system under test, and measurement errors
- assess how sampling affects test results
- appreciate the benefits and short comings of fully automated testing
- identify parameters that can lead to poor results.
- learn about evolving standardized testing concepts

INTENDED AUDIENCE

The course is for managers, specification writers, and test engineers involved with all phases of imaging system characterization ranging from satisfying customer requirements to ensuring that specifications are unambiguous and testable.

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference Infrared Imaging Systems: Design, Analysis, Modeling and Testing since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Testing and Evaluation of Infrared Imaging Systems, Third Edition* (SPIE Press and JCD Publishing, 2008) by Gerald C. Holst.

Electro-Optical Imaging System Performance

SC154

Course Level: Intermediate
CEU: 0.65 $595 Members | $690 Non-Members USD
Friday 8:30 am to 5:30 pm

While this course highlights thermal imaging systems, the concepts are generic and can be applied to all imaging systems (CCDs, intensified CCDs, CMOS, and near IR cameras). System analysis could be performed in the spatial domain. However, it is far easier to work in the frequency domain using MTFs. Subsystem MTFs are combined for overall system analysis. This is often called image chain modeling. Although the math is sometimes complex, the equations are graphed for easy understanding. With the Sept 2002 models (e.g., NVTherm), the minimum resolvable temperature (MRT) and minimum resolvable contrast (MRC) are coupled with the target signature and atmospheric transmittance to provide range performance predictions (target acquisition modeling). Three ranges are predicted: detection, recognition, and identification (often shorten to DRI). DRI ranges depend upon the subsystem MTFs, noise (primarily random and fixed pattern noise), the display, and the eye's response. The two-dimensional (fictitious) spatial frequency approach, three-dimensional noise model, and target discrimination metrics (Johnson's N50) are applied to performance predictions. The 2007 models (e.g., NVThermIP) employ contrast rather than MRT (MRC) for target acquisition and use V50 as a discrimination metric. Limitations and applications of NVTherm and NVThermIP are discussed with a brief demonstration of the models. Selection and optimization of a specific sensor depends upon a myriad of radiometric, spectral, and spatial parameters (e.g., target signature, atmospheric conditions, optics f-number, field-of-view, and detector responsivity). MTFs and their effect on imagery are interactively demonstrated. Spatial sampling is present in all cameras. Super-resolution reconstruction and microscan minimize sampling artifacts. Several optimization examples are discussed (case study examples).

LEARNING OUTCOMES

This course will enable you to:

- use the correct MTFs for image chain analysis
- describe the radiometric relationship between delta-T and spectral radiance
- compare the differences among scanning, staring, and microscan staring array performance
- recognize the limitations of back-of-the-envelope approximations such as resolution and sensitivity
- identify the subsystem (e.g., motion, optics, detector, electronics, and display) that limits performance
- appreciate limitations of range performance predictions (target acquisition predictions)
- determine if mid-wave (MWIR) or long-wave (LWIR) infrared is appropriate for your application
- appreciate the value of graphs rather than a table of numbers
- be conversant with the myriad of technological terms
- become a smart buyer, analyst, and/or user of imaging systems

INTENDED AUDIENCE

This course is intended for engineers, managers, and buyers who want to understand the wealth of information available from imaging system end-to-end analysis. It is helpful if the students are familiar with linear system theory (MTF analysis).

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference Infrared Imaging Systems: Design, Analysis, Modeling and Testing since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Electro-Optical Imaging System Performance, Fifth Edition* (SPIE Press and JCD Publishing, 2008) by Gerald C. Holst.

Multispectral and Hyperspectral Image Sensors

SC194

Course Level: Advanced
CEU: 0.35 $375 Members | $425 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

This course will describe the imaging capabilities and applications of the principal types of multispectral (MS) and hyperspectral (HS) sensors. The focus will be on sensors that work in the visible, near-infrared and shortwave-infrared spectral regimes, but the course will touch on longwave-infrared applications. A summary of the salient features of classical color imaging (human observation) will also be provided in an appendix.

LEARNING OUTCOMES

This course will enable you to:

- understand many of the applications and advantages of multispectral (MS) and hyperspectral (HS) imaging
- describe and categorize the properties of the principal MS / HS design types (multi-band scanner, starers with filter wheels, dispersive, wedge, and Fourier transform imagers with 2D arrays, etc.)
- list and define the relevant radiometric radiometric quantities, concepts and phenomenology
- understand the process of translating system requirements into sensor hardware constraints and specifications
- analyze signal-to-noise ratio, modulation-transfer-function, and spatial / spectral sampling for MS and HS sensors
- define, understand and apply the relevant noise-equivalent figures-of-merit (Noise-equivalent reflectance difference, Noise-equivalent temperature difference, Noise-equivalent spectral radiance, Noise-equivalent irradiance, etc.)
- describe the elements of the image chain from photons-in to bits-out (photon detection, video signal manipulation, analog processing, and digitization)
- list and review key imager subsystem technology elements (optical, focal plane, video electronics, and thermal)
- formulate a detailed end-to-end design example of a satellite imaging scanning HS sensor
- provide an appendix that summarizes color imaging principles and sensor associated elements for human observation applications (e.g. color television, still cameras, etc.)

INTENDED AUDIENCE

Engineers, scientists, and technical managers who are interested in understanding and applying multispectral and hyperspectral sensors in advanced military, civil, scientific and commercial applications.

INSTRUCTOR

Terrence Lomheim holds the position of Distinguished Engineer at The Aerospace Corp. He has 34 years of hardware and analysis experience in visible and infrared electro-optical systems, focal plane technology, and applied optics, and has authored and co-authored 63 publications in these technical areas. He is a Fellow of the SPIE.

COURSE PRICE INCLUDES the text *CMOS/CCD Sensors and Camera Systems, 2nd edition* (SPIE Press, 2011) by Terrence Lomheim and Gerald Holst.

Introduction to Optical and Infrared Sensor Systems

SC789

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides a broad introduction to optical (near UV-visible) and infrared sensor systems, with an emphasis on systems used in defense and security. Topics include both passive imagers and active laser radars (lidar/ladar). We begin with a discussion of radiometry and radiometric calculations to determine how much optical power is captured by a sensor system. We survey atmospheric propagation and phenomenology (absorption, emission, scattering, and turbulence) and explore how these issues affect sensor systems. Finally, we perform signal calculations that consider the source, the atmosphere, and the optical system and detector, to arrive at a signal-to-noise ratio for typical passive and active sensor systems. These principles of optical radiometry, atmospheric propagation, and optical detection are combined in examples of real sensors studied at the block-diagram level. Sensor system examples include passive infrared imagers, polarization imagers, and hyperspectral imaging spectrometers, and active laser radars (lidars or ladars) for sensing distributed or hard targets. The course organization is approximately one third on the radiometric analysis of sensor systems, one third on atmospheric phenomenology and detector parameters, and one third on example calculations and examination of sensor systems at the block-diagram level.

LEARNING OUTCOMES

This course will enable you to:

- explain and use radiometry for describing and calculating the flow of optical energy in an optical or infrared sensor system
- determine the radiometric throughput of sensor systems
- describe atmospheric phenomenology relevant to propagation of optical and infrared radiation
- explain how the atmosphere affects the performance of sensor systems
- use detector parameters with radiometric calculations to predict the signal received by passive and active sensors
- calculate signal-to-noise ratio for typical sensor systems
- explain real-world sensor systems at the block-diagram level
- explain the difference between and important concepts of passive reflection-based and emission-based imaging
- describe the basic operating principles of passive imagers and active laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who find themselves working on (or curious about) optical (uv-vis) and infrared sensor systems without formal training in this area. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw has been developing optical remote sensing systems and using them in environmental and military sensing for two decades, first at NOAA and currently as professor of electrical engineering and physics at Montana State University. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a Ph.D. in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

Introduction to Night Vision

SC1068

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

Night vision devices have become ubiquitous in both commercial and military environments. From the very high end systems used for aviation, to the low-performance systems sold for outdoorsmen, these devices have changed the way their users operate at night. This course explains the basic principles behind night vision and discusses the different types of night vision devices, both “analog” and “digital”. In addition to a survey of night vision devices, we also examine the inner workings of night vision systems and explain them in an easy to understand manner. We will discuss the design of night vision systems, both handheld and head mounted.

Although we will talk briefly about SWIR and thermal devices to differentiate them from night vision devices, this course is primarily aimed at visible and near infra-red (NIR) imagers. Imagery from both night vision cameras as well as thermal imagers will be presented and the differences between them will be compared/contrasted.

LEARNING OUTCOMES

This course will enable you to:

- identify the three basic components of a night vision imager: the sensor, the amplifier and the output component
- specify input optics (objective lenses) and output optics (eyepieces) for both analog and digital night vision devices
- explain the difference between VIS/NIR night vision, SWIR, MWIR and LWIR sensors as well as when each should be chosen
- differentiate the different generations of night vision goggles
- define appropriate light levels for night vision device testing
- describe new digital night vision devices and their advantages and disadvantages
- explain the important attributes of night vision systems and how they should be specified for “best value” performance
- predict night vision performance using NVESD models

INTENDED AUDIENCE

Scientists, engineers, technicians, procurement personnel or managers who wish to learn more about night vision devices. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Michael Browne is the Vice President of Product Development at SA Photonics. He has a Ph.D. in Optical Engineering from the University of Arizona’s Optical Sciences Center. Mike has been involved in the design, test and measurement of night vision systems since 1986. At Kaiser Electronics, he led the design of numerous head mounted night vision systems including those for the RAH-66 Comanche helicopter and the USAF NVS program. He leads SA Photonics’ efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. His current research includes investigations into the design of wide field of view night vision devices, binocular rivalry in head mounted displays, and smear reduction in digital displays.

Radiometry and its Practical Applications

SC1073

Course Level: Introductory
CEU: 0.65 $625 Members | $720 Non-Members USD
Monday 8:30 am to 5:30 pm

The first half of this course presents the basic quantities and units of radiometry and photometry. It describes radiometric laws and approximations including the inverse square and cosine power laws, and introduces the equation of radiative transfer. It provides an overview of optical radiation sources , blackbody radiation laws, and optical material properties including transmission, reflection, absorption, and emission. It surveys photon and thermal optical radiation detectors, instrumentation, and calibration.

The course’s second half focuses on practical problem solving. It applies the concepts presented in Part I to calculate the amount of optical radiation reaching a system’s entrance aperture or focal plane for a variety of source-receiver combinations. Its applications include problems in some or all of the following areas: solar thermal systems, sun and sky irradiance delivered to a collector, diffuse and specular signals in the thermal infrared, star sensing in the visible, and integrating spheres. It incorporates several examples from the associated text The Art of Radiometry.

LEARNING OUTCOMES

This course will enable you to:

- master the basics of radiometry and photometry and their systems of terminology and units
- master key radiometric laws and approximations
- describe the characterization of optical properties of surfaces, materials, and objects
- gain insight into basic properties of optical detectors and instrumentation
- identify approaches to problem-solving based on source and geometry considerations
- calculate the amount of radiation received from single and multiple sources
- compare point and extended source calibration methods
- qualify the limitations of your solution

INTENDED AUDIENCE

This course is designed for engineers and scientists dealing with electromagnetic radiation who need to quantify this radiation using international standard units and terminology. It is aimed at technologists seeking to gain familiarity with radiometric concepts in order to solve practical problems.

INSTRUCTOR

Barbara Grant is the author of the Field Guide to Radiometry (SPIE Press, 2011) and the co-author, with Jim Palmer, of The Art of Radiometry (SPIE Press, 2009). For more than twenty years she has utilized a systems engineering approach to radiometric problem solving in industries as diverse as aerospace and indoor tanning. She received the MS degree in Optical Sciences from the University of Arizona and two NASA awards for work on the GOES weather satellite imager and sounder. Her previous work for SPIE includes developing and chairing a special session on FLIR image analysis.

COURSE PRICE INCLUDES the texts *The Art of Radiometry* (SPIE Press, 2009) by James M. Palmer and Barbara G. Grant, and the *Field Guide to Radiometry* (SPIE Press, 2011) by Barbara G. Grant .

Imaging Polarimetry

SC180

Course Level: Advanced
CEU: 0.35 $295 Members | $345 Non-Members USD
Tuesday 8:30 am to 12:30 pm

This course covers imaging polarimeters from an instrumentation-design point of view. Basic polarization elements for the visible, mid-wave infrared, and long-wave infrared are described in terms of Mueller matrices and the Poincaré sphere. Polarization parameters such as the degree of polarization (DOP), the degree of linear polarization (DOLP) and the degree of circular polarization (DOCP) are explained in an imaging context. Emphasis is on imaging systems designed to detect polarized light in a 2-D image format. System concepts are discussed using a Stokes-parameter (s0,s1,s2,s3) image. Imaging-polarimeter systems design, pixel registration, and signal to noise ratios are explored. Temporal artifacts, characterization and calibration techniques are defined.

LEARNING OUTCOMES

This course will enable you to:

- explain imaging-polarimetry fundamentals using a Mueller matrix description and make use of the Poincaré sphere
- formulate mathematical models to describe an imaging polarimeter and to optimize its design

- discuss natural and manmade phenomena that give rise to polarized light in the visible and the infrared parts of the spectrum
- discuss techniques for spectro-polarimetry, i.e., the collection of (x,y,...)data hypercubes
- evaluate polarimeter designs
- compare representative scanning and non-scanning imaging-polarimeter designs
- explain sources of error in imaging polarimeters

INTENDED AUDIENCE

This course is for engineers, scientists, and program managers interested in an overview of imaging polarimetry. The tutorial is intended to give students intuitive insight into fundamental concepts with a minimum of rigorous mathematical treatment. To benefit maximally from this course, attendees should be familiar with the materials covered in SPIE SC206, Introductory and Intermediate Topics in Polarized Light.

INSTRUCTOR

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the University of Arizona, Tucson, AZ. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

Brian Miles is a consultant with Optical Sensing Consultants, where he performs optical system design, systems engineering analysis and test development for U.S. Government/Military and commercial clients. He was previously a Senior Scientist for FastMetrix Inc. and a Senior Research Physicist with the Seeker Branch of the Munitions Directorate of the Air Force Research Lab at Eglin Air Force Base, Florida. Dr. Miles' professional interests include laser radar, laser remote sensing, imaging polarimetry, imaging spectro-polarimetry, and mine detection. Dr. Miles is an Optical Sciences Ph.D. graduate from the University of Arizona Optical Sciences Center.

Derek Sabatke holds M.S. and Ph.D. degrees in Optical Engineering and Optical Sciences from the Univ. of Arizona. His research interests center on optical sensors and instruments, and include microsensors, imaging polarimeters and spectropolarimeters. He has conducted research at the Univ. of Minnesota, Honeywell Technology Center, and Univ. of Arizona, and is currently an optical engineer with Ball Aerospace and Technologies Corp. in Bolder, Colorado.

Understanding Diffractive Optics

SC1071

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Monday 8:30 am to 5:30 pm

The course will cover the fundamental principles of diffraction phenomena. A qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics, as well as the unique properties associated with the diffraction of laser beams during propagation. The instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics
- describe diffraction phenomena associated with the propagation of laser beams
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and resonant domains, diffraction efficiency, and the blazing condition
- receive an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was published in 2011 by SPIE Press.

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics* , FG21 (SPIE Press, 2011) by Yakov Soskind.

Optical and Optomechanical Engineering

Infrared Radiometric Calibration

SC1109 **New**

Course level: Intermediate
CEU .35 $295 Members | $345 Non-Members
Wednesday 1:30 to 5:30 pm

This course describes the radiometric calibration techniques used for SI-traceable measurements of sources, detectors and material properties in the infrared wavelength region. The main goal is to enable understanding of infrared measurements with quantified uncertainties so that full uncertainty budgets can be established for the final quantities. Examples from NIST calibrations of sources, detectors and materials will be described.

The properties and measurements of various different blackbody and lamp sources will be discussed. Detector calibrations using both thermal and quantum detectors with monochromators and Fourier-transform spectrometers will be covered. Also, infrared reflectance measurements using Fourier-transform spectrometers will be explained. Examples of NIST-developed infrared transfer and working standard radiometers in field deployments will be utilized to illustrate the above concepts.

LEARNING OUTCOMES

This course will enable you to:

- choose the optimal sources for the measurement needs from the different sources available in the field
- list the procedures for selecting and calibrating infrared detectors and their associated uncertainties
- describe the uncertainty propagation principles in both source and detector calibrations
- utilize techniques for infrared material reflectance measurements and their uncertainty propagation
- characterize a radiation thermometer according to ASTM standards

INTENDED AUDIENCE

This course is designed for technical staff involved in radiometric calibrations of sources, detectors and radiometers.

INSTRUCTORS

Howard Yoon graduated with a B.S. Physics and Chemistry degree from Swarthmore College and earned his M.S. and Ph.D. Physics degrees from the University of Illinois at Urbana-Champaign. He has worked for Bell Communications Research and Dartmouth College. He currently serves as the US Representative to the Consultative Committee on Thermometry and is a member of the IEC TC65/SC65B/WG5 committee. While at NIST, he has received the Allen V. Astin Award and the DOC Silver Award. Currently at NIST he is a physicist working on several projects related to advancing spectroradiometry for improvements in fundamental and disseminated standards of spectral radiance, spectral irradiance, and radiance temperature.

George Eppeldauer received his M.E. and Ph.D. Electronics Engineering degrees from the Technical University of Budapest. Previously, he has worked at the Research Institute for Technical Physics at the Hungarian Academy of Sciences. He won the Best Paper Award at the NCSLI Conference in 2004, and he chairs the CIE TC2-48 Technical Committee (TC) on Spectral Responsivity Calibrations and the CIE TC2-29 TC on Detector Linearity. He is an electronics engineer with research areas in detector metrology developing transfer and working standard optical radiometers, photometers, and colorimeters and realizing detector responsivity based scales. The standards he has developed have been utilized to improve the two NIST SI units, the candela and kelvin, the illuminance responsivity scale, the tristimulus color scale, the spectral power, irradiance, and radiance responsivity reference-scales, and the spectral irradiance scale. He was one of the three pioneers who developed the SIRCUS reference responsivity-calibration facility.

Simon Kaplan received a B.A. Physics degree from Oberlin College and Ph.D. Physics degree from Cornell University. Prior to joining NIST, he has worked at the University of Maryland, College Park. He is a physicist with research interests in spectrophotometry and radiometry. He has worked on the characterization of optical materials and components in support of UV photolithography and infrared remote sensing applications. Currently he is leading the Low Background Infrared (LBIR) facility for absolute detector-based irradiance and radiance calibrations in support of missile defense as well as climate monitoring technology.

Carol Johnson earned a B.S. Engineering Physics degree from the University of Colorado and M.A. and Ph.D. in Astronomy from Harvard University, where she also worked before joining NIST. At NIST, she has earned the NIST Bronze Medal and DOC Silver and Gold Medals, as well as the Arthur S. Flemming and Edward Bennett Rosa Awards. Currently she is a physicist developing methods for improved radiometric characterization and calibration of instruments, transferring this knowledge to the user community, and improving the metrology of radiometry in remote sensing global climate change research. She serves on instrument design and calibration and validation peer reviews for NASA and NOAA sensors, participates in the Working Group on Calibration and Validation (WGCV) for the Committee on Earth Observation Satellites (CEOS), and collaborates with ocean color calibration scientists.

ADDITIONAL COMMENTS: This course has been designed to complement and build upon the content presented in SC1073, Radiometry and its Practical Applications. Attendees will benefit maximally from attending both courses.

Basic Optics for Engineers

SC156

Course Level: Introductory
CEU: 0.65 $555 Members | $650 Non-Members USD
Monday 8:30 am to 5:30 pm

This course introduces each of the following basic areas of optics, from an engineering point of view: geometrical optics, image quality, flux transfer, sources, detectors, and lasers. Basic calculations and concepts are emphasized.

LEARNING OUTCOMES

This course will enable you to:

- compute the following image properties: size, location, fidelity, brightness
- estimate diffraction-limited imaging performance
- explain optical diagrams
- describe the factors that affect flux transfer efficiency, and their quantitative description
- compute the spectral distribution of a source
- describe the difference between photon and thermal detectors
- calculate the signal to noise performance of a sensor (D* and noise equivalent power)
- differentiate between sensitivity and responsivity
- explain the main factors of laser beams: monochromaticity, collimation, and propagation

INTENDED AUDIENCE

This class is intended for engineers, technicians, and managers who need to understand and apply basic optics concepts in their work. The basics in each of the areas are covered, and are intended for those with little or no prior background in optics, or for those who need a fundamental refresher course.

INSTRUCTOR

Glenn Boreman is the Chairman of the Department of Physics and Optical Science at the University of North Carolina at Charlotte. He received a BS in Optics from Rochester and PhD in Optics from Arizona. Prof. Boreman served on the faculty of University of Central Florida for 27 years, with 24 PhD students supervised to completion. His research interests are in infrared detectors, infrared metamaterials, and electro-optical sensing systems. Prof. Boreman is a Fellow of SPIE, OSA, and the Military Sensing Symposium.

COURSE PRICE INCLUDES the text *Basic Electro-Optics for Electrical Engineers* (SPIE Press, 1998) by Glenn D. Boreman.

Optical Systems Engineering

SC1052

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

Optical Systems Engineering emphasizes first-order, system-level estimates of optical performance. Building on the basic principles of optical design, this course uses numerous examples to illustrate the systems-engineering processes of requirements analysis, feasibility and trade studies, subsystem interfaces, error budgets, requirements flowdown and allocation, component specifications, and vendor selection. Topics covered will include an introduction to systems engineering, geometrical optics, aberrations and image quality, radiometry, optical sources, detectors and FPAs, optomechanics, and the integration of these topics for developing a complete optical system.

LEARNING OUTCOMES

This course will enable you to:

- utilize the concepts and terminology of systems engineering as applied to optical system development
- calculate geometrical-optics parameters such as image size, image location, FOV, IFOV, and ground-sample distance (GSD)
- distinguish the various types of optical aberrations; estimate blur size and blur-to-pixel ratio, and their effects on MTF, ground-resolved distance (GRD), and image quality
- quantify radiometric performance, using the concepts of optical transmission, f/#, etendue, scattering, and stray light
- compare source types and properties; estimate radiometric performance; develop source-selection tradeoffs and specifications such as output power, irradiance, radiance, uniformity, stability, and SWaP
- compare FPA and detector types and properties; predict SNR performance combining optical, source, and detector parameters; develop detector-selection tradeoffs and specifications such as sensitivity, dynamic range, uniformity, operability, and SWaP (Size, Weight, and Power)
- explain optical component specifications; estimate thermal, structural, and dynamic effects on the performance of an optical system; utilize the results of STOP (structural, thermal, and optical) analysis and error budgets

INTENDED AUDIENCE

Intended for engineers, scientists, technicians, and managers who are developing, specifying, or purchasing optical, electro-optical, and infrared systems. Prerequisites include a familiarity with Snell's law, the lens equation for simple imaging, and the concepts of wavelength and wavefronts.

INSTRUCTOR

Keith Kasunic has more than 25 years of experience developing optical, electro-optical, infrared, and laser systems. He holds a Ph.D. in Optical Sciences from the University of Arizona, an MS in Mechanical Engineering from Stanford University, and a BS in Mechanical Engineering from MIT. He has worked for or been a consultant to a number of organizations, including Lockheed Martin, Ball Aerospace, Sandia National Labs, Nortel Networks, and Bookham. He is currently the Technical Director of Optical Systems Group, LLC. He is also an Adjunct Professor at Univ. of Central Florida's CREOL – The College of Optics and Photonics, as well as an Affiliate Instructor with Georgia Tech's SENSIAC, and an Instructor for the Optical Engineering Certificate Program at Univ. of California Irvine. This course is based on his textbook Optical Systems Engineering, published by McGraw-Hill in 2011.

Introduction to Optomechanical Design

SC014

Course Level: Introductory
CEU: 1.3 $890 Members | $1,110 Non-Members USD
Wednesday - Thursday 8:30 am to 5:30 pm

This course will provide the training needed for the optical engineer to work with the mechanical features of optical systems. The emphasis is on providing techniques for rapid estimation of optical system performance. Subject matter includes material properties for optomechanical design, kinematic design, athermalization techniques, window design, lens and mirror mounting.

LEARNING OUTCOMES

This course will enable you to:
- select materials for use in optomechanical systems
- determine the effects of temperature changes on optical systems, and develop design solutions for those effects
- design high performance optical windows
- design low stress mounts for lenses
- select appropriate mounting techniques for mirrors and prisms
- describe different approaches to large and lightweight mirror design

INTENDED AUDIENCE

Engineers who need to solve optomechanical design problems. Optical designers will find that the course will give insight into the mechanical aspects of optical systems. The course will also interest those managing projects involving optomechanics. Short course SC690, Optical System Design: Layout Principles and Practice, or a firm understanding of its content, is required as background to this course.

INSTRUCTOR

Daniel Vukobratovich is a senior principal engineer at Raytheon. He has over 30 years of experience in optomechanics, is a founding member of the SPIE working group in optomechanics, and is fellow of SPIE. He has taught optomechanics in 11 countries, consulted with over 50 companies and written over 50 publications in optomechanics.

Mounting of Optical Components

SC1019

New

Course Level: Introductory
CEU: 0.65 $595 Members | $690 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course introduces the principles and standard practices for mounting of optical components such as lenses, mirrors, windows, prisms, and filters. Particular case studies are used to show how mount design is driven by a combination of the environmental and performance requirements.

Common mounting techniques are explained such as:
- Mounting of lenses into barrels using adhesives or retaining rings
- Mounting of prisms and small mirrors using adhesives
- Mounting of assemblies using flexures
- Mounting and sealing of windows

Engineering analysis is performed for each type of mount to predict stress, survivability, and performance.

LEARNING OUTCOMES

This course will enable you to:
- appreciate the effects of the environment on optics
- identify critical aspects of the optic-to-mount interface
- compare alternate mounting techniques for common types of elements
- design mounting interfaces that balance performance, survivability, and cost
- estimate survivability for shock and thermal loading
- estimate tolerances for optical assemblies built up using standard designs

INTENDED AUDIENCE

Participation in this course will help optical and mechanical technicians, engineers, designers, scientists, and program managers understand how optical components can best be integrated into instruments. It will provide these attendees with basic techniques for analyzing optomechanical designs.

INSTRUCTOR

Keith Kasunic has more than 25 years of experience developing optical, electro-optical, infrared, and laser systems. He holds a Ph.D. in Optical Sciences from the University of Arizona, an MS in Mechanical Engineering from Stanford University, and a BS in Mechanical Engineering from MIT. He has worked for or been a consultant to a number of organizations, including Lockheed Martin, Ball Aerospace, Sandia National Labs, Nortel Networks, and Bookham. He is currently the Technical Director of Optical Systems Group, LLC. He is also an Adjunct Professor at Univ. of Central Florida's CREOL – The College of Optics and Photonics, as well as an Affiliate Instructor with Georgia Tech's SENSIAC, and an Instructor for the Optical Engineering Certificate Program at Univ. of California Irvine.

COURSE PRICE INCLUDES the text *Mounting Optics in Optical Instruments, 2nd edition* (SPIE Press, 2008), by Paul R. Yoder, Jr.

Integrated Opto-Mechanical Analysis

SC254

Course Level: Advanced
CEU: 0.65 $565 Members | $660 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course presents opto-mechanical analysis methods to design, analyze, and optimize the performance of imaging systems subject to environmental influences. Emphasized is the application of finite element techniques to develop efficient and practical models for optical elements and support structures from early design concepts to final production models. Students will learn how to design, analyze, and predict performance of optical systems subject to the influence of gravity, pressure, stress, harmonic, random, transient, and thermal loading. The integration of optical element thermal and structural response quantities into optical design software including ZEMAX and CODEV is also presented that allow optical performance metrics such as wavefront error to be computed as a function of the environment and mechanical design variables. Advanced techniques including the modeling of adaptive optics and design optimization are also discussed. Examples will be drawn from ground-based, airborne, and spaceborne optical systems.

LEARNING OUTCOMES

This course will enable you to:

- efficiently model optical mounts, flexures, and metering structures
- design and analyze optical bonds including structural adhesives and RTV
- predict optical errors and line-of-sight jitter in random environments
- design and analyze vibration isolation systems
- perform thermo-elastic analysis of optical systems
- predict the effects of stress birefringence on optical performance
- develop diagnostic analyses and back-outs for test and assembly induced errors
- effectively model lightweight mirrors
- integrate thermal and structural results into optical models
- predict and represent the distortion of optical surfaces using Zernike polynomials
- model adaptive optics, predict system correctability and system performance
- use numerical optimization techniques to improve designs

INTENDED AUDIENCE

This course is intended for mechanical and optical engineers interested in learning about opto-mechanical analysis techniques and the use of modern software tools including finite element analysis and optical design software to design and analyze optical systems. Working knowledge or familiarity with finite element software and/or optical design software is recommended.

INSTRUCTOR

Victor Genberg has over 40 years' experience in the application of finite element methods to high-performance optical structures and is a recognized expert in opto-mechanics. He is currently President of Sigmadyne, Inc. and a Professor of Mechanical Engineering at the University of Rochestor where he teaches courses in optomechanics, finite element analysis, and design optimization. He has over 40 publications in this field including two chapters in the CRC Handbook of Optomechanical Engineering. Prior to founding Sigmadyne, Dr. Genberg spent 28-years at Eastman Kodak serving as a technical specialist for military and commercial optical systems.

Keith Doyle has over 20 years' experience in the field of optical engineering, specializing in opto-mechanics and the multidisciplinary modeling of optical systems. He has authored or co-authored over 30 publications in this field. He is currently employed at MIT Lincoln Laboratory as a Group Leader in the Engineering Division. Previously he served as Vice President of Sigmadyne Inc. and as a Senior Systems Engineer at Optical Research Associates. He received his Ph.D. in engineering mechanics with a minor in optical sciences from the University of Arizona in 1993.

COURSE PRICE INCLUDES the text *Integrated Optomechanical Analysis* (SPIE Press, 2002) by Keith Doyle, Victor Genberg, and Gregory Michels. The text includes an accompanying CD-ROM with examples.

Understanding Diffractive Optics

SC1071

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Monday 8:30 am to 5:30 pm

The course will cover the fundamental principles of diffraction phenomena. A qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics, as well as the unique properties associated with the diffraction of laser beams during propagation. The instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics
- describe diffraction phenomena associated with the propagation of laser beams
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and resonant domains, diffraction efficiency, and the blazing condition
- receive an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was published in 2011 by SPIE Press.

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics* , FG21 (SPIE Press, 2011) by Yakov Soskind.

Radiometry and its Practical Applications

SC1073

Course Level: Introductory
CEU: 0.65 $625 Members | $720 Non-Members USD
Monday 8:30 am to 5:30 pm

The first half of this course presents the basic quantities and units of radiometry and photometry. It describes radiometric laws and approximations including the inverse square and cosine power laws, and introduces the equation of radiative transfer. It provides an overview of optical radiation sources , blackbody radiation laws, and optical material properties including transmission, reflection, absorption, and emission. It surveys photon and thermal optical radiation detectors, instrumentation, and calibration.

The course's second half focuses on practical problem solving. It applies the concepts presented in Part I to calculate the amount of optical radiation reaching a system's entrance aperture or focal plane for a variety of source-receiver combinations. Its applications include problems in some or all of the following areas: solar thermal systems, sun and sky irradiance delivered to a collector, diffuse and specular signals in the thermal infrared, star sensing in the visible, and integrating spheres. It incorporates several examples from the associated text The Art of Radiometry.

LEARNING OUTCOMES

This course will enable you to:

- master the basics of radiometry and photometry and their systems of terminology and units
- master key radiometric laws and approximations

- describe the characterization of optical properties of surfaces, materials, and objects
- gain insight into basic properties of optical detectors and instrumentation
- identify approaches to problem-solving based on source and geometry considerations
- calculate the amount of radiation received from single and multiple sources
- compare point and extended source calibration methods
- qualify the limitations of your solution

INTENDED AUDIENCE

This course is designed for engineers and scientists dealing with electromagnetic radiation who need to quantify this radiation using international standard units and terminology. It is aimed at technologists seeking to gain familiarity with radiometric concepts in order to solve practical problems.

INSTRUCTOR

Barbara Grant is the author of the Field Guide to Radiometry (SPIE Press, 2011) and the co-author, with Jim Palmer, of The Art of Radiometry (SPIE Press, 2009). For more than twenty years she has utilized a systems engineering approach to radiometric problem solving in industries as diverse as aerospace and indoor tanning. She received the MS degree in Optical Sciences from the University of Arizona and two NASA awards for work on the GOES weather satellite imager and sounder. Her previous work for SPIE includes developing and chairing a special session on FLIR image analysis.

COURSE PRICE INCLUDES the texts *The Art of Radiometry* (SPIE Press, 2009) by James M. Palmer and Barbara G. Grant, and the *Field Guide to Radiometry* (SPIE Press, 2011) by Barbara G. Grant .

Introduction to Infrared and Ultraviolet Imaging Technology

SC1000

Course Level: Introductory
CEU: 0.35 $330 Members | $380 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The words infrared and ultraviolet are coming into much more widespread use, as ideas about the technology penetrates the public's awareness and becomes part of popular culture through TV and film. In industry and academia, applications for infrared and ultraviolet cameras are multiplying rapidly, because both of the continued reduction in system cost as the technology penetrates the commercial marketplace, and the forward march of technology. At the same time, there is a fairly limited body of information about applications for these cameras. This is because camera manufacturers tend focus on the products themselves, not applications, and because most textbooks on IR and UV technology are outdated and tend to emphasize the basics of radiometry and detection by single detectors, not imaging applications.

This course gives a non-technical overview of commercial infrared and ultraviolet camera systems, the "taxonomy" of infrared and ultraviolet wavebands, and the wide variety of applications for these wavebands. The course relies heavily on interesting imagery captured by the presenter over the last ten years and uses a SPIE monograph written by the author as a supplementary textbook.

LEARNING OUTCOMES

This course will enable you to:

- identify the different wavebands of the infrared and ultraviolet spectrum and describe their differences
- gain familiarity with the different types of cameras, sensors and optics used for imaging in the infrared and ultraviolet wavebands
- describe some of the key imaging applications for different wavebands of the infrared and ultraviolet

INTENDED AUDIENCE

The course is suitable both for technology professionals and non-technical persons that are new to infrared and ultraviolet imaging and want a very basic, qualitative overview of the fields with minimal mathematics. Little to no mathematic background is required.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Systems in Santa Barbara, CA. He holds a PhD in Astrophysics from UC Berkeley, and has worked in the commercial infrared industry for over 10 years. He is also the CTO of Oculus Photonics, a small company devoted to near-ultraviolet imaging systems manufacturing, sales and support. Richards is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* and an adjunct professor at the Brooks Institute of Photography in Santa Barbara.

COURSE PRICE INCLUDES the text *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* (SPIE Press, 2001) by Austin A. Richards.

Infrared Imaging Radiometry

SC950

Course Level: Advanced
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course will enable the user to understand how an infrared camera system can be calibrated to measure radiance and/or temperature and how the digital data is converted into radiometric data. The user will learn how to perform their own external, "by hand" calibrations on a science-grade infrared camera system using area or cavity blackbodies and an Excel spreadsheet provided by the instructor. The influences of lenses, ND and bandpass filters, windows, emissivity, reflections and atmospheric absorption on the system calibration will be covered. The instructor will use software to illustrate these concepts and will show how to measure emissivity using an infrared camera and how to predict system performance outside the calibration range.

LEARNING OUTCOMES

This course will enable you to:

- classify the measurement units of radiometry and thermography
- describe infrared camera transfer functions - electrical signal output versus radiance signal input
- determine which cameras, lenses and both cold and warm filters to select for your application
- assess effects of ND filters and bandpass filters on calibrations, and calculate which ND warm filter you need for a given temperature range of target
- perform radiometric calibration of camera systems using cavity and area blackbodies
- convert raw data to radiometric data, and convert radiometric data to temperatures
- measure target emissivity and calibrate emissivity into the system
- gauge and account for reflections and atmospheric effects on measurements

INTENDED AUDIENCE

This material is intended for engineers, scientists, graduate students and range technicians that are working with science-grade infrared cameras in the lab, on military test ranges, or similar situations.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Commercial Vision Systems in Santa Barbara, and has specialized in scientific applications of infrared imaging technology for over 9 years. He holds a Ph.D. in astrophysics from UC Berkeley and is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* .

Infrared Optics and Zoom Lenses

SC755

Course Level: Intermediate
CEU: 0.35 $340 Members | $390 Non-Members USD
Thursday 8:30 am to 12:30 pm

This course describes the fundamental properties of the infrared region of the spectrum and explains the techniques involved in the design and analysis of representative infrared zoom lenses. The use of computer optimization is discussed with examples to illustrate the step-by-step development of any optical system and zoom lenses in particular. It gives attendees an insight into zoom lens characteristics in general and the design and analysis process involved in developing an infrared zoom lens system. Civil and military applications are discussed which match the optics with infrared detectors and sensors. Recent trends include the advent of focal plane arrays and the shift to the near infrared spectral region. 32 refractive zoom lens systems and 9 representative reflective zoom systems are presented, along with many new diagrams.

LEARNING OUTCOMES

After completing this course, attendees will be able to:

- describe the fundamental properties of zoom lenses as to whether they are mechanically or optically compensated and with regard to positive or negative moving groups
- describe the relevant issues that are unique to the infrared region of the spectrum, including sources, detectors, CCD arrays, optical materials, athermalization, narcissus, and coatings
- gain an insight into the optical design techniques utilized in the design of infrared zoom lenses, including achieving high magnification ratios, achromatization, aberration control, the use of aspherics and diffractive optical elements, compactness techniques, computer optimization, global search, scaling, and tolerances
- classify infrared zoom lenses according to their application: scanning telescopes, target simulators, surveillance systems, target recognition, battlefield detection, imaging systems, solar observatories, laser beam expanders, and cell phone cameras
- establish requirements for your particular application
- decide whether a given zoom lens optical system meets your requirements and matches the capabilities of the detector

INTENDED AUDIENCE

This course is for engineers and scientists interested in learning more about the infrared region of the spectrum and about infrared zoom lenses and their applications.

INSTRUCTOR

Allen Mann has over forty years' experience in the design and analysis of optical systems, including visual and infrared zoom lenses. Mr. Mann has written several papers on the subject of infrared zoom lenses and is the editor for the SPIE Milestone Volume on Zoom Lenses. He was chairman of SPIE Zoom Lens Conference I and co-chair of Zoom Lens Conference II. He is retired from Hughes Aircraft Company and is now an independent consultant. Mr. Mann has been elected to be a Fellow of SPIE.

COURSE PRICE INCLUDES the text *Infrared Optics and Zoom Lenses, Second Edition* (SPIE, 2009) by Allen Mann.

Infrared Window and Dome Materials

SC214

Course Level: Advanced
CEU: 0.65 $580 Members | $680 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course presents an overview of the optical, thermal and mechanical characteristics of infrared-transmitting window and dome materials. Other topics include thermal shock response, rain and particle erosion, protective coatings, antireflection coatings, electromagnetic shielding, proof testing, and fabrication of optical ceramics. The course concludes with a brief discussion of sapphire and diamond as infrared materials.

LEARNING OUTCOMES

This course will enable you to:

- identify the optical, thermal and mechanical characteristics of a window material that are critical to its selection for a particular application
- predict optical, thermal and mechanical performance of window materials under a range of conditions, based on tabulated data
- compare the strengths and weaknesses of different materials and different coatings for a given application
- describe the principal methods by which optical ceramics are manufactured

INTENDED AUDIENCE

The course is directed at engineers, scientists, managers and marketing personnel who need an introduction to properties, performance, and manufacture of windows and domes. A basic degree in engineering or science is the expected background, but care will be taken to provide introductory background information for each topic.

INSTRUCTOR

Daniel Harris is a Senior Scientist at the Naval Air Warfare Center, China Lake, California, where he directs programs in optical materials.

COURSE PRICE INCLUDES the text *Materials for Infrared Windows and Domes* (SPIE Press, 1999) by Daniel Harris. **Attendees should bring a calculator to this course.**

Basic Optics for Non-Optics Personnel

WS609

Course Level: Introductory
CEU: 0.2 $100 Members | $150 Non-Members USD
Tuesday 1:30 pm to 4:00 pm

This course will provide the technical manager, sales engineering, marketing staff, or other non-optics personnel with a basic, non-mathematical introduction to the terms, specifications, and concepts used in optical technology to facilitate effective communication with optics professionals on a functional level. Topics to be covered include basic concepts such as imaging, interference, diffraction, polarization and aberrations, definitions relating to color and optical quality, and an overview of the basic measures of optical performance such as MTF and wavefront error. The material will be presented with a minimal amount of math, rather emphasizing working concepts, definitions, rules of thumb, and visual interpretation of specifications. Specific applications will include defining basic imaging needs such as magnification, depth-of-field, and MTF as well as the definitions of radiometric terms.

LEARNING OUTCOMES

This course will enable you to:

- read optical system descriptions and papers
- ask the right questions about optical component performance
- describe basic optical specifications for lenses, filters, and other components
- assess differences in types of filters, mirrors and beam directing optics
- know how optics is used in our everyday lives

INTENDED AUDIENCE

This course is intended for the non-optical professional who needs to understand basic optics and interface with optics professionals.

INSTRUCTOR

Kevin Harding has been active in the optics industry for over 30 years, and has taught machine vision and optical methods for over 25 years in over 70 workshops and tutorials, including engineering workshops on machine vision, metrology, NDT, and interferometry used by vendors and system houses to train their own engineers. He has been recognized for his leadership in optics and machine vision by the Society of Manufacturing Engineers, Automated Imaging Association, and Engineering Society of Detroit. Kevin is a Fellow of SPIE and was the 2008 President of the Society.

Defense, Homeland Security, and Law Enforcement

Applications of Detection Theory

SC952

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a “target.” In this case the term “target” may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the “Receiver Operating Characteristic” (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind “Decision Tree Analysis” culminating with an in class exercise. Decision tree analysis allows one to “fuse together” multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:

- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a “Spider Chart” from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years’ service; his decorations include the “Defense Superior Service Medal” from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

Coherent Mid-Infrared Sources and Applications

SC1012 **New**

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 1:30 pm to 5:30 pm

This course explains why the mid-IR spectral range is so important for molecular spectroscopy, standoff sensing, and trace molecular detection. We will regard different approaches for generating coherent light in the mid-IR including solid state lasers, fiber lasers, semiconductor (including quantum cascade) lasers, and laser sources based on nonlinear optical methods. The course will discuss several applications of mid-IR coherent light: spectral recognition of molecules, trace gas sensing, standoff detection, and frequency comb Fourier transform spectroscopy.

LEARNING OUTCOMES

This course will enable you to:

- define the “molecular fingerprint” region
- identify existing direct laser sources of mid-IR coherent radiation, including solid state lasers, fiber lasers, semiconductor heterojunction and quantum cascade lasers
- identify laser sources based on nonlinear optical methods, including difference Frequency generators and optical parametric oscillators and generators
- describe the principles of trace gas sensing and standoff detection
- explain mid-IR frequency combs and how they can be used for advanced spectroscopic detection

INTENDED AUDIENCE

Students, academics, researchers and engineers in various disciplines who require a broad introduction to the subject and would like to learn more about the state-of-the-art and upcoming trends in mid-infrared coherent source development and applications. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Konstantin Vodopyanov is a world expert in mid-IR solid state lasers, nonlinear optics and laser spectroscopy. He has both industrial and academic experience, has > 300 technical publications and he is a co-author, with I.T. Sorokina, of the book Solid-State Mid-Infrared Laser Sources (Springer, 2003). He is a member of program committees for several major laser conferences including CLEO (most recent, General Chair in 2010) and Photonics West (LA106 Conference Chair). Currently he teaches and does scientific research at Stanford University and his research interests include mid-IR and terahertz-wave generation using micro-and nano-structured materials, nano-IR spectroscopy, generation of mid-infrared frequency combs and their applications. Dr. Vodopyanov has delivered numerous invited talks and tutorials at scientific meetings on the subject of mid-IR technology.

Terahertz Wave Technology and Applications

SC547

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Thursday 1:30 pm to 5:30 pm

A pulsed terahertz (THz) wave with a frequency range from 0.1 THz to 10 THz is called a “T-ray.” T-rays occupy a large portion of the electromagnetic spectrum between the infrared and microwave bands. However, compared to the relatively well-developed science and technology in the microwave, optical, and x-ray frequencies for defense and commercial applications, basic research, new initiatives and advanced technology developments in the THz band are very limited and remain unexplored. However, just as one can use visible light to create a photograph, radio waves to transmit music and speech, microwave radiation (MRI) or X-rays to reveal broken bones, T-ray can be used to create images or communicate information. This course will provide the fundamentals of free-space THz optoelectronics. We will cover the basic concepts of generation, detection, propagation, and applications of the T-rays, and how the up-to-date research results apply to industry. The free-space T-ray optoelectronic detection system, which uses photoconductive antennas or electro-optic crystals, provides diffraction-limited spatial resolution, femtosecond temporal resolution, DC-THz spectral bandwidth and mV/cm field sensitivity. Examples of homeland security and defense related projects will be highlighted.

LEARNING OUTCOMES

This course will enable you to:

- identify the proper optical sources of a THz beam, including femtosecond lasers and cw lasers
- distinguish and select the correct THz emitters, including photoconductive antennae, surface field screening and optical rectification
- appraise two dominant THz detectors: a photoconductive dipole antenna and an electro-optic sensor
- describe a THz system and optimize its performance in spatial and temporal resolutions, bandwidth and dynamic range
- construct a THz imaging setup and discuss the recent developments in 2D imaging and real-time & single-short measurement
- highlight recent advances of THz research and development from the academic and industrial sectors
- summarize state-of-the-art THz applications and predict new opportunities and applications

INTENDED AUDIENCE

This course is designed for researchers in academia and industry, who are interested in the mid-infrared and far-infrared pulsed THz radiation.

INSTRUCTOR

Xi-Cheng Zhang is the M. Parker Givens Professor and Director of The Institute of Optics at University of Rochester. Previously, he was the Erik Jonsson Chair Professor of Science, the Acting Head of the Department of Physics, Applied Physics, and Astronomy, and Director of the Center for Terahertz Research at Rensselaer Polytechnic Institute. Since 1982 he has been involved in ultrafast optoelectronics, especially the implementation of unique technical approaches for the generation and detection of THz beams with photonic approaches.

Introduction to Night Vision

SC1068

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

Night vision devices have become ubiquitous in both commercial and military environments. From the very high end systems used for aviation, to the low-performance systems sold for outdoorsmen, these devices have changed the way their users operate at night. This course explains the basic principles behind night vision and discusses the different types of night vision devices, both “analog” and “digital”. In addition to a survey of night vision devices, we also examine the inner workings of night vision systems and explain them in an easy to understand manner. We will discuss the design of night vision systems, both handheld and head mounted.

Although we will talk briefly about SWIR and thermal devices to differentiate them from night vision devices, this course is primarily aimed at visible and near infra-red (NIR) imagers. Imagery from both night vision cameras as well as thermal imagers will be presented and the differences between them will be compared/contrasted.

LEARNING OUTCOMES

This course will enable you to:

- identify the three basic components of a night vision imager: the sensor, the amplifier and the output component
- specify input optics (objective lenses) and output optics (eyepieces) for both analog and digital night vision devices
- explain the difference between VIS/NIR night vision, SWIR, MWIR and LWIR sensors as well as when each should be chosen
- differentiate the different generations of night vision goggles
- define appropriate light levels for night vision device testing
- describe new digital night vision devices and their advantages and disadvantages
- explain the important attributes of night vision systems and how they should be specified for “best value” performance
- predict night vision performance using NVESD models

INTENDED AUDIENCE

Scientists, engineers, technicians, procurement personnel or managers who wish to learn more about night vision devices. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Michael Browne is the Vice President of Product Development at SA Photonics. He has a Ph.D. in Optical Engineering from the University of Arizona’s Optical Sciences Center. Mike has been involved in the design, test and measurement of night vision systems since 1986. At Kaiser Electronics, he led the design of numerous head mounted night vision systems including those for the RAH-66 Comanche helicopter and the USAF NVS program. He leads SA Photonics’ efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. His current research includes investigations into the design of wide field of view night vision devices, binocular rivalry in head mounted displays, and smear reduction in digital displays.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of automatic target and object detection and its applications in Hyperspectral Imagery (HSI). The primary goal of this course is to introduce the well known target detection algorithms in hyperspectral imagery. Examples of the classical target detection techniques such as spectral matched filter, subspace matched filter, adaptive matched filter, orthogonal subspace, support vector machine (SVM) and machine learning are reviewed. Construction of invariance subspaces for target and background as well as the use of regularization techniques are presented. Standard atmospheric correction and compensation techniques are reviewed. Anomaly detection techniques for HSI and dual band FLIR imagery are also discussed. Applications of HSI for detection of mines, targets, humans, chemical plumes and anomalies are reviewed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental concepts of target detection algorithms as applied to HSI
- learn the procedure to use the generalized maximum likelihood ratio test to design spectral detectors
- describe the fundamental differences between different detection algorithms based on their model representations
- develop statistical models as well as subspace models for HSI data
- explain the difference between anomaly detection and classification
- distinguish between linear and nonlinear approaches (SVM and Kernel learning techniques)
- develop anomaly detection techniques for different environmental scenarios
- describe linear models and unmixing techniques for abundance measures
- plot ROC curves to evaluate the performance of the algorithms

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about target detection in hyperspectral, multispectral or dual-band FLIR imagery. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a senior research scientist (ST) at US Army Research Laboratory (ARL). He is also an adjunct professor in the Electrical and Computer Engineering Department at the Johns Hopkins University. He is actively engaged in research in image processing, neural networks, automatic target recognition, and video compression and its transmission over high speed networks. He has published over 200 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing,IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

Methods of Energy Harvesting for Low-Power Sensors

SC1075

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course focuses on the transformation of mechanical energy into low-power electricity with an emphasis on vibration-based energy harvesting. A primary goal is to describe the methods of mechanical energy harvesting to use in low-power sensors. Piezoelectric, electromagnetic, electrostatic and magnetostrictive conversion mechanisms will be discussed along with the use of electroactive polymers. Special focus will be placed on piezoelectric materials due to their substantially large power density and ease of application at different geometric scales. System-level modeling and analysis, power density levels, storage devices, deterministic and random energy harvesting, kinetic energy harvesting, flow energy harvesting from aeroelastic and hydroelastic vibrations, acoustic energy harvesting and nonlinear energy harvesting for frequency bandwidth enhancement will be addressed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental principles of mechanical energy harvesting from ambient vibrations
- explain the characteristics and relative advantages of different energy harvesting methods
- identify the concept of power density and differentiate the concepts of input power and the power density of an energy harvester
- distinguish between resonant and non-resonant energy harvesting as well as deterministic and random energy harvesting
- compare linear and nonlinear energy harvesting and classify their characteristics to construct the optimal energy harvester given the input energy characteristics
- combine other sources of energy input (e.g., wind or wave energy, kinetic energy in walking) with mechanical energy harvesting devices for multi-physics problems
- distinguish between the characteristics of conventional and unconventional storage components
- become familiar with recent advances and other methods in energy harvesting

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers from industry and academia who wish to learn about the fundamentals and recent advances in low-power energy harvesting. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Alper Erturk is an Assistant Professor of Mechanical Engineering at Georgia Institute of Technology. Over the past five years, he has published more than 70 articles in refereed international journals and conference proceedings on smart materials and dynamical systems, and a book titled Piezoelectric Energy Harvesting. He is an elected member of the ASME Technical Committee on Adaptive Structures and Material Systems and ASME Technical Committee on Vibration and Sound, and a member of ASME, AIAA, IEEE, SPIE, and SEM. Dr. Erturk received his Ph.D. in Engineering Mechanics at Virginia Tech.

Introduction to Optical and Infrared Sensor Systems

SC789

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides a broad introduction to optical (near UV-visible) and infrared sensor systems, with an emphasis on systems used in defense and security. Topics include both passive imagers and active laser radars (lidar/ladar). We begin with a discussion of radiometry and radiometric calculations to determine how much optical power is captured by a sensor system. We survey atmospheric propagation and phenomenology (absorption, emission, scattering, and turbulence) and explore how these issues affect sensor systems. Finally, we perform signal calculations that consider the source, the atmosphere, and the optical system and detector, to arrive at a signal-to-noise ratio for typical passive and active sensor systems. These principles of optical radiometry, atmospheric propagation, and optical detection are combined in examples of real sensors studied at the block-diagram level. Sensor system examples include passive infrared imagers, polarization imagers, and hyperspectral imaging spectrometers, and active laser radars (lidars or ladars) for sensing distributed or hard targets. The course organization is approximately one third on the radiometric analysis of sensor systems, one third on atmospheric phenomenology and detector parameters, and one third on example calculations and examination of sensor systems at the block-diagram level.

LEARNING OUTCOMES

This course will enable you to:
- explain and use radiometry for describing and calculating the flow of optical energy in an optical or infrared sensor system
- determine the radiometric throughput of sensor systems
- describe atmospheric phenomenology relevant to propagation of optical and infrared radiation
- explain how the atmosphere affects the performance of sensor systems
- use detector parameters with radiometric calculations to predict the signal received by passive and active sensors
- calculate signal-to-noise ratio for typical sensor systems
- explain real-world sensor systems at the block-diagram level
- explain the difference between and important concepts of passive reflection-based and emission-based imaging
- describe the basic operating principles of passive imagers and active laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who find themselves working on (or curious about) optical (uv-vis) and infrared sensor systems without formal training in this area. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw has been developing optical remote sensing systems and using them in environmental and military sensing for two decades, first at NOAA and currently as professor of electrical engineering and physics at Montana State University. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a Ph.D. in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

IR Atmospheric Propagation for Sensor Systems

SC1107

New

Course Level: Intermediate
CEU: 0.65 $685 Members | $780 Non-Members USD
Monday 8:30 am to 5:30 pm

This course reviews the fundamental principles and applications concerning absorption and scattering phenomena in the atmosphere that impact infrared sensor performance. Topics include an introduction to atmospheric structure, a background reviewing the basic formulas concerning the complex index of refraction, a survey of molecular absorption bands and continuum absorption, the HITRAN database, atmospheric refractivity, molecular Rayleigh scattering, particle distribution functions, Mie scattering and anomalous diffraction approximation. This background is applied to atmospheric transmittance, path radiance and path fluctuations with examples from computer codes such as MODTRAN and FASCODE. These topics are further reinforced by practical examples on atmospheric optics whenever possible. A set of contemporary references is provided.

LEARNING OUTCOMES

This course will enable you to:
- summarize the basics of absorption, refraction and scatter in the atmosphere
- distinguish between the optical properties of gases and condensed matter
- identify the structure of the atmosphere
- compute atmospheric transmittance
- compute atmospheric scattering
- relate course concepts to observable phenomena in the atmosphere

INTENDED AUDIENCE

The course is intended for engineers and scientists working with EO/IR systems in the atmosphere of earth. The material is beneficial to experimentalists and modelers. The course material is presented at an intermediate level, suitable for those with some experience in optical propagation in the atmosphere. Working knowledge of undergraduate electromagnetic theory as applied to optical frequencies is desired.

INSTRUCTOR

Michael Thomas is currently a Principal Staff Engineer at the Applied Physics Laboratory, and a Research Professor in the Department of Electrical and Computer Engineering at Johns Hopkins University. He has been at APL since 1979, and is currently in the EO/IR Systems and Technologies Group at APL. Dr. Thomas holds a Ph.D. in electrical engineering from The Ohio State University. Dr. Thomas is a specialist in electromagnetic theory, optical propagation, and quantum electronics with research interests in measurement and theoretical modeling of atmospheric propagation and remote sensing, optical properties of solids and high pressure gases. He has over 190 journal type publications in these areas. Dr. Thomas is a Fellow of the Optical Society of America, a senior member of IEEE and also holds membership in SPIE, Sigma Xi and Tau Beta Pi.

COURSE PRICE INCLUDES the text *Optical Propagation in Linear Media* (Oxford University Press , 2006) by M. E. Thomas.

Imaging and Sensing

Infrared Radiometric Calibration

SC1109

New

Course level: Intermediate
CEU .35 $295 Members | $345 Non-Members
Wednesday 1:30 to 5:30 pm

This course describes the radiometric calibration techniques used for SI-traceable measurements of sources, detectors and material properties in the infrared wavelength region. The main goal is to enable understanding of infrared measurements with quantified uncertainties so that full uncertainty budgets can be established for the final quantities. Examples from NIST calibrations of sources, detectors and materials will be described.

The properties and measurements of various different blackbody and lamp sources will be discussed. Detector calibrations using both thermal and quantum detectors with monochromators and Fourier-transform spectrometers will be covered. Also, infrared reflectance measurements using Fourier-transform spectrometers will be explained. Examples of NIST-developed infrared transfer and working standard radiometers in field deployments will be utilized to illustrate the above concepts.

LEARNING OUTCOMES

This course will enable you to:
- choose the optimal sources for the measurement needs from the different sources available in the field
- list the procedures for selecting and calibrating infrared detectors and their associated uncertainties
- describe the uncertainty propagation principles in both source and detector calibrations
- utilize techniques for infrared material reflectance measurements and their uncertainty propagation
- characterize a radiation thermometer according to ASTM standards

INTENDED AUDIENCE

This course is designed for technical staff involved in radiometric calibrations of sources, detectors and radiometers.

INSTRUCTORS

Howard Yoon graduated with a B.S. Physics and Chemistry degree from Swarthmore College and earned his M.S. and Ph.D. Physics degrees from the University of Illinois at Urbana-Champaign. He has worked for Bell Communications Research and Dartmouth College. He currently serves as the US Representative to the Consultative Committee on Thermometry and is a member of the IEC TC65/SC65B/WG5 committee. While at NIST, he has received the Allen V. Astin Award and the DOC Silver Award. Currently at NIST he is a physicist working on several projects related to advancing spectroradiometry for improvements in fundamental and disseminated standards of spectral radiance, spectral irradiance, and radiance temperature.

George Eppeldauer received his M.E. and Ph.D. Electronics Engineering degrees from the Technical University of Budapest. Previously, he has worked at the Research Institute for Technical Physics at the Hungarian Academy of Sciences. He won the Best Paper Award at the NC-SLI Conference in 2004, and he chairs the CIE TC2-48 Technical Committee (TC) on Spectral Responsivity Calibrations and the CIE TC2-29 TC on Detector Linearity. He is an electronics engineer with research areas in detector metrology developing transfer and working standard optical radiometers, photometers, and colorimeters and realizing detector responsivity based scales. The standards he has developed have been utilized to improve the two NIST SI units, the candela and kelvin, the illuminance responsivity scale, the tristimulus color scale, the spectral power, irradiance, and radiance responsivity reference-scales, and the spectral irradiance scale. He was one of the three pioneers who developed the SIRCUS reference responsivity-calibration facility.

Simon Kaplan received a B.A. Physics degree from Oberlin College and Ph.D. Physics degree from Cornell University. Prior to joining NIST, he has worked at the University of Maryland, College Park. He is a physicist with research interests in spectrophotometry and radiometry. He has worked on the characterization of optical materials and components in support of UV photolithography and infrared remote sensing applications. Currently he is leading the Low Background Infrared (LBIR) facility for absolute detector-based irradiance and radiance calibrations in support of missile defense as well as climate monitoring technology.

Carol Johnson earned a B.S. Engineering Physics degree from the University of Colorado and M.A. and Ph.D. in Astronomy from Harvard University, where she also worked before joining NIST. At NIST, she has earned the NIST Bronze Medal and DOC Silver and Gold Medals, as well as the Arthur S. Flemming and Edward Bennett Rosa Awards. Currently she is a physicist developing methods for improved radiometric characterization and calibration of instruments, transferring this knowledge to the user community, and improving the metrology of radiometry in remote sensing global climate change research. She serves on instrument design and calibration and validation peer reviews for NASA and NOAA sensors, participates in the Working Group on Calibration and Validation (WGCV) for the Committee on Earth Observation Satellites (CEOS), and collaborates with ocean color calibration scientists.

ADDITIONAL COMMENTS: This course has been designed to complement and build upon the content presented in SC1073, Radiometry and its Practical Applications. Attendees will benefit maximally from attending both courses.

Terahertz Wave Technology and Applications

SC547

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Thursday 1:30 pm to 5:30 pm

A pulsed terahertz (THz) wave with a frequency range from 0.1 THz to 10 THz is called a “T-ray.” T-rays occupy a large portion of the electromagnetic spectrum between the infrared and microwave bands. However, compared to the relatively well-developed science and technology in the microwave, optical, and x-ray frequencies for defense and commercial applications, basic research, new initiatives and advanced technology developments in the THz band are very limited and remain unexplored. However, just as one can use visible light to create a photograph, radio waves to transmit music and speech, microwave radiation (MRI) or X-rays to reveal broken bones, T-ray can be used to create images or communicate information. This course will provide the fundamentals of free-space THz optoelectronics. We will cover the basic concepts of generation, detection, propagation, and applications of the T-rays, and how the up-to-date research results apply to industry. The free-space T-ray optoelectronic detection system, which uses photoconductive antennas or electro-optic crystals, provides diffraction-limited spatial resolution, femtosecond temporal resolution, DC-THz spectral bandwidth and mV/cm field sensitivity. Examples of homeland security and defense related projects will be highlighted.

LEARNING OUTCOMES

This course will enable you to:

- identify the proper optical sources of a THz beam, including femtosecond lasers and cw lasers
- distinguish and select the correct THz emitters, including photoconductive antennae, surface field screening and optical rectification
- appraise two dominant THz detectors: a photoconductive dipole antenna and an electro-optic sensor
- describe a THz system and optimize its performance in spatial and temporal resolutions, bandwidth and dynamic range
- construct a THz imaging setup and discuss the recent developments in 2D imaging and real-time & single-short measurement
- highlight recent advances of THz research and development from the academic and industrial sectors
- summarize state-of-the-art THz applications and predict new opportunities and applications

INTENDED AUDIENCE

This course is designed for researchers in academia and industry, who are interested in the mid-infrared and far-infrared pulsed THz radiation.

INSTRUCTOR

Xi-Cheng Zhang is the M. Parker Givens Professor and Director of The Institute of Optics at University of Rochester. Previously, he was the Erik Jonsson Chair Professor of Science, the Acting Head of the Department of Physics, Applied Physics, and Astronomy, and Director of the Center for Terahertz Research at Rensselaer Polytechnic Institute. Since 1982 he has been involved in ultrafast optoelectronics, especially the implementation of unique technical approaches for the generation and detection of THz beams with photonic approaches.

Courses

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $560 Members | $655 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:

- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

GPU for Defense Applications

SC1069

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course teaches the basics of utilizing modern programmable graphics processing units (GPUs) for military applications. The modern GPU is a fully programmable parallel programming environment that performs computations an order of magnitude faster than the modern CPU. In this course, we will learn broadly about the architecture of the GPU, the appropriate situations where speedups may be obtained and gain an understanding of the tools and languages that are available for development. Programming is not a part of the curriculum.

We will also discuss the available GPU platforms, with an emphasis on rugged, deployable, and low-power offerings. Lastly, the bulk of the course will center on applications and case studies, with emphasis on applications we have produced, including: real-time image processing for the reduction of atmospheric turbulence, applied accelerated linear algebra, image enhancement via super resolution, computational fluid dynamics, and computational electromagnetics.

LEARNING OUTCOMES

This course will enable you to:

- summarize how a graphics processing unit functions
- describe the architecture of a modern compute-capable GPU
- describe which types of applications can be improved by the GPU, and to what degree
- determine the suitability of your algorithm for the GPU
- purchase a system well suited to your application
- assess the tools and languages available to the GPU programmer
- appreciate the applicability of the GPU to many defense industry applications via case studies

INTENDED AUDIENCE

Scientists, engineers, mathematicians, and management who are evaluating the graphics processing unit as a candidate to reduce computational time or costs. We will cover both large scale (e.g. clusters) and small-scale (e.g. low-power, deployable) applications.

INSTRUCTOR

John Humphrey is a member of the Accelerated Computing Solutions group at EM Photonics. He earned his MSEE degree from the University of Delaware studying the acceleration of electromagnetics algorithms using custom hardware platforms. At EM Photonics, he launched a GPU research effort in 2005 with a GPU-based FDTD solver based on OpenGL methods and then later explored working in CUDA. Since then, he has worked on accelerated algorithms in a variety of fields, including linear algebra solvers and computational fluid dynamics engines.

Imaging Polarimetry

SC180

Course Level: Advanced
CEU: 0.35 $295 Members | $345 Non-Members USD
Tuesday 8:30 am to 12:30 pm

This course covers imaging polarimeters from an instrumentation-design point of view. Basic polarization elements for the visible, mid-wave infrared, and long-wave infrared are described in terms of Mueller matrices and the Poincaré sphere. Polarization parameters such as the degree of polarization (DOP), the degree of linear polarization (DOLP) and the degree of circular polarization (DOCP) are explained in an imaging context. Emphasis is on imaging systems designed to detect polarized light in a 2-D image format. System concepts are discussed using a Stokes-parameter (s0,s1,s2,s3) image. Imaging-polarimeter systems design, pixel registration, and signal to noise ratios are explored. Temporal artifacts, characterization and calibration techniques are defined.

LEARNING OUTCOMES

This course will enable you to:

- explain imaging-polarimetry fundamentals using a Mueller matrix description and make use of the Poincaré sphere
- formulate mathematical models to describe an imaging polarimeter and to optimize its design
- discuss natural and manmade phenomena that give rise to polarized light in the visible and the infrared parts of the spectrum
- discuss techniques for spectro-polarimetry, i.e., the collection of (x,y,...)data hypercubes
- evaluate polarimeter designs
- compare representative scanning and non-scanning imaging-polarimeter designs
- explain sources of error in imaging polarimeters

INTENDED AUDIENCE

This course is for engineers, scientists, and program managers interested in an overview of imaging polarimetry. The tutorial is intended to give students intuitive insight into fundamental concepts with a minimum of rigorous mathematical treatment. To benefit maximally from this course, attendees should be familiar with the materials covered in SPIE SC206, Introductory and Intermediate Topics in Polarized Light.

INSTRUCTOR

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the University of Arizona, Tucson, AZ. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

Brian Miles is a consultant with Optical Sensing Consultants, where he performs optical system design, systems engineering analysis and test development for U.S. Government/Military and commercial clients. He was previously a Senior Scientist for FastMetrix Inc. and a Senior Research Physicist with the Seeker Branch of the Munitions Directorate of the Air Force Research Lab at Eglin Air Force Base, Florida. Dr. Miles' professional interests include laser radar, laser remote sensing, imaging polarimetry, imaging spectro-polarimetry, and mine detection. Dr. Miles is an Optical Sciences Ph.D. graduate from the University of Arizona Optical Sciences Center.

Derek Sabatke holds M.S. and Ph.D. degrees in Optical Engineering and Optical Sciences from the Univ. of Arizona. His research interests center on optical sensors and instruments, and include microsensors, imaging polarimeters and spectropolarimeters. He has conducted research at the Univ. of Minnesota, Honeywell Technology Center, and Univ. of Arizona, and is currently an optical engineer with Ball Aerospace and Technologies Corp. in Bolder, Colorado.

MTF in Optical and Electro-Optical Systems

SC157

Course Level: Introductory
CEU: 0.65 $555 Members | $650 Non-Members USD
Tuesday 8:30 am to 5:30 pm

Modulation transfer function (MTF)is used to specify the image quality achieved by an imaging system. It is useful in analysis of situations where several independent subsystems are combined. This course provides a background in the application of MTF techniques to performance specification, estimation and characterization of optical and electro-optical systems.

LEARNING OUTCOMES

This course will enable you to:

- list the basic assumptions of linear systems theory, including the concept of spatial frequency
- identify relationship between impulse response, resolution, MTF, OTF, PTF, and CTF
- estimate the MTF for both diffraction-limited and aberration-limited systems
- explain the relationship between MTF, line response, and edge response functions
- identify MTF contributions from finite detector size, crosstalk, charge transfer inefficiency, and electronics
- summarize the effects of noise

INTENDED AUDIENCE

Engineers, scientists, and managers who need to understand and apply the basic concepts of MTF to specifying, estimating, or characterizing performance. Some prior background in Fourier concepts is helpful.

INSTRUCTOR

Glenn Boreman is the Chairman of the Department of Physics and Optical Science at the University of North Carolina at Charlotte. He received a BS in Optics from Rochester and PhD in Optics from Arizona. Prof. Boreman served on the faculty of University of Central Florida for 27 years, with 23 PhD students supervised to completion. His research interests are in infrared detectors, infrared metamaterials, and electro-optical sensing systems. Prof. Boreman is a Fellow of SPIE, OSA, and the Military Sensing Symposium.

Multispectral and Hyperspectral Image Sensors

SC194

Course Level: Advanced
CEU: 0.35 $375 Members | $425 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

This course will describe the imaging capabilities and applications of the principal types of multispectral (MS) and hyperspectral (HS) sensors. The focus will be on sensors that work in the visible, near-infrared and shortwave-infrared spectral regimes, but the course will touch on longwave-infrared applications. A summary of the salient features of classical color imaging (human observation) will also be provided in an appendix.

LEARNING OUTCOMES

This course will enable you to:

- understand many of the applications and advantages of multispectral (MS) and hyperspectral (HS) imaging
- describe and categorize the properties of the principal MS / HS design types (multi-band scanner, starers with filter wheels, dispersive, wedge, and Fourier transform imagers with 2D arrays, etc.)
- list and define the relevant radiometric radiometric quantities, concepts and phenomenology
- understand the process of translating system requirements into sensor hardware constraints and specifications
- analyze signal-to-noise ratio, modulation-transfer-function, and spatial / spectral sampling for MS and HS sensors
- define, understand and apply the relevant noise-equivalent figures-of-merit (Noise-equivalent reflectance difference, Noise-equivalent temperature difference, Noise-equivalent spectral radiance, Noise-equivalent irradiance, etc.)
- describe the elements of the image chain from photons-in to bits-out (photon detection, video signal manipulation, analog processing, and digitization)
- list and review key imager subsystem technology elements (optical, focal plane, video electronics, and thermal)
- formulate a detailed end-to-end design example of a satellite imaging scanning HS sensor
- provide an appendix that summarizes color imaging principles and sensor associated elements for human observation applications (e.g. color television, still cameras, etc.)

INTENDED AUDIENCE

Engineers, scientists, and technical managers who are interested in understanding and applying multispectral and hyperspectral sensors in advanced military, civil, scientific and commercial applications.

INSTRUCTOR

Terrence Lomheim holds the position of Distinguished Engineer at The Aerospace Corp. He has 34 years of hardware and analysis experience in visible and infrared electro-optical systems, focal plane technology, and applied optics, and has authored and co-authored 63 publications in these technical areas. He is a Fellow of the SPIE.

COURSE PRICE INCLUDES the text *CMOS/CCD Sensors and Camera Systems, 2nd edition* (SPIE Press, 2011) by Terrence Lomheim and Gerald Holst.

Introduction to Optical and Infrared Sensor Systems

SC789

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides a broad introduction to optical (near UV-visible) and infrared sensor systems, with an emphasis on systems used in defense and security. Topics include both passive imagers and active laser radars (lidar/ladar). We begin with a discussion of radiometry and radiometric calculations to determine how much optical power is captured by a sensor system. We survey atmospheric propagation and phenomenology (absorption, emission, scattering, and turbulence) and explore how these issues affect sensor systems. Finally, we perform signal calculations that consider the source, the atmosphere, and the optical system and detector, to arrive at a signal-to-noise ratio for typical passive and active sensor systems. These principles of optical radiometry, atmospheric propagation, and optical detection are combined in examples of real sensors studied at the block-diagram level. Sensor system examples include passive infrared imagers, polarization imagers, and hyperspectral imaging spectrometers, and active laser radars (lidars or ladars) for sensing distributed or hard targets. The course organization is approximately one third on the radiometric analysis of sensor systems, one third on atmospheric phenomenology and detector parameters, and one third on example calculations and examination of sensor systems at the block-diagram level.

LEARNING OUTCOMES

This course will enable you to:

- explain and use radiometry for describing and calculating the flow of optical energy in an optical or infrared sensor system
- determine the radiometric throughput of sensor systems
- describe atmospheric phenomenology relevant to propagation of optical and infrared radiation
- explain how the atmosphere affects the performance of sensor systems
- use detector parameters with radiometric calculations to predict the signal received by passive and active sensors
- calculate signal-to-noise ratio for typical sensor systems
- explain real-world sensor systems at the block-diagram level
- explain the difference between and important concepts of passive reflection-based and emission-based imaging
- describe the basic operating principles of passive imagers and active laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who find themselves working on (or curious about) optical (uv-vis) and infrared sensor systems without formal training in this area. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw has been developing optical remote sensing systems and using them in environmental and military sensing for two decades, first at NOAA and currently as professor of electrical engineering and physics at Montana State University. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a Ph.D. in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

Ocean Sensing and Monitoring

SC1077

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 8:30 am to 12:30 pm

This course covers basic principles and applications of optical oceanography. The course is aimed to provide background information for those interested in exploring oceanography using optical techniques, including sensing and monitoring via remote sensing (passive and active), as well as traditional in situ sampling approaches. Ocean optics principles including absorption, scattering by both particles and optical turbulence, polarization and impacts on underwater imaging and communication are presented in theory and through examples. Typical sensors and platforms including unmanned underwater vehicles are introduced. Topics associated with data collection, processing, analysis, fusion and assimilation to ocean models are also discussed. This course can also be used as a refresher for recent advances in related areas. Anyone who wants to answer questions such as, "what are the issues oceanographers working on these days (that can benefit from our technology)?", "what does the ocean color tell us?", or "how far can we see in the water?" will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- grasp core concepts and fundamentals of oceanography, including major processes such as mixing and mixed layer depth, upwelling, red tide, currents, waves, euphotic zone, primary production, turbulence, SST, wind, altimetry, boundary layers and resuspention. The background information provided is the key to the understanding and appreciation of ocean sensing techniques and instrumentation developed.
- assess the basic principles and challenges associated with ocean sensing and monitoring with optical methods, including remote sensing and in situ sampling methods
- identify recent advances in sensing platforms including unmanned aerial/ underwater vehicles, and monitoring networks
- gain new understanding of visibility theory from a MTF perspective, which can be easily incorporated to imaging system design and evaluation
- calculate underwater visibility ranges under different turbidity and turbulence conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn how to apply their technology to monitor 70% of the earth surface, to know more about how to quantify visibility, ocean color and other oceanic phenomenon such as currents, waves, temperature, wind and salinity. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Weilin (Will) Hou has been working on research and engineering projects in optical oceanography for the past twenty years, with primary focus on underwater visibility theories and imaging application, in situ and remote sensing of ocean phenomenon. He is currently an oceanographer and the head of the Hydro Optics Sensors and Systems Section at the U. S. Naval Research Laboratory. He earned his PhD in Optical Oceanography at the University of South Florida in 1997. He developed and co-chairs the SPIE Ocean Sensing and Monitoring conference and is the editor of 3 SPIE proceedings. He has 2 patents and numerous publications. He serves as a panel expert on underwater imaging for NATO and defense technology export control.

This course includes content from the upcoming text *Ocean Sensing and Monitoring: Optics and other methods* (SPIE Press, 2013) by Weilin Hou.

Engineering Approach to Imaging System Design

SC713

Course Level: Intermediate
CEU: 0.65 $565 Members | $660 Non-Members USD
Monday 8:30 am to 5:30 pm

This course discusses the three popular approaches to electro-optical imaging system design: spatial resolution, sensitivity (signal-to-noise ratio), and modulation transfer function (MTF) analysis. While often evaluated individually, all three must be considered to optimize system design. Usually, the dominant MTFs in machine vision devices are image motion (including random vibration of the sensor), optics (including aberrations), and the detector. For man-in-the-loop operation, the display and the eye are of concern and, in many situations, these limit the overall system performance.

Equally important, but often neglected is sampling; an inherent feature of all electronic imaging systems. Sampling, which creates blocky images are particularly bothersome with periodic targets such as test targets and bar codes. An engineering approach is taken. This course will provide numerous practical design examples (case studies) to illustrate the interplay between subsystem MTFs, resolution, sensitivity, and sampling.

LEARNING OUTCOMES

This course will enable you to:

- use approximations; often called 'rules-of-thumb,' or 'back-of-the-envelope' analysis
- identify the subsystem components that affect resolution and sensitivity
- determine if your system is resolution or sensitivity limited
- equivalently determine if your system is detector-limited or optics-limited
- determine which subsystem limits system performance and why
- understand sampling artifacts (Nyquist frequency limit, aliasing, Moiré patterns, and variations in object edge location and width)
- use MTFs, resolution, sensitivity, and sampling concepts for system optimization
- understand the trade-off between MTF and aliasing

INTENDED AUDIENCE

The course is for managers, system designers, test engineers, machine vision specialists, and camera users who want the best performance from their systems. It is helpful if the students are familiar with linear system theory (MTF analysis).

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference *Infrared Imaging Systems: Design, Analysis, Modeling and Testing* since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and IEEE and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Holst's Practical Guide to Electro-Optical Systems* (JCD Publishing, 2003) by Gerald C. Holst.

Testing and Evaluation of E-O Imaging Systems

SC067

Course Level: Advanced
CEU: 0.65 $595 Members | $690 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course describes all the quantitative and qualitative metrics that are used to characterize imaging system performance. While this course highlights thermal imaging systems, the concepts are generic and can be applied to all imaging systems (CCDs, intensified CCDs, CMOS, and near IR cameras). Data analysis techniques are independent of the sensor selected (i.e., wavelength independent). The difference lies in the input variable name (watts, lumens, or delta-T) and the output variable name (volts, lumens, or observer response). Slightly different test methodologies are used for visible and thermal imaging systems. Performance parameters discussed include resolution, responsivity, aperiodic transfer function, slit response function, random noise, uniformity, fixed pattern noise, modulation transfer function (MTF), contrast transfer function (CTF), minimum resolvable temperature (MRT), and the minimum resolvable contrast (MRC). The eye's spatial and temporal integration allows perception of images whose signal-to-noise ratio (SNR) is less than unity. Since all imaging system spatially sample the scene, sampling artifacts occur in all imagery and therefore affects all measurements. Sampling can significantly affect MRT and MTF tests. Low SNR and sampling effects are interactively demonstrated. This course describes the most common testing techniques. Equally important is identifying those parameters that adversely affect results.

LEARNING OUTCOMES

This course will enable you to:

- write concise test procedures with unambiguous system specifications
- identify all appropriate test parameters
- describe the radiometric relationship between delta-T and spectral radiance
- differentiate between observer variability and system response during MRC and MRT testing
- describe the difference between the CTF and the MTF
- learn about the latest MTF measurement techniques
- discern the difference between poor system performance, peculiarities of the system under test, and measurement errors
- assess how sampling affects test results
- appreciate the benefits and short comings of fully automated testing
- identify parameters that can lead to poor results.
- learn about evolving standardized testing concepts

INTENDED AUDIENCE

The course is for managers, specification writers, and test engineers involved with all phases of imaging system characterization ranging from satisfying customer requirements to ensuring that specifications are unambiguous and testable.

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference Infrared Imaging Systems: Design, Analysis, Modeling and Testing since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Testing and Evaluation of Infrared Imaging Systems, Third Edition* (SPIE Press and JCD Publishing, 2008) by Gerald C. Holst.

Electro-Optical Imaging System Performance

SC154

Course Level: Intermediate
CEU: 0.65 $595 Members | $690 Non-Members USD
Friday 8:30 am to 5:30 pm

While this course highlights thermal imaging systems, the concepts are generic and can be applied to all imaging systems (CCDs, intensified CCDs, CMOS, and near IR cameras). System analysis could be performed in the spatial domain. However, it is far easier to work in the frequency domain using MTFs. Subsystem MTFs are combined for overall system analysis. This is often called image chain modeling. Although the math is sometimes complex, the equations are graphed for easy understanding. With the Sept 2002 models (e.g., NVTherm), the minimum resolvable temperature (MRT) and minimum resolvable contrast (MRC) are coupled with the target signature and atmospheric transmittance to provide range performance predictions (target acquisition modeling). Three ranges are predicted: detection, recognition, and identification (often shorten to DRI). DRI ranges depend upon the subsystem MTFs, noise (primarily random and fixed pattern noise), the display, and the eye's response. The two-dimensional (fictitious) spatial frequency approach, three-dimensional noise model, and target discrimination metrics (Johnson's N50) are applied to performance predictions. The 2007 models (e.g., NVThermIP) employ contrast rather than MRT (MRC) for target acquisition and use V50 as a discrimination metric. Limitations and applications of NVTherm and NVThermIP are discussed with a brief demonstration of the models. Selection and optimization of a specific sensor depends upon a myriad of radiometric, spectral, and spatial parameters (e.g., target signature, atmospheric conditions, optics f-number, field-of-view, and detector responsivity). MTFs and their effect on imagery are interactively demonstrated. Spatial sampling is present in all cameras. Super-resolution reconstruction and microscan minimize sampling artifacts. Several optimization examples are discussed (case study examples).

LEARNING OUTCOMES

This course will enable you to:
- use the correct MTFs for image chain analysis
- describe the radiometric relationship between delta-T and spectral radiance
- compare the differences among scanning, staring, and microscan staring array performance
- recognize the limitations of back-of-the-envelope approximations such as resolution and sensitivity
- identify the subsystem (e.g., motion, optics, detector, electronics, and display) that limits performance
- appreciate limitations of range performance predictions (target acquisition predictions)
- determine if mid-wave (MWIR) or long-wave (LWIR) infrared is appropriate for your application
- appreciate the value of graphs rather than a table of numbers
- be conversant with the myriad of technological terms
- become a smart buyer, analyst, and/or user of imaging systems

INTENDED AUDIENCE

This course is intended for engineers, managers, and buyers who want to understand the wealth of information available from imaging system end-to-end analysis. It is helpful if the students are familiar with linear system theory (MTF analysis).

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference Infrared Imaging Systems: Design, Analysis, Modeling and Testing since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Electro-Optical Imaging System Performance, Fifth Edition* (SPIE Press and JCD Publishing, 2008) by Gerald C. Holst.

Analog-to-Digital Converters for Digital ROICs

SC1076

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course surveys structure and operation of analog-to-digital converters (ADCs) implemented on digital readout integrated circuits (ROICs) and digital image sensors. Attendees will learn how to evaluate ADC architectures using basic figures of merit for use in different sensor formats. We will cover a wide range of cutting edge architectures and see published examples without delving into transistor level theory. We will survey both academia and industrial ADC architectures. From this survey attendees will discover the industrial design evolution convergence down to a few workhorse architectures and what lessons it imparts to the image sensor community. If you are interested in the digital ROIC revolution or if you ever interface with designers or evaluate digital ROIC proposals, then you will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:
- identify analog-to-digital architectures used for creating digital ROICs and image sensors
- calculate ADC architecture figures of merit important to image sensors
- evaluate ADC architecture compatibility with image sensor format and requirements
- infer the direction in which state-of-the-art digital image sensors are headed
- name the top ADC architectures used by commercial industry and explain how this knowledge benefits the image sensor industry
- stimulate your own creativity and help you develop new ideas and applications for digital ROICs and digital image sensors

INTENDED AUDIENCE

This course is intended for engineers and physicists with a background in basic electrical theory (electrical stimuli, resistors, capacitors and block diagramming) who wish to learn about analog-to-digital converter architectures and how they are applied to digital ROICs and digital image sensors. An undergraduate degree in science or engineering is assumed, and basic knowledge of electrical engineering will be particularly helpful.

INSTRUCTOR

Kenton Veeder is a ROIC design engineer, systems engineer, and part time detector physicist. He has been in the defense and commercial image sensor field for over 12 years and is the president of Senseeker Engineering Inc. in Santa Barbara, California. He has nine patents and several publications, one of which earned the MSS Detectors best paper award in 2006. While working for Raytheon he was awarded recognition as Raytheon's 'Father of the Digital Focal Plane Array' and he and his team were given the company wide 'Excellence In Technology' award. Kenton earned his M.S. in electrical engineering from the Analog-and-Mixed Signal Center at Texas A&M University. Kenton is a member of SPIE and IEEE.

Introduction to Infrared and Ultraviolet Imaging Technology

SC1000

Course Level: Introductory
CEU: 0.35 $330 Members | $380 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The words infrared and ultraviolet are coming into much more widespread use, as ideas about the technology penetrates the public's awareness and becomes part of popular culture through TV and film. In industry and academia, applications for infrared and ultraviolet cameras are multiplying rapidly, because both of the continued reduction in system cost as the technology penetrates the commercial marketplace, and the forward march of technology. At the same time, there is a fairly limited body of information about applications for these cameras. This is because camera manufacturers tend focus on the products themselves, not applications, and because most textbooks on IR and UV technology are outdated and tend to emphasize the basics of radiometry and detection by single detectors, not imaging applications. This course gives a non-technical overview of commercial infrared and ultraviolet camera systems, the "taxonomy" of infrared and ultraviolet wavebands, and the wide variety of applications for these wavebands. The course relies heavily on interesting imagery captured by the presenter over the last ten years and uses a SPIE monograph written by the author as a supplementary textbook.

LEARNING OUTCOMES

This course will enable you to:
- identify the different wavebands of the infrared and ultraviolet spectrum and describe their differences
- gain familiarity with the different types of cameras, sensors and optics used for imaging in the infrared and ultraviolet wavebands
- describe some of the key imaging applications for different wavebands of the infrared and ultraviolet

INTENDED AUDIENCE

The course is suitable both for technology professionals and non-technical persons that are new to infrared and ultraviolet imaging and want a very basic, qualitative overview of the fields with minimal mathematics. Little to no mathematic background is required.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Systems in Santa Barbara, CA. He holds a PhD in Astrophysics from UC Berkeley, and has worked in the commercial infrared industry for over 10 years. He is also the CTO of Oculus Photonics, a small company devoted to near-ultraviolet imaging systems manufacturing, sales and support. Richards is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* and an adjunct professor at the Brooks Institute of Photography in Santa Barbara.

COURSE PRICE INCLUDES the text *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* (SPIE Press, 2001) by Austin A. Richards.

Infrared Imaging Radiometry

SC950

Course Level: Advanced
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course will enable the user to understand how an infrared camera system can be calibrated to measure radiance and/or temperature and how the digital data is converted into radiometric data. The user will learn how to perform their own external, “by hand” calibrations on a science-grade infrared camera system using area or cavity blackbodies and an Excel spreadsheet provided by the instructor. The influences of lenses, ND and bandpass filters, windows, emissivity, reflections and atmospheric absorption on the system calibration will be covered. The instructor will use software to illustrate these concepts and will show how to measure emissivity using an infrared camera and how to predict system performance outside the calibration range.

LEARNING OUTCOMES

This course will enable you to:
- classify the measurement units of radiometry and thermography
- describe infrared camera transfer functions - electrical signal output versus radiance signal input
- determine which cameras, lenses and both cold and warm filters to select for your application
- assess effects of ND filters and bandpass filters on calibrations, and calculate which ND warm filter you need for a given temperature range of target
- perform radiometric calibration of camera systems using cavity and area blackbodies
- convert raw data to radiometric data, and convert radiometric data to temperatures
- measure target emissivity and calibrate emissivity into the system
- gauge and account for reflections and atmospheric effects on measurements

INTENDED AUDIENCE

This material is intended for engineers, scientists, graduate students and range technicians that are working with science-grade infrared cameras in the lab, on military test ranges, or similar situations.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Commercial Vision Systems in Santa Barbara, and has specialized in scientific applications of infrared imaging technology for over 9 years. He holds a Ph.D. in astrophysics from UC Berkeley and is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* .

Radiometry and its Practical Applications

SC1073

Course Level: Introductory
CEU: 0.65 $625 Members | $720 Non-Members USD
Monday 8:30 am to 5:30 pm

The first half of this course presents the basic quantities and units of radiometry and photometry. It describes radiometric laws and approximations including the inverse square and cosine power laws, and introduces the equation of radiative transfer. It provides an overview of optical radiation sources , blackbody radiation laws, and optical material properties including transmission, reflection, absorption, and emission. It surveys photon and thermal optical radiation detectors, instrumentation, and calibration.

The course’s second half focuses on practical problem solving. It applies the concepts presented in Part I to calculate the amount of optical radiation reaching a system’s entrance aperture or focal plane for a variety of source-receiver combinations. Its applications include problems in some or all of the following areas: solar thermal systems, sun and sky irradiance delivered to a collector, diffuse and specular signals in the thermal infrared, star sensing in the visible, and integrating spheres. It incorporates several examples from the associated text The Art of Radiometry.

LEARNING OUTCOMES

This course will enable you to:
- master the basics of radiometry and photometry and their systems of terminology and units
- master key radiometric laws and approximations
- describe the characterization of optical properties of surfaces, materials, and objects
- gain insight into basic properties of optical detectors and instrumentation
- identify approaches to problem-solving based on source and geometry considerations
- calculate the amount of radiation received from single and multiple sources
- compare point and extended source calibration methods
- qualify the limitations of your solution

INTENDED AUDIENCE

This course is designed for engineers and scientists dealing with electromagnetic radiation who need to quantify this radiation using international standard units and terminology. It is aimed at technologists seeking to gain familiarity with radiometric concepts in order to solve practical problems.

INSTRUCTOR

Barbara Grant is the author of the Field Guide to Radiometry (SPIE Press, 2011) and the co-author, with Jim Palmer, of The Art of Radiometry (SPIE Press, 2009). For more than twenty years she has utilized a systems engineering approach to radiometric problem solving in industries as diverse as aerospace and indoor tanning. She received the MS degree in Optical Sciences from the University of Arizona and two NASA awards for work on the GOES weather satellite imager and sounder. Her previous work for SPIE includes developing and chairing a special session on FLIR image analysis.

COURSE PRICE INCLUDES the texts *The Art of Radiometry* (SPIE Press, 2009) by James M. Palmer and Barbara G. Grant, and the *Field Guide to Radiometry* (SPIE Press, 2011) by Barbara G. Grant .

Applications of Detection Theory

SC952

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a “target.” In this case the term “target” may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the “Receiver Operating Characteristic” (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind “Decision Tree Analysis” culminating with an in class exercise. Decision tree analysis allows one to “fuse together” multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:

- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a “Spider Chart” from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years’ service; his decorations include the “Defense Superior Service Medal” from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of automatic target and object detection and its applications in Hyperspectral Imagery (HSI). The primary goal of this course is to introduce the well known target detection algorithms in hyperspectral imagery. Examples of the classical target detection techniques such as spectral matched filter, subspace matched filter, adaptive matched filter, orthogonal subspace, support vector machine (SVM) and machine learning are reviewed. Construction of invariance subspaces for target and background as well as the use of regularization techniques are presented. Standard atmospheric correction and compensation techniques are reviewed. Anomaly detection techniques for HSI and dual band FLIR imagery are also discussed. Applications of HSI for detection of mines, targets, humans, chemical plumes and anomalies are reviewed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental concepts of target detection algorithms as applied to HSI
- learn the procedure to use the generalized maximum likelihood ratio test to design spectral detectors
- describe the fundamental differences between different detection algorithms based on their model representations
- develop statistical models as well as subspace models for HSI data
- explain the difference between anomaly detection and classification
- distinguish between linear and nonlinear approaches (SVM and Kernel learning techniques)
- develop anomaly detection techniques for different environmental scenarios
- describe linear models and unmixing techniques for abundance measures
- plot ROC curves to evaluate the performance of the algorithms

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about target detection in hyperspectral, multispectral or dual-band FLIR imagery. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a senior research scientist (ST) at US Army Research Laboratory (ARL). He is also an adjunct professor in the Electrical and Computer Engineering Department at the Johns Hopkins University. He is actively engaged in research in image processing, neural networks, automatic target recognition, and video compression and its transmission over high speed networks. He has published over 200 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing,IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

Understanding Diffractive Optics

SC1071

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Monday 8:30 am to 5:30 pm

The course will cover the fundamental principles of diffraction phenomena. A qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics, as well as the unique properties associated with the diffraction of laser beams during propagation. The instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics
- describe diffraction phenomena associated with the propagation of laser beams
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and resonant domains, diffraction efficiency, and the blazing condition
- receive an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was published in 2011 by SPIE Press.

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics* , FG21 (SPIE Press, 2011) by Yakov Soskind.

IR Atmospheric Propagation for Sensor Systems

SC1107 **New**

Course Level: Intermediate
CEU: 0.65 $685 Members | $780 Non-Members USD
Monday 8:30 am to 5:30 pm

This course reviews the fundamental principles and applications concerning absorption and scattering phenomena in the atmosphere that impact infrared sensor performance. Topics include an introduction to atmospheric structure, a background reviewing the basic formulas concerning the complex index of refraction, a survey of molecular absorption bands and continuum absorption, the HITRAN database, atmospheric refractivity, molecular Rayleigh scattering, particle distribution functions, Mie scattering and anomalous diffraction approximation. This background is applied to atmospheric transmittance, path radiance and path fluctuations with examples from computer codes such as MODTRAN and FASCODE. These topics are further reinforced by practical examples on atmospheric optics whenever possible. A set of contemporary references is provided.

LEARNING OUTCOMES

This course will enable you to:

- summarize the basics of absorption, refraction and scatter in the atmosphere
- distinguish between the optical properties of gases and condensed matter
- identify the structure of the atmosphere
- compute atmospheric transmittance
- compute atmospheric scattering
- relate course concepts to observable phenomena in the atmosphere

INTENDED AUDIENCE

The course is intended for engineers and scientists working with EO/IR systems in the atmosphere of earth. The material is beneficial to experimentalists and modelers. The course material is presented at an intermediate level, suitable for those with some experience in optical propagation in the atmosphere. Working knowledge of undergraduate electromagnetic theory as applied to optical frequencies is desired.

INSTRUCTOR

Michael Thomas is currently a Principal Staff Engineer at the Applied Physics Laboratory, and a Research Professor in the Department of Electrical and Computer Engineering at Johns Hopkins University. He has been at APL since 1979, and is currently in the EO/IR Systems and Technologies Group at APL. Dr. Thomas holds a Ph.D. in electrical engineering from The Ohio State University. Dr. Thomas is a specialist in electromagnetic theory, optical propagation, and quantum electronics with research interests in measurement and theoretical modeling of atmospheric propagation and remote sensing, optical properties of solids and high pressure gases. He has over 190 journal type publications in these areas. Dr. Thomas is a Fellow of the Optical Society of America, a senior member of IEEE and also holds membership in SPIE, Sigma Xi and Tau Beta Pi.

COURSE PRICE INCLUDES THE text *Optical Propagation in Linear Media* (Oxford University Press , 2006) by M. E. Thomas.

Sensing for Industry, Environment, and Health

Infrared Radiometric Calibration

SC1109 **New**

Course level: Intermediate
CEU .35 $295 Members | $345 Non-Members
Wednesday 1:30 to 5:30 pm

This course describes the radiometric calibration techniques used for SI-traceable measurements of sources, detectors and material properties in the infrared wavelength region. The main goal is to enable understanding of infrared measurements with quantified uncertainties so that full uncertainty budgets can be established for the final quantities. Examples from NIST calibrations of sources, detectors and materials will be described.

The properties and measurements of various different blackbody and lamp sources will be discussed. Detector calibrations using both thermal and quantum detectors with monochromators and Fourier-transform spectrometers will be covered. Also, infrared reflectance measurements using Fourier-transform spectrometers will be explained. Examples of NIST-developed infrared transfer and working standard radiometers in field deployments will be utilized to illustrate the above concepts.

LEARNING OUTCOMES

This course will enable you to:

- choose the optimal sources for the measurement needs from the different sources available in the field
- list the procedures for selecting and calibrating infrared detectors and their associated uncertainties
- describe the uncertainty propagation principles in both source and detector calibrations
- utilize techniques for infrared material reflectance measurements and their uncertainty propagation
- characterize a radiation thermometer according to ASTM standards

INTENDED AUDIENCE

This course is designed for technical staff involved in radiometric calibrations of sources, detectors and radiometers.

INSTRUCTORS

Howard Yoon graduated with a B.S. Physics and Chemistry degree from Swarthmore College and earned his M.S. and Ph.D. Physics degrees from the University of Illinois at Urbana-Champaign. He has worked for Bell Communications Research and Dartmouth College. He currently serves as the US Representative to the Consultative Committee on Thermometry and is a member of the IEC TC65/SC65B/WG5 committee. While at NIST, he has received the Allen V. Astin Award and the DOC Silver Award. Currently at NIST he is a physicist working on several projects related to advancing spectroradiometry for improvements in fundamental and disseminated standards of spectral radiance, spectral irradiance, and radiance temperature.

George Eppeldauer received his M.E. and Ph.D. Electronics Engineering degrees from the Technical University of Budapest. Previously, he has worked at the Research Institute for Technical Physics at the Hungarian Academy of Sciences. He won the Best Paper Award at the NCSLI Conference in 2004, and he chairs the CIE TC2-48 Technical Committee (TC) on Spectral Responsivity Calibrations and the CIE TC2-29 TC on Detector Linearity. He is an electronics engineer with research areas in detector metrology developing transfer and working standard optical radiometers, photometers, and colorimeters and realizing detector responsivity based scales. The standards he has developed have been utilized to improve the two NIST SI units, the candela and kelvin, the illuminance responsivity scale, the tristimulus color scale, the spectral power, irradiance, and radiance responsivity reference-scales, and the spectral irradiance scale. He was one of the three pioneers who developed the SIRCUS reference responsivity-calibration facility.

Simon Kaplan received a B.A. Physics degree from Oberlin College and Ph.D. Physics degree from Cornell University. Prior to joining NIST, he has worked at the University of Maryland, College Park. He is a physicist with research interests in spectrophotometry and radiometry. He has worked on the characterization of optical materials and components in support of UV photolithography and infrared remote sensing applications. Currently he is leading the Low Background Infrared (LBIR) facility for absolute detector-based irradiance and radiance calibrations in support of missile defense as well as climate monitoring technology.

Carol Johnson earned a B.S. Engineering Physics degree from the University of Colorado and M.A. and Ph.D. in Astronomy from Harvard University, where she also worked before joining NIST. At NIST, she has earned the NIST Bronze Medal and DOC Silver and Gold Medals, as well as the Arthur S. Flemming and Edward Bennett Rosa Awards. Currently she is a physicist developing methods for improved radiometric characterization and calibration of instruments, transferring this knowledge to the user community, and improving the metrology of radiometry in remote sensing global climate change research. She serves on instrument design and calibration and validation peer reviews for NASA and NOAA sensors, participates in the Working Group on Calibration and Validation (WGCV) for the Committee on Earth Observation Satellites (CEOS), and collaborates with ocean color calibration scientists.

ADDITIONAL COMMENTS: This course has been designed to complement and build upon the content presented in SC1073, Radiometry and its Practical Applications. Attendees will benefit maximally from attending both courses.

Introduction to Optical and Infrared Sensor Systems

SC789

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides a broad introduction to optical (near UV-visible) and infrared sensor systems, with an emphasis on systems used in defense and security. Topics include both passive imagers and active laser radars (lidar/ladar). We begin with a discussion of radiometry and radiometric calculations to determine how much optical power is captured by a sensor system. We survey atmospheric propagation and phenomenology (absorption, emission, scattering, and turbulence) and explore how these issues affect sensor systems. Finally, we perform signal calculations that consider the source, the atmosphere, and the optical system and detector, to arrive at a signal-to-noise ratio for typical passive and active sensor systems. These principles of optical radiometry, atmospheric propagation, and optical detection are combined in examples of real sensors studied at the block-diagram level. Sensor system examples include passive infrared imagers, polarization imagers, and hyperspectral imaging spectrometers, and active laser radars (lidars or ladars) for sensing distributed or hard targets. The course organization is approximately one third on the radiometric analysis of sensor systems, one third on atmospheric phenomenology and detector parameters, and one third on example calculations and examination of sensor systems at the block-diagram level.

LEARNING OUTCOMES

This course will enable you to:

- explain and use radiometry for describing and calculating the flow of optical energy in an optical or infrared sensor system
- determine the radiometric throughput of sensor systems
- describe atmospheric phenomenology relevant to propagation of optical and infrared radiation
- explain how the atmosphere affects the performance of sensor systems
- use detector parameters with radiometric calculations to predict the signal received by passive and active sensors
- calculate signal-to-noise ratio for typical sensor systems
- explain real-world sensor systems at the block-diagram level
- explain the difference between and important concepts of passive reflection-based and emission-based imaging
- describe the basic operating principles of passive imagers and active laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who find themselves working on (or curious about) optical (uv-vis) and infrared sensor systems without formal training in this area. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw has been developing optical remote sensing systems and using them in environmental and military sensing for two decades, first at NOAA and currently as professor of electrical engineering and physics at Montana State University. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a Ph.D. in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

Ocean Sensing and Monitoring

SC1077

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 8:30 am to 12:30 pm

This course covers basic principles and applications of optical oceanography. The course is aimed to provide background information for those interested in exploring oceanography using optical techniques, including sensing and monitoring via remote sensing (passive and active), as well as traditional in situ sampling approaches. Ocean optics principles including absorption, scattering by both particles and optical turbulence, polarization and impacts on underwater imaging and communication are presented in theory and through examples. Typical sensors and platforms including unmanned underwater vehicles are introduced. Topics associated with data collection, processing, analysis, fusion and assimilation to ocean models are also discussed. This course can also be used as a refresher for recent advances in related areas. Anyone who wants to answer questions such as, “what are the issues oceanographers working on these days (that can benefit from our technology)?”, “what does the ocean color tell us?”, or “how far can we see in the water?” will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- grasp core concepts and fundamentals of oceanography, including major processes such as mixing and mixed layer depth, upwelling, red tide, currents, waves, euphotic zone, primary production, turbulence, SST, wind, altimetry, boundary layers and resuspention. The background information provided is the key to the understanding and appreciation of ocean sensing techniques and instrumentation developed.
- assess the basic principles and challenges associated with ocean sensing and monitoring with optical methods, including remote sensing and in situ sampling methods
- identify recent advances in sensing platforms including unmanned aerial/ underwater vehicles, and monitoring networks
- gain new understanding of visibility theory from a MTF perspective, which can be easily incorporated to imaging system design and evaluation
- calculate underwater visibility ranges under different turbidity and turbulence conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn how to apply their technology to monitor 70% of the earth surface, to know more about how to quantify visibility, ocean color and other oceanic phenomenon such as currents, waves, temperature, wind and salinity. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Weilin (Will) Hou has been working on research and engineering projects in optical oceanography for the past twenty years, with primary focus on underwater visibility theories and imaging application, in situ and remote sensing of ocean phenomenon. He is currently an oceanographer and the head of the Hydro Optics Sensors and Systems Section at the U. S. Naval Research Laboratory. He earned his PhD in Optical Oceanography at the University of South Florida in 1997. He developed and co-chairs the SPIE Ocean Sensing and Monitoring conference and is the editor of 3 SPIE proceedings. He has 2 patents and numerous publications. He serves as a panel expert on underwater imaging for NATO and defense technology export control.

This course includes content from the upcoming text *Ocean Sensing and Monitoring: Optics and other methods* (SPIE Press, 2013) by Weilin Hou.

Terahertz Wave Technology and Applications

SC547

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Thursday 1:30 pm to 5:30 pm

A pulsed terahertz (THz) wave with a frequency range from 0.1 THz to 10 THz is called a “T-ray.” T-rays occupy a large portion of the electromagnetic spectrum between the infrared and microwave bands. However, compared to the relatively well-developed science and technology in the microwave, optical, and x-ray frequencies for defense and commercial applications, basic research, new initiatives and advanced technology developments in the THz band are very limited and remain unexplored. However, just as one can use visible light to create a photograph, radio waves to transmit music and speech, microwave radiation (MRI) or X-rays to reveal broken bones, T-ray can be used to create images or communicate information. This course will provide the fundamentals of free-space THz optoelectronics. We will cover the basic concepts of generation, detection, propagation, and applications of the T-rays, and how the up-to-date research results apply to industry. The free-space T-ray optoelectronic detection system, which uses photoconductive antennas or electro-optic crystals, provides diffraction-limited spatial resolution, femtosecond temporal resolution, DC-THz spectral bandwidth and mV/cm field sensitivity. Examples of homeland security and defense related projects will be highlighted.

LEARNING OUTCOMES

This course will enable you to:

- identify the proper optical sources of a THz beam, including femtosecond lasers and cw lasers
- distinguish and select the correct THz emitters, including photoconductive antennae, surface field screening and optical rectification
- appraise two dominant THz detectors: a photoconductive dipole antenna and an electro-optic sensor
- describe a THz system and optimize its performance in spatial and temporal resolutions, bandwidth and dynamic range
- construct a THz imaging setup and discuss the recent developments in 2D imaging and real-time & single-short measurement
- highlight recent advances of THz research and development from the academic and industrial sectors
- summarize state-of-the-art THz applications and predict new opportunities and applications

INTENDED AUDIENCE

This course is designed for researchers in academia and industry, who are interested in the mid-infrared and far-infrared pulsed THz radiation.

INSTRUCTOR

Xi-Cheng Zhang is the M. Parker Givens Professor and Director of The Institute of Optics at University of Rochester. Previously, he was the Erik Jonsson Chair Professor of Science, the Acting Head of the Department of Physics, Applied Physics, and Astronomy, and Director of the Center for Terahertz Research at Rensselaer Polytechnic Institute. Since 1982 he has been involved in ultrafast optoelectronics, especially the implementation of unique technical approaches for the generation and detection of THz beams with photonic approaches.

Methods of Energy Harvesting for Low-Power Sensors

SC1075

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course focuses on the transformation of mechanical energy into low-power electricity with an emphasis on vibration-based energy harvesting. A primary goal is to describe the methods of mechanical energy harvesting to use in low-power sensors. Piezoelectric, electromagnetic, electrostatic and magnetostrictive conversion mechanisms will be discussed along with the use of electroactive polymers. Special focus will be placed on piezoelectric materials due to their substantially large power density and ease of application at different geometric scales. System-level modeling and analysis, power density levels, storage devices, deterministic and random energy harvesting, kinetic energy harvesting, flow energy harvesting from aeroelastic and hydroelastic vibrations, acoustic energy harvesting and nonlinear energy harvesting for frequency bandwidth enhancement will be addressed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental principles of mechanical energy harvesting from ambient vibrations
- explain the characteristics and relative advantages of different energy harvesting methods
- identify the concept of power density and differentiate the concepts of input power and the power density of an energy harvester
- distinguish between resonant and non-resonant energy harvesting as well as deterministic and random energy harvesting
- compare linear and nonlinear energy harvesting and classify their characteristics to construct the optimal energy harvester given the input energy characteristics
- combine other sources of energy input (e.g., wind or wave energy, kinetic energy in walking) with mechanical energy harvesting devices for multi-physics problems
- distinguish between the characteristics of conventional and unconventional storage components
- become familiar with recent advances and other methods in energy harvesting

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers from industry and academia who wish to learn about the fundamentals and recent advances in low-power energy harvesting. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Alper Erturk is an Assistant Professor of Mechanical Engineering at Georgia Institute of Technology. Over the past five years, he has published more than 70 articles in refereed international journals and conference proceedings on smart materials and dynamical systems, and a book titled Piezoelectric Energy Harvesting. He is an elected member of the ASME Technical Committee on Adaptive Structures and Material Systems and ASME Technical Committee on Vibration and Sound, and a member of ASME, AIAA, IEEE, SPIE, and SEM. Dr. Erturk received his Ph.D. in Engineering Mechanics at Virginia Tech.

Applications of Detection Theory

SC952

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a “target.” In this case the term “target” may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the “Receiver Operating Characteristic” (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind “Decision Tree Analysis” culminating with an in class exercise. Decision tree analysis allows one to “fuse together” multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:

- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a “Spider Chart” from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years’ service; his decorations include the “Defense Superior Service Medal” from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of automatic target and object detection and its applications in Hyperspectral Imagery (HSI). The primary goal of this course is to introduce the well known target detection algorithms in hyperspectral imagery. Examples of the classical target detection techniques such as spectral matched filter, subspace matched filter, adaptive matched filter, orthogonal subspace, support vector machine (SVM) and machine learning are reviewed. Construction of invariance subspaces for target and background as well as the use of regularization techniques are presented. Standard atmospheric correction and compensation techniques are reviewed. Anomaly detection techniques for HSI and dual band FLIR imagery are also discussed. Applications of HSI for detection of mines, targets, humans, chemical plumes and anomalies are reviewed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental concepts of target detection algorithms as applied to HSI
- learn the procedure to use the generalized maximum likelihood ratio test to design spectral detectors
- describe the fundamental differences between different detection algorithms based on their model representations
- develop statistical models as well as subspace models for HSI data
- explain the difference between anomaly detection and classification
- distinguish between linear and nonlinear approaches (SVM and Kernel learning techniques)
- develop anomaly detection techniques for different environmental scenarios
- describe linear models and unmixing techniques for abundance measures
- plot ROC curves to evaluate the performance of the algorithms

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about target detection in hyperspectral, multispectral or dual-band FLIR imagery. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a senior research scientist (ST) at US Army Research Laboratory (ARL). He is also an adjunct professor in the Electrical and Computer Engineering Department at the Johns Hopkins University. He is actively engaged in research in image processing, neural networks, automatic target recognition, and video compression and its transmission over high speed networks. He has published over 200 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing,IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

IR Atmospheric Propagation for Sensor Systems

SC1107 New

Course Level: Intermediate
CEU: 0.65 $685 Members | $780 Non-Members USD
Monday 8:30 am to 5:30 pm

This course reviews the fundamental principles and applications concerning absorption and scattering phenomena in the atmosphere that impact infrared sensor performance. Topics include an introduction to atmospheric structure, a background reviewing the basic formulas concerning the complex index of refraction, a survey of molecular absorption bands and continuum absorption, the HITRAN database, atmospheric refractivity, molecular Rayleigh scattering, particle distribution functions, Mie scattering and anomalous diffraction approximation. This background is applied to atmospheric transmittance, path radiance and path fluctuations with examples from computer codes such as MODTRAN and FASCODE. These topics are further reinforced by practical examples on atmospheric optics whenever possible. A set of contemporary references is provided.

LEARNING OUTCOMES

This course will enable you to:

- summarize the basics of absorption, refraction and scatter in the atmosphere
- distinguish between the optical properties of gases and condensed matter
- identify the structure of the atmosphere
- compute atmospheric transmittance
- compute atmospheric scattering
- relate course concepts to observable phenomena in the atmosphere

INTENDED AUDIENCE

The course is intended for engineers and scientists working with EO/IR systems in the atmosphere of earth. The material is beneficial to experimentalists and modelers. The course material is presented at an intermediate level, suitable for those with some experience in optical propagation in the atmosphere. Working knowledge of undergraduate electromagnetic theory as applied to optical frequencies is desired.

INSTRUCTOR

Michael Thomas is currently a Principal Staff Engineer at the Applied Physics Laboratory, and a Research Professor in the Department of Electrical and Computer Engineering at Johns Hopkins University. He has been at APL since 1979, and is currently in the EO/IR Systems and Technologies Group at APL. Dr. Thomas holds a Ph.D. in electrical engineering from The Ohio State University. Dr. Thomas is a specialist in electromagnetic theory, optical propagation, and quantum electronics with research interests in measurement and theoretical modeling of atmospheric propagation and remote sensing, optical properties of solids and high pressure gases. He has over 190 journal type publications in these areas. Dr. Thomas is a Fellow of the Optical Society of America, a senior member of IEEE and also holds membership in SPIE, Sigma Xi and Tau Beta Pi.

COURSE PRICE INCLUDES THE text *Optical Propagation in Linear Media* (Oxford University Press , 2006) by M. E. Thomas.

Coherent Mid-Infrared Sources and Applications

SC1012 New

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 1:30 pm to 5:30 pm

This course explains why the mid-IR spectral range is so important for molecular spectroscopy, standoff sensing, and trace molecular detection. We will regard different approaches for generating coherent light in the mid-IR including solid state lasers, fiber lasers, semiconductor (including quantum cascade) lasers, and laser sources based on nonlinear optical methods. The course will discuss several applications of mid-IR coherent light: spectral recognition of molecules, trace gas sensing, standoff detection, and frequency comb Fourier transform spectroscopy.

LEARNING OUTCOMES

This course will enable you to:

- define the “molecular fingerprint” region
- identify existing direct laser sources of mid-IR coherent radiation, including solid state lasers, fiber lasers, semiconductor heterojunction and quantum cascade lasers
- identify laser sources based on nonlinear optical methods, including difference Frequency generators and optical parametric oscillators and generators
- describe the principles of trace gas sensing and standoff detection
- explain mid-IR frequency combs and how they can be used for advanced spectroscopic detection

INTENDED AUDIENCE

Students, academics, researchers and engineers in various disciplines who require a broad introduction to the subject and would like to learn more about the state-of-the-art and upcoming trends in mid-infrared coherent source development and applications. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Konstantin Vodopyanov is a world expert in mid-IR solid state lasers, nonlinear optics and laser spectroscopy. He has both industrial and academic experience, has > 300 technical publications and he is a co-author, with I.T. Sorokina, of the book Solid-State Mid-Infrared Laser Sources (Springer, 2003). He is a member of program committees for several major laser conferences including CLEO (most recent, General Chair in 2010) and Photonics West (LA106 Conference Chair). Currently he teaches and does scientific research at Stanford University and his research interests include mid-IR and terahertz-wave generation using micro-and nano-structured materials, nano-IR spectroscopy, generation of mid-infrared frequency combs and their applications. Dr. Vodopyanov has delivered numerous invited talks and tutorials at scientific meetings on the subject of mid-IR technology.

Fiber Lasers and their Applications

SC1105 New

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

Fiber laser technology has the potential to make a significant impact in many defense applications, from LIDAR and remote sensing to high energy laser weapons systems, in addition to numerous industrial, medical and scientific applications. This revolutionary new laser technology offers many intrinsic advantages over traditional DPSSLs and has received considerable support from key funding agencies over the last 10 years, including DARPA and the Joint Technology office (JTO) amongst others. With the aid of this funding several groups have now demonstrated small, compact and lightweight single mode fiber devices operating at the 1-10kW power level. There are research and development programs in the Air Force, Navy and Army currently. Funding to demonstrate beam combining of fiber lasers to the 25kW level is in place with programs such as RELI and Excalibur. More recently, the BAA call from the Office of Naval Research specifically calls for the development of high energy laser weapon technology suitable for ship board defense to be demonstrated on platform by 2016 and fiber technology is one possible solution being considered. Active deployment in the next decade is anticipated by some branches of the military.

Widespread publications in the research community have demonstrated an impressive array of power scaling fiber laser results, both CW and pulsed at wavelengths from 1um to the eyesafe 1.5um and 2um wavelengths. Advantages associated with fiber technology are not only high wallplug efficiency leading to reduced electrical power requirements and easier system cooling, but also robustness, good beam quality, compactness and highly flexible system performance. These, coupled with (remote) fiber delivery options make the technology unique in many applications.

This tutorial will cover the major aspects of designing and building a fiber laser, from the fiber itself through the various state of the art fiber components, and discussing the system parameter space that best makes use of the intrinsic advantages of the technology. Applications from industrial material processing though to defense and homeland security will be reviewed.

LEARNING OUTCOMES

This course will enable you to:
- compare the advantages of fiber laser technology to other lasers and know how the technology is best utilized in various system designs and applications
- describe the relevant architectures, components and fibers involved in designing a fiber laser and know the steps involved in building one
- gain an overview of the recent advances in fiber laser technology and an understanding of what the future technology roadmap looks like

INTENDED AUDIENCE

The tutorial is designed for researchers and engineers interested in investigating this application area but without the detailed knowledge of fibers and fiber based devices. Higher level managers and system designers/integrators will also be interested in the broad comparisons made between the fiber laser technology and current lasers and how this can impact future system designs.

INSTRUCTOR

Bryce Samson is Vice-President of Business Development for Nufern, and previously served as a senior research scientist at the corporate research labs of Corning Inc. for 5 years. Previous to that, Dr. Samson was a research fellow at Southampton University's Optoelectronic Research Centre (ORC) based in the UK, also for 5 years. He holds a PhD in semiconductor physics from Essex University, UK, has published over 100 refereed scientific and conference papers, and has more than 10 patents. Dr. Samson has been active in the field of optical fiber research for over 20 years, specializing in fiber laser and amplifiers for sensors, telecom and industrial applications and has a documented interest in optical spectroscopy of rare earth doped glasses.

Liang Dong is currently an associate professor at Department of Electrical and Computer Engineering at Clemson University. Prior to joining Clemson University, Liang Dong served as senior technical manager at IMRA America Incorporated, R&D director at Lightwaves2020 Incorporated and R&D manager at Corvis Incorporated. He also worked as senior scientist at Corning Incorporated and managed optical fiber fabrication activities at Southampton University. Dr. Dong has over 20 years of experience in research and development in photonics and optical fibers, covering a wide range of topics in materials, designs, simulations, photosensitive processes, nonlinear processes, optical amplifiers, lasers, active/passive optical devices and system integrations for wide range applications such as telecommunications, industrial machining, medical and sensing. He is the author of several invited articles and book chapters, and has given a large number of invited talks at international conferences. He has published over 200 papers and has over 20 granted patents.

Laser Lab Design - Laser Safety and PracticalityNew

SC1106

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

This course presents and reviews lessons learned on how to layout and set up a Research & Development laser laboratory in a university or technology research facility. There will be an initial review of laser safety concepts, and lab design requirements. The rest of the class time will be spent on items to be aware of in setting up a laser lab and solutions to problems. A number of good and bad scenarios will be covered.

LEARNING OUTCOMES

This course will enable you to:
- describe and understand the fundamentals of Laser Safety
- comprehend laser hazard classification and its relationship to laser safety
- use real world considerations in putting together an R&D laser lab
- develop proper signage, access control measures and visual barriers for your lab
- avoid common laser lab set up problems
- effectively communicate your laser safety needs to a facility or construction project manager overseeing your space

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn about laser safety and how to avoid problems when setting up a laser lab.

INSTRUCTOR

Ken Barat has been involved in laser safety for over 30 years, including serving until 2013 as the Laser Safety Officer at Lawrence Berkeley National Laboratory, the LSO for the National Ignition Facility and laser safety advisor for LIGO. He is Chair of ANSI Z136.8 Standard, Safe Use of Lasers in the Research, Development or Testing, Chair and originator of the LSO Workshop Series, and first chair of DOE Laser Safety Officers Working Group. He has authored three texts on laser safety, numerous articles, speaker at national and international conferences and Universities. Recognition for his work in this field includes Laser Institute of America Fellow, Rockwell Award for both Education and Laser Safety Contributions, IEEE Senior member and a CLSO.

Basic Laser Technology

SC972

New

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Friday 8:30 am to 12:30 pm

If you are uncomfortable working with lasers as "black boxes" and would like to have a basic understanding of their inner workings, this introductory course will be of benefit to you. The workshop will cover the basic principles common to the operation of any laser/laser system. Next, we will discuss laser components and their functionality. Components covered will include laser pumps/energy sources, mirrors, active media, nonlinear crystals, and Q-switches. The properties of laser beams will be described in terms of some of their common performance specifications such as longitudinal modes and monochromaticity, transverse electromagnetic (TEM) modes and focusability, continuous wave (CW) power, peak power and power stability. Laser slope and wall-plug efficiencies will also be discussed.

LEARNING OUTCOMES

This course will enable you to:
- describe the overall inner workings of any laser
- describe the functionality of the key laser components
- know the difference between how acousto- and electro-optic Q-switches work
- explain how each key component in a laser may contribute to laser performance
- intelligently engage your clients or customers using proper laser terminology
- build stronger relationships with clients and customers by demonstrating product knowledge
- obtain the technical knowledge and confidence to enhance your job performance and rise above the competition, inside and outside your company

INTENDED AUDIENCE

Managers, engineers, technicians, assemblers, sales/marketing, customer service, and other support staff. This workshop will help cultivate a common/standardized understanding of lasers across the company.

INSTRUCTOR

Sydney Sukuta is currently a Laser Technology professor at San Jose City College. He also has industry experience working for the some the world's leading laser manufacturers in Silicon Valley where he saw first-hand the issues they encounter on a daily basis. In response, Dr. Sukuta developed prescriptive short courses to help absolve most of these issues.

Imaging Polarimetry

SC180

Course Level: Advanced
CEU: 0.35 $295 Members | $345 Non-Members USD
Tuesday 8:30 am to 12:30 pm

This course covers imaging polarimeters from an instrumentation-design point of view. Basic polarization elements for the visible, mid-wave infrared, and long-wave infrared are described in terms of Mueller matrices and the Poincaré sphere. Polarization parameters such as the degree of polarization (DOP), the degree of linear polarization (DOLP) and the degree of circular polarization (DOCP) are explained in an imaging context. Emphasis is on imaging systems designed to detect polarized light in a 2-D image format. System concepts are discussed using a Stokes-parameter (s0,s1,s2,s3) image. Imaging-polarimeter systems design, pixel registration, and signal to noise ratios are explored. Temporal artifacts, characterization and calibration techniques are defined.

LEARNING OUTCOMES

This course will enable you to:
- explain imaging-polarimetry fundamentals using a Mueller matrix description and make use of the Poincaré sphere
- formulate mathematical models to describe an imaging polarimeter and to optimize its design
- discuss natural and manmade phenomena that give rise to polarized light in the visible and the infrared parts of the spectrum
- discuss techniques for spectro-polarimetry, i.e., the collection of (x,y,...)data hypercubes
- evaluate polarimeter designs
- compare representative scanning and non-scanning imaging-polarimeter designs
- explain sources of error in imaging polarimeters

INTENDED AUDIENCE

This course is for engineers, scientists, and program managers interested in an overview of imaging polarimetry. The tutorial is intended to give students intuitive insight into fundamental concepts with a minimum of rigorous mathematical treatment. To benefit maximally from this course, attendees should be familiar with the materials covered in SPIE SC206, Introductory and Intermediate Topics in Polarized Light.

INSTRUCTOR

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the University of Arizona, Tucson, AZ. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

Brian Miles is a consultant with Optical Sensing Consultants, where he performs optical system design, systems engineering analysis and test development for U.S. Government/Military and commercial clients. He was previously a Senior Scientist for FastMetrix Inc. and a Senior Research Physicist with the Seeker Branch of the Munitions Directorate of the Air Force Research Lab at Eglin Air Force Base, Florida. Dr. Miles' professional interests include laser radar, laser remote sensing, imaging polarimetry, imaging spectro-polarimetry, and mine detection. Dr. Miles is an Optical Sciences Ph.D. graduate from the University of Arizona Optical Sciences Center.

Derek Sabatke holds M.S. and Ph.D. degrees in Optical Engineering and Optical Sciences from the Univ. of Arizona. His research interests center on optical sensors and instruments, and include microsensors, imaging polarimeters and spectropolarimeters. He has conducted research at the Univ. of Minnesota, Honeywell Technology Center, and Univ. of Arizona, and is currently an optical engineer with Ball Aerospace and Technologies Corp. in Bolder, Colorado.

Emerging Technologies

Methods of Energy Harvesting for Low-Power Sensors

SC1075

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course focuses on the transformation of mechanical energy into low-power electricity with an emphasis on vibration-based energy harvesting. A primary goal is to describe the methods of mechanical energy harvesting to use in low-power sensors. Piezoelectric, electromagnetic, electrostatic and magnetostrictive conversion mechanisms will be discussed along with the use of electroactive polymers. Special focus will be placed on piezoelectric materials due to their substantially large power density and ease of application at different geometric scales. System-level modeling and analysis, power density levels, storage devices, deterministic and random energy harvesting, kinetic energy harvesting, flow energy harvesting from aeroelastic and hydroelastic vibrations, acoustic energy harvesting and nonlinear energy harvesting for frequency bandwidth enhancement will be addressed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental principles of mechanical energy harvesting from ambient vibrations
- explain the characteristics and relative advantages of different energy harvesting methods
- identify the concept of power density and differentiate the concepts of input power and the power density of an energy harvester
- distinguish between resonant and non-resonant energy harvesting as well as deterministic and random energy harvesting
- compare linear and nonlinear energy harvesting and classify their characteristics to construct the optimal energy harvester given the input energy characteristics
- combine other sources of energy input (e.g., wind or wave energy, kinetic energy in walking) with mechanical energy harvesting devices for multi-physics problems
- distinguish between the characteristics of conventional and unconventional storage components
- become familiar with recent advances and other methods in energy harvesting

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers from industry and academia who wish to learn about the fundamentals and recent advances in low-power energy harvesting. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Alper Erturk is an Assistant Professor of Mechanical Engineering at Georgia Institute of Technology. Over the past five years, he has published more than 70 articles in refereed international journals and conference proceedings on smart materials and dynamical systems, and a book titled Piezoelectric Energy Harvesting. He is an elected member of the ASME Technical Committee on Adaptive Structures and Material Systems and ASME Technical Committee on Vibration and Sound, and a member of ASME, AIAA, IEEE, SPIE, and SEM. Dr. Erturk received his Ph.D. in Engineering Mechanics at Virginia Tech.

Terahertz Wave Technology and Applications

SC547

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Thursday 1:30 pm to 5:30 pm

A pulsed terahertz (THz) wave with a frequency range from 0.1 THz to 10 THz is called a "T-ray." T-rays occupy a large portion of the electromagnetic spectrum between the infrared and microwave bands. However, compared to the relatively well-developed science and technology in the microwave, optical, and x-ray frequencies for defense and commercial applications, basic research, new initiatives and advanced technology developments in the THz band are very limited and remain unexplored. However, just as one can use visible light to create a photograph, radio waves to transmit music and speech, microwave radiation (MRI) or X-rays to reveal broken bones, T-ray can be used to create images or communicate information. This course will provide the fundamentals of free-space THz optoelectronics. We will cover the basic concepts of generation, detection, propagation, and applications of the T-rays, and how the up-to-date research results apply to industry. The free-space T-ray optoelectronic detection system, which uses photoconductive antennas or electro-optic crystals, provides diffraction-limited spatial resolution, femtosecond temporal resolution, DC-THz spectral bandwidth and mV/cm field sensitivity. Examples of homeland security and defense related projects will be highlighted.

LEARNING OUTCOMES

This course will enable you to:

- identify the proper optical sources of a THz beam, including femtosecond lasers and cw lasers
- distinguish and select the correct THz emitters, including photoconductive antennae, surface field screening and optical rectification
- appraise two dominant THz detectors: a photoconductive dipole antenna and an electro-optic sensor
- describe a THz system and optimize its performance in spatial and temporal resolutions, bandwidth and dynamic range
- construct a THz imaging setup and discuss the recent developments in 2D imaging and real-time & single-short measurement
- highlight recent advances of THz research and development from the academic and industrial sectors
- summarize state-of-the-art THz applications and predict new opportunities and applications

INTENDED AUDIENCE

This course is designed for researchers in academia and industry, who are interested in the mid-infrared and far-infrared pulsed THz radiation.

INSTRUCTOR

Xi-Cheng Zhang is the M. Parker Givens Professor and Director of The Institute of Optics at University of Rochester. Previously, he was the Erik Jonsson Chair Professor of Science, the Acting Head of the Department of Physics, Applied Physics, and Astronomy, and Director of the Center for Terahertz Research at Rensselaer Polytechnic Institute. Since 1982 he has been involved in ultrafast optoelectronics, especially the implementation of unique technical approaches for the generation and detection of THz beams with photonic approaches.

Analog-to-Digital Converters for Digital ROICs

SC1076

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course surveys structure and operation of analog-to-digital converters (ADCs) implemented on digital readout integrated circuits (ROICs) and digital image sensors. Attendees will learn how to evaluate ADC architectures using basic figures of merit for use in different sensor formats. We will cover a wide range of cutting edge architectures and see published examples without delving into transistor level theory. We will survey both academia and industrial ADC architectures. From this survey attendees will discover the industrial design evolution convergence down to a few workhorse architectures and what lessons it imparts to the image sensor community. If you are interested in the digital ROIC revolution or if you ever interface with designers or evaluate digital ROIC proposals, then you will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify analog-to-digital architectures used for creating digital ROICs and image sensors
- calculate ADC architecture figures of merit important to image sensors
- evaluate ADC architecture compatibility with image sensor format and requirements
- infer the direction in which state-of-the-art digital image sensors are headed
- name the top ADC architectures used by commercial industry and explain how this knowledge benefits the image sensor industry
- stimulate your own creativity and help you develop new ideas and applications for digital ROICs and digital image sensors

INTENDED AUDIENCE

This course is intended for engineers and physicists with a background in basic electrical theory (electrical stimuli, resistors, capacitors and block diagramming) who wish to learn about analog-to-digital converter architectures and how they are applied to digital ROICs and digital image sensors. An undergraduate degree in science or engineering is assumed, and basic knowledge of electrical engineering will be particularly helpful.

INSTRUCTOR

Kenton Veeder is a ROIC design engineer, systems engineer, and part time detector physicist. He has been in the defense and commercial image sensor field for over 12 years and is the president of Senseeker Engineering Inc. in Santa Barbara, California. He has nine patents and several publications, one of which earned the MSS Detectors best paper award in 2006. While working for Raytheon he was awarded recognition as Raytheon's 'Father of the Digital Focal Plane Array' and he and his team were given the company wide 'Excellence In Technology' award. Kenton earned his M.S. in electrical engineering from the Analog-and-Mixed Signal Center at Texas A&M University. Kenton is a member of SPIE and IEEE.

Understanding Diffractive Optics

SC1071

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Monday 8:30 am to 5:30 pm

The course will cover the fundamental principles of diffraction phenomena. A qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics, as well as the unique properties associated with the diffraction of laser beams during propagation. The instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics
- describe diffraction phenomena associated with the propagation of laser beams
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and resonant domains, diffraction efficiency, and the blazing condition
- receive an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was published in 2011 by SPIE Press.

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics* , FG21 (SPIE Press, 2011) by Yakov Soskind.

Laser Sensors and Systems

3D Imaging Laser Radar

SC1103 **New**

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

This course will explain the basic principles of operation and the fundamental theoretical basis of 3D imaging laser radar systems. An analytical approach to evaluation of system performance will be presented. The design and applications of 3D imaging laser radars will be discussed. Optimization strategies and trade space boundaries will be described. Major system components will be identified and effects of the limitations of current component performance will be identified. These limitations will form the basis of a discussion of current research objectives.

LEARNING OUTCOMES

This course will enable you to:

- identify the major elements of 3D imaging laser radar systems
- list important applications of laser radar
- predict the performance of real or conceptual 3D imaging laser radar systems
- estimate the effect of environmental factors on system performance and image quality
- estimate the effect of improved component performance on overall system performance and image quality
- formulate system level designs for common applications
- compare the 3D imaging laser radar approaches for selected applications
- identify test requirements and strategies for 3D imaging laser radar calibration and test

INTENDED AUDIENCE

Engineers, managers, scientists, and students who want to become familiar with basic principles and applications of 3D imaging laser radars or who want to be able to evaluate the performance of 3D laser radar systems.

INSTRUCTOR

Gary Kamerman is the Chief Scientist at FastMetrix, Inc. He is a Fellow of SPIE, the author of the "Laser Radar" chapter in the Infrared and Electro-Optical Handbook and the editor of the SPIE Milestone series Selected Papers on Laser Radar and more than 30 other volumes. He has designed, built, and tested laser radars and coherent optical systems for over 30 years. He is a technical advisor to the United States Department of Defense, National Aviation and Space Administration, and major international corporations.

Applications and Performance of High Power Lasers in the Battlefield

SC1104 **New**

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 8:30 am to 12:30 pm

The course will provide a general overview on various types of high power lasers that can be used in the future battlefield as a part of an effective defense layer against ballistic missiles, rockets, and mortars. Various types of high power lasers, their mechanism of operation and interception, and the current technological status will be discussed as well. We will demonstrate how a basic laser configuration can be upgraded into a high power military laser system. The advantages and disadvantages of various types of laser systems will be reviewed and future prospects of the potentially promising laser systems will be discussed.

LEARNING OUTCOMES

This course will enable you to:

- become familiar with the various types of high power lasers that are used for military applications
- classify high power lasers according to their specific application areas and the environmental conditions in which they are best utilized
- evaluate and analyze the design considerations and performance of high power lasers
- analyze the advantages and limitations of lasers for military applications
- analyze the role of laser beams against present threats
- become familiar with the main concepts used in designing high power military lasers
- describe and estimate the operational characteristics required for effective high power laser deployment

INTENDED AUDIENCE

Laser engineers, optical engineers, laser scientists, laser system engineers, graduate students in laser physics, project officers, and anybody who wants to acquire knowledge in specific applications of high power lasers.

INSTRUCTOR

Yehoshua Kalisky is with the Chemistry Division of NRCN, Beer-Sheva, Israel. He is an SPIE Fellow, and holds several patents and numerous publications on laser physics, spectroscopy of laser materials, and various types of lasers such as gas and dye lasers, as well as diode-pumped solid state lasers.

Fiber Lasers and their Applications

SC1105 New

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

Fiber laser technology has the potential to make a significant impact in many defense applications, from LIDAR and remote sensing to high energy laser weapons systems, in addition to numerous industrial, medical and scientific applications. This revolutionary new laser technology offers many intrinsic advantages over traditional DPSSLs and has received considerable support from key funding agencies over the last 10 years, including DARPA and the Joint Technology office (JTO) amongst others. With the aid of this funding several groups have now demonstrated small, compact and lightweight single mode fiber devices operating at the 1-10kW power level. There are research and development programs in the Air Force, Navy and Army currently. Funding to demonstrate beam combining of fiber lasers to the 25kW level is in place with programs such as RELI and Excalibur. More recently, the BAA call from the Office of Naval Research specifically calls for the development of high energy laser weapon technology suitable for ship board defense to be demonstrated on platform by 2016 and fiber technology is one possible solution being considered. Active deployment in the next decade is anticipated by some branches of the military.

Widespread publications in the research community have demonstrated an impressive array of power scaling fiber laser results, both CW and pulsed at wavelengths from 1um to the eyesafe 1.5um and 2um wavelengths. Advantages associated with fiber technology are not only high wallplug efficiency leading to reduced electrical power requirements and easier system cooling, but also robustness, good beam quality, compactness and highly flexible system performance. These, coupled with (remote) fiber delivery options make the technology unique in many applications.

This tutorial will cover the major aspects of designing and building a fiber laser, from the fiber itself through the various state of the art fiber components, and discussing the system parameter space that best makes use of the intrinsic advantages of the technology. Applications from industrial material processing though to defense and homeland security will be reviewed.

LEARNING OUTCOMES

This course will enable you to:

- compare the advantages of fiber laser technology to other lasers and know how the technology is best utilized in various system designs and applications
- describe the relevant architectures, components and fibers involved in designing a fiber laser and know the steps involved in building one
- gain an overview of the recent advances in fiber laser technology and an understanding of what the future technology roadmap looks like

INTENDED AUDIENCE

The tutorial is designed for researchers and engineers interested in investigating this application area but without the detailed knowledge of fibers and fiber based devices. Higher level managers and system designers/integrators will also be interested in the broad comparisons made between the fiber laser technology and current lasers and how this can impact future system designs.

INSTRUCTOR

Bryce Samson is Vice-President of Business Development for Nufern, and previously served as a senior research scientist at the corporate research labs of Corning Inc. for 5 years. Previous to that, Dr. Samson was a research fellow at Southampton University's Optoelectronic Research Centre (ORC) based in the UK, also for 5 years. He holds a PhD in semiconductor physics from Essex University, UK, has published over 100 refereed scientific and conference papers, and has more than 10 patents. Dr. Samson has been active in the field of optical fiber research for over 20 years, specializing in fiber laser and amplifiers for sensors, telecom and industrial applications and has a documented interest in optical spectroscopy of rare earth doped glasses.

Liang Dong is currently an associate professor at Department of Electrical and Computer Engineering at Clemson University. Prior to joining Clemson University, Liang Dong served as senior technical manager at IMRA America Incorporated, R&D director at Lightwaves2020 Incorporated and R&D manager at Corvis Incorporated. He also worked as senior scientist at Corning Incorporated and managed optical fiber fabrication activities at Southampton University. Dr. Dong has over 20 years of experience in research and development in photonics and optical fibers, covering a wide range of topics in materials, designs, simulations, photosensitive processes, nonlinear processes, optical amplifiers, lasers, active/passive optical devices and system integrations for wide range applications such as telecommunications, industrial machining, medical and sensing. He is the author of several invited articles and book chapters, and has given a large number of invited talks at international conferences. He has published over 200 papers and has over 20 granted patents.

Laser Lab Design - Laser Safety and Practicality

SC1106 New

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

This course presents and reviews lessons learned on how to layout and set up a Research & Development laser laboratory in a university or technology research facility. There will be an initial review of laser safety concepts, and lab design requirements. The rest of the class time will be spent on items to be aware of in setting up a laser lab and solutions to problems. A number of good and bad scenarios will be covered.

LEARNING OUTCOMES

This course will enable you to:

- describe and understand the fundamentals of Laser Safety
- comprehend laser hazard classification and its relationship to laser safety
- use real world considerations in putting together an R&D laser lab

- develop proper signage, access control measures and visual barriers for your lab
- avoid common laser lab set up problems
- effectively communicate your laser safety needs to a facility or construction project manager overseeing your space

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn about laser safety and how to avoid problems when setting up a laser lab.

INSTRUCTOR

Ken Barat has been involved in laser safety for over 30 years, including serving until 2013 as the Laser Safety Officer at Lawrence Berkeley National Laboratory, the LSO for the National Ignition Facility and laser safety advisor for LIGO. He is Chair of ANSI Z136.8 Standard, Safe Use of Lasers in the Research, Development or Testing, Chair and originator of the LSO Workshop Series, and first chair of DOE Laser Safety Officers Working Group. He has authored three texts on laser safety, numerous articles, speaker at national and international conferences and Universities. Recognition for his work in this field includes Laser Institute of America Fellow, Rockwell Award for both Education and Laser Safety Contributions, IEEE Senior member and a CLSO.

Basic Laser Technology

SC972

New

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Friday 8:30 am to 12:30 pm

If you are uncomfortable working with lasers as “black boxes” and would like to have a basic understanding of their inner workings, this introductory course will be of benefit to you. The workshop will cover the basic principles common to the operation of any laser/laser system. Next, we will discuss laser components and their functionality. Components covered will include laser pumps/energy sources, mirrors, active media, nonlinear crystals, and Q-switches. The properties of laser beams will be described in terms of some of their common performance specifications such as longitudinal modes and monochromaticity, transverse electromagnetic (TEM) modes and focusability, continuous wave (CW) power, peak power and power stability. Laser slope and wall-plug efficiencies will also be discussed.

LEARNING OUTCOMES

This course will enable you to:
- describe the overall inner workings of any laser
- describe the functionality of the key laser components
- know the difference between how acousto- and electro-optic Q-switches work
- explain how each key component in a laser may contribute to laser performance
- intelligently engage your clients or customers using proper laser terminology
- build stronger relationships with clients and customers by demonstrating product knowledge
- obtain the technical knowledge and confidence to enhance your job performance and rise above the competition, inside and outside your company

INTENDED AUDIENCE

Managers, engineers, technicians, assemblers, sales/marketing, customer service, and other support staff. This workshop will help cultivate a common/standardized understanding of lasers across the company.

INSTRUCTOR

Sydney Sukuta is currently a Laser Technology professor at San Jose City College. He also has industry experience working for the some the world’s leading laser manufacturers in Silicon Valley where he saw first-hand the issues they encounter on a daily basis. In response, Dr. Sukuta developed prescriptive short courses to help absolve most of these issues.

Coherent Mid-Infrared Sources and Applications

SC1012

New

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 1:30 pm to 5:30 pm

This course explains why the mid-IR spectral range is so important for molecular spectroscopy, standoff sensing, and trace molecular detection. We will regard different approaches for generating coherent light in the mid-IR including solid state lasers, fiber lasers, semiconductor (including quantum cascade) lasers, and laser sources based on nonlinear optical methods. The course will discuss several applications of mid-IR coherent light: spectral recognition of molecules, trace gas sensing, standoff detection, and frequency comb Fourier transform spectroscopy.

LEARNING OUTCOMES

This course will enable you to:
- define the “molecular fingerprint” region
- identify existing direct laser sources of mid-IR coherent radiation, including solid state lasers, fiber lasers, semiconductor heterojunction and quantum cascade lasers
- identify laser sources based on nonlinear optical methods, including difference Frequency generators and optical parametric oscillators and generators
- describe the principles of trace gas sensing and standoff detection
- explain mid-IR frequency combs and how they can be used for advanced spectroscopic detection

INTENDED AUDIENCE

Students, academics, researchers and engineers in various disciplines who require a broad introduction to the subject and would like to learn more about the state-of-the-art and upcoming trends in mid-infrared coherent source development and applications. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Konstantin Vodopyanov is a world expert in mid-IR solid state lasers, nonlinear optics and laser spectroscopy. He has both industrial and academic experience, has > 300 technical publications and he is a coauthor, with I.T. Sorokina, of the book Solid-State Mid-Infrared Laser Sources (Springer, 2003). He is a member of program committees for several major laser conferences including CLEO (most recent, General Chair in 2010) and Photonics West (LA106 Conference Chair). Currently he teaches and does scientific research at Stanford University and his research interests include mid-IR and terahertz-wave generation using micro-and nano-structured materials, nano-IR spectroscopy, generation of mid-infrared frequency combs and their applications. Dr. Vodopyanov has delivered numerous invited talks and tutorials at scientific meetings on the subject of mid-IR technology.

High Power Laser Beam Quality

SC997

Course Level: Introductory
CEU: 0.35 $340 Members | $390 Non-Members USD
Thursday 8:30 am to 12:30 pm

This course covers definitions and applications of common measures of beam quality, including Brightness, Power-in-the-bucket, M^2, ‘times diffraction limited’, Strehl ratio, beam parameter product etc. Special emphasis will be given to choosing an appropriate beam quality metric, tracing the metric to the application of the laser system, and to various conceptual pitfalls which arise in this field. This course is especially applicable to novel lasers that may not have Gaussian modes, especially high energy lasers or unstable resonators. Material presented will come from general scientific literature as well as original work done by Dr. Sean Ross and Dr. William Latham, both from the Air Force Research Laboratory Directed Energy Directorate.

LEARNING OUTCOMES

- convert between common measures of beam quality
- design an appropriate beam quality measure for your own laser application
- evaluate the suitability of commercial, black box beam quality analyzers for your application
- comprehend and take correct ISO 11146 M^2 measurements

INTENDED AUDIENCE

This course should benefit anyone with an interest in laser beam quality, including program managers, scientists and engineers who are not experts in the field.

INSTRUCTOR

T. Sean Ross has been with the Air Force Research Laboratory, Directed Energy Directorate, High Power Solid State Laser Branch since he received his PhD from the Center for Research and Education in Optics and Lasers (CREOL) in 1998. Research interests include nonlinear frequency conversion, high power solid state lasers, thermal management and laser beam quality. Beginning in 2000, frustration with commercial beam quality devices led to the work eventually presented in the Journal of Directed Energy, Vol. 2 No. 1 Summer 2006 “Appropriate Measures and Consistent Standard for High Energy Laser Beam Quality”. This paper and its conference version (presented at the 2005 DEPS Symposium) have received awards from the Directed Energy Professional Society and the Directed Energy Directorate.

COURSE PRICE INCLUDES the text *Laser Beam Quality Metrics* (SPIE Press, 2013) by T. Sean Ross.

Direct Detection Laser Radar Systems for Imaging Applications

SC1032

Course Level: Advanced
CEU: 0.65 $555 Members | $650 Non-Members USD
Monday 8:30 am to 5:30 pm

As laser radar detection and ranging (LADAR) technologies continue to mature, more and more these systems are being applied to military, commercial and scientific applications. From simple time of flight range measurements to high resolution terrain mapping and 3-dimensional imaging, the utility of LADAR is being investigated across a wide range of applications.

In direct detection LADAR the measurements depend solely on the amplitude of the returned signal. This course is designed to teach students the basics of direct detection LADAR and how to transform customer or mission requirements into LADAR system performance specifications. Tools for modeling LADAR systems are introduced through the lecture material that allows quantification of important system performance metrics.

The course begins with the LADAR range equation and how it can be used to evaluate the impact factors such as atmospheric turbulence on LADAR performance. Students are introduced to direct detection LADAR modeling methods which help to explain how various LADAR subsystems affect LADAR range accuracy. A number of representative systems will be introduced as examples throughout the lectures. This course closely follows the included text *Direct Detection LADAR Systems* , SPIE Vol. TT85. The examples and problems presented in the book will be explored more fully during the course.

LEARNING OUTCOMES

This course will enable you to:

- compute the amount of laser power reflected from a target to a LADAR receiver
- calculate the expected signal to noise ratio obtained by a LADAR receiver
- determine the probability of detection and false alarm for different kinds of LADAR receivers
- explain the effects of atmospheric turbulence on LADAR system performance
- compare the performance of different algorithms for extracting range information from LADAR signals
- predict the effects of reflection from different surfaces on the performance of LADAR systems
- explain the functional differences between different types of 3-D LADAR systems.

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about how to evaluate the performance of direct detection laser radar systems and to quantify the impact that various effects have on LADAR performance as well as university professors who wish to offer courses in LADAR. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Richard Richmond worked in the Electro-Optics Technology Division of the Air Force Research Laboratory prior to his retirement in 2009. He was the Team Leader for Laser Radar Technology in the Multi-function Electro-optics Branch. Mr. Richmond has been the Project Engineer or Program Manager on numerous laser radar development and research efforts. Application areas of the various efforts have included both ground-based and airborne wind sensing, imaging and vibration sensing of hard targets, and remote chemical sensing. He has over 30 years experience in the development and application of laser based remote sensing, and is a Fellow of the MSS.

COURSE PRICE INCLUDES the text *Direct Detection LADAR Systems* (SPIE Press, 2010) by Richard Richmond and Stephen Cain.

Introduction to Optical and Infrared Sensor Systems

SC789

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides a broad introduction to optical (near UV-visible) and infrared sensor systems, with an emphasis on systems used in defense and security. Topics include both passive imagers and active laser radars (lidar/ladar). We begin with a discussion of radiometry and radiometric calculations to determine how much optical power is captured by a sensor system. We survey atmospheric propagation and phenomenology (absorption, emission, scattering, and turbulence) and explore how these issues affect sensor systems. Finally, we perform signal calculations that consider the source, the atmosphere, and the optical system and detector, to arrive at a signal-to-noise ratio for typical passive and active sensor systems. These principles of optical radiometry, atmospheric propagation, and optical detection are combined in examples of real sensors studied at the block-diagram level. Sensor system examples include passive infrared imagers, polarization imagers, and hyperspectral imaging spectrometers, and active laser radars (lidars or ladars) for sensing distributed or hard targets. The course organization is approximately one third on the radiometric analysis of sensor systems, one third on atmospheric phenomenology and detector parameters, and one third on example calculations and examination of sensor systems at the block-diagram level.

LEARNING OUTCOMES

This course will enable you to:

- explain and use radiometry for describing and calculating the flow of optical energy in an optical or infrared sensor system
- determine the radiometric throughput of sensor systems
- describe atmospheric phenomenology relevant to propagation of optical and infrared radiation
- explain how the atmosphere affects the performance of sensor systems
- use detector parameters with radiometric calculations to predict the signal received by passive and active sensors
- calculate signal-to-noise ratio for typical sensor systems
- explain real-world sensor systems at the block-diagram level

- explain the difference between and important concepts of passive reflection-based and emission-based imaging
- describe the basic operating principles of passive imagers and active laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who find themselves working on (or curious about) optical (uv-vis) and infrared sensor systems without formal training in this area. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw has been developing optical remote sensing systems and using them in environmental and military sensing for two decades, first at NOAA and currently as professor of electrical engineering and physics at Montana State University. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a Ph.D. in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

IR Atmospheric Propagation for Sensor Systems

SC1107

New

Course Level: Intermediate
CEU: 0.65 $685 Members | $780 Non-Members USD
Monday 8:30 am to 5:30 pm

This course reviews the fundamental principles and applications concerning absorption and scattering phenomena in the atmosphere that impact infrared sensor performance. Topics include an introduction to atmospheric structure, a background reviewing the basic formulas concerning the complex index of refraction, a survey of molecular absorption bands and continuum absorption, the HITRAN database, atmospheric refractivity, molecular Rayleigh scattering, particle distribution functions, Mie scattering and anomalous diffraction approximation. This background is applied to atmospheric transmittance, path radiance and path fluctuations with examples from computer codes such as MODTRAN and FASCODE. These topics are further reinforced by practical examples on atmospheric optics whenever possible. A set of contemporary references is provided.

LEARNING OUTCOMES

This course will enable you to:

- summarize the basics of absorption, refraction and scatter in the atmosphere
- distinguish between the optical properties of gases and condensed matter
- identify the structure of the atmosphere
- compute atmospheric transmittance
- compute atmospheric scattering
- relate course concepts to observable phenomena in the atmosphere

INTENDED AUDIENCE

The course is intended for engineers and scientists working with EO/IR systems in the atmosphere of earth. The material is beneficial to experimentalists and modelers. The course material is presented at an intermediate level, suitable for those with some experience in optical propagation in the atmosphere. Working knowledge of undergraduate electromagnetic theory as applied to optical frequencies is desired.

INSTRUCTOR

Michael Thomas is currently a Principal Staff Engineer at the Applied Physics Laboratory, and a Research Professor in the Department of Electrical and Computer Engineering at Johns Hopkins University. He has been at APL since 1979, and is currently in the EO/IR Systems and Technologies Group at APL. Dr. Thomas holds a Ph.D. in electrical engineering from The Ohio State University. Dr. Thomas is a specialist in electromagnetic theory, optical propagation, and quantum electronics with research interests in measurement and theoretical modeling of atmospheric propagation and remote sensing, optical properties of solids and high pressure gases. He has over 190 journal type publications in these areas. Dr. Thomas is a Fellow of the Optical Society of America, a senior member of IEEE and also holds membership in SPIE, Sigma Xi and Tau Beta Pi.

COURSE PRICE INCLUDES THE text *Optical Propagation in Linear Media* (Oxford University Press , 2006) by M. E. Thomas.

Precision Stabilized Pointing and Tracking Systems

SC160

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Monday 8:30 am to 5:30 pm

This course provides a practical description of the design, analysis, integration, and evaluation processes associated with development of precision stabilization, pointing and tracking systems. Major topics include stabilized platform technology, electro-mechanical system configuration and analysis, and typical pointing and tracking system architectures.

LEARNING OUTCOMES

This course will enable you to:

- acquire the terminology of stabilization, pointing, and tracking systems and understand the common system architectures and operation
- define typical electro-mechanical configurations and key subsystems and components used in precision stabilization and laser pointing systems
- describe the primary systems engineering tradeoffs and decisions that are required to configure and design stabilization, pointing and tracking systems
- distinguish the performance capabilities of specific design configurations

INTENDED AUDIENCE

This material is designed for engineers and managers responsible for design, analysis, development, or test of electro-optical stabilization, pointing and tracking systems or components. A minimum BS degree in an engineering discipline and familiarity with basic control systems is recommended.

INSTRUCTOR

James Hilkert is president of Alpha-Theta Technologies, an engineering consulting firm specializing in precision pointing, tracking and stabilization applications for clients such as Raytheon, General Dynamics, Northrop Grumman, DRS, Atlantic Positioning and the U.S. Navy. Prior to founding Alpha-Theta Technologies in 1994, he spent 20 years at Texas Instruments Defense Systems (now Raytheon) where he designed inertial tracking and pointing systems for a variety of military applications and later managed the Control Systems Technology Center. He received the Dr. Engineering degree from Southern Methodist University and MSME and BSME degrees from Mississippi State University, is a member of ASME, AIAA and SPIE, and lectures on control systems at The University of Texas at Dallas.

Understanding Diffractive Optics

SC1071

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Monday 8:30 am to 5:30 pm

The course will cover the fundamental principles of diffraction phenomena. A qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics, as well as the unique properties associated with the diffraction of laser beams during propagation. The instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics
- describe diffraction phenomena associated with the propagation of laser beams
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and resonant domains, diffraction efficiency, and the blazing condition
- receive an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was published in 2011 by SPIE Press.

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics* , FG21 (SPIE Press, 2011) by Yakov Soskind.

Displays for Innovative Applications

Head-Mounted Displays: Design and Applications

SC159

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Tuesday 8:30 am to 5:30 pm

Head-mounted displays (HMD) and the military counterpart helmet-mounted displays, are personal information-viewing devices that can provide information in a way that no other display can because the information is always available for viewing. By making the imagery reactive to head and body movements we replicate the way humans view, navigate and explore the world. This unique capability lends itself to applications such as Virtual Reality for creating artificial environments, medical visualization as an aid in surgical procedures, military vehicles for viewing sensor imagery, aircraft simulation and training, and for fixed and rotary wing avionics display applications.

This course covers design fundamentals for head-mounted displays from the user's point of view starting with the basics of human perception, head and neck biomechanics, image sources, optical design and head mounting. We will also discuss the impact of user task requirements and applications on various HMD parameters, as well as a detailed discussion of HMD optical designs (pupil and non-pupil forming, see-through and non-see-through, monocular, biocular and binocular, exit pupil and eye relief).

From there we will delve into various image source technologies, discussing advantages and disadvantages of the various approaches and methods for producing color imagery, with their implications for use in the near-eye presentation of imagery. We will also discuss head/neck anatomy and biomechanics and the implications of HMD weight and center of gravity on crash and ejection safety. Also presented will be guidelines for preventing eye fatigue, neck strain, cybersickness and other adverse physiological effects that have been attributed to poor HMD design. Throughout the course, we will use examples of current HMD systems and hardware to illustrate these issues.

LEARNING OUTCOMES

This course will enable you to:

- define basic components and attributes of head-mounted displays and visually coupled systems
- describe important features and enabling technologies of an HMD and their impact on user performance and acceptance
- identify key user-oriented performance requirements and link their impact on HMD design parameters
- list basic features of the human visual system and biomechanical attributes of the head and neck and the guidelines to follow to prevent fatigue or strain
- identify key tradeoffs for monocular, binocular and biocular systems
- classify current image source technologies and their methods for producing color imagery
- describe methods of producing wide field of view, high resolution HMDs
- evaluate tradeoffs for critical display performance parameters

INTENDED AUDIENCE

This course is intended for managers, engineers and scientists involved in the procurement, evaluation, specification or design of HMDs for air or ground-based applications.

INSTRUCTOR

James Melzer is Manager of Research and Technology at Rockwell Collins Optronics, in Carlsbad, California. He has extensive experience in optical and displays engineering, and is an expert in display design for head-mounted systems, aviation life-support, and user interface. He has authored over 35 technical papers and holds four patents in HMD design. He was recently IPT lead for the US Army's Future Force Warrior and Air Warrior Integrated Headgear Product teams.

Michael Browne is the Vice President of Product Development at SA Photonics in San Francisco, California. He has a Ph.D. in Optical Engineering from the University of Arizona's Optical Sciences Center. Mike has been involved in the design, test, and measurement of head mounted display systems since 1991. At Kaiser Electronics, Mike led the design of numerous head mounted display and rear-projection display systems, including those for the F-35 Joint Strike Fighter. Mike leads SA Photonics' efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. Mike's current research includes investigations into binocular rivalry in head mounted displays, simulator sickness prediction and prevention, and the design of wide field of view night vision systems.

COURSE PRICE INCLUDES the text *Head Mounted Displays: Designing for the User* (republished 2011) by James Melzer and Kirk Moffitt.

Fundamentals of Three-Dimensional Optical Microscopy

SC979

New

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides an introduction to the principles that govern the acquisition of 3D images with optical microscopes. Specifically, it provides attendees with practical knowledge to understand the limitations of conventional microscopes when imaging 3D samples, as well as the principles of different emerging microscopy techniques with optical-sectioning capacity.

The course will include three parts. In the first part, we describe the fundamentals of 2D imaging processes in conventional microscopes, and why they are not well adapted for imaging 3D samples. In the second part, we will focus on different optical-sectioning microscopy techniques, such as confocal, 4Pi, multi-photon, and structured illumination microscopy. In the third part, we will focus on emerging approaches, including one-shot 3D microscopes, digital holographic microscopes, etc. The attendee will benefit from a concise and realistic overview of microscopy procedures, which may help them to select the adequate microscope for various applications. The course will provide discussions of optical hardware and various practical applications of 3D optical microscopy. Also, discussions and examples will be presented on the benefits of 3D optical microscopy over conventional 2D optical microscopy.

LEARNING OUTCOMES

This course will enable you to:

- describe the process of 2D imaging microscopy in terms of the 2D point-spread function (PSF) and its spectral counterpart, the 2D optical transfer function (OTF)
- describe the process of imaging of 3D samples with conventional, wide-field microscopes in terms of the 3D PSF and the 3D OTF
- describe the concept of optical sectioning of 3D images, and also understand why conventional microscopes lack the capacity of optical sectioning
- know the principles of single-photon confocal scanning microscopes (CSM) and explain why such microscopes are specially adapted to image 3D samples with high optical sectioning capacity
- explain the principles of two-photon excitation (TPE) scanning microscopes, and understand their advantages and drawbacks as compared with CSMs
- describe the optical-sectioning and super resolving features of structured-illumination microscopes (SIM)
- explain the principles of emerging one-shot 3D microscopes such as digital holographic microscopes (DHM), integral-imaging microscopes, etc.
- know about the hardware of front-end microscopy techniques
- describe some practical applications of 3D optical microscopy in various disciplines such as biomedical field and industrial inspection

INTENDED AUDIENCE

This course is intended for scientists, engineers, researchers, physicists, biomedical engineers, biologists, product development managers, directors of engineering, development engineers, or anyone who is interested in microscopy images of 3D specimens and objects. The course intends to help the students to understand the imaging capacity of conventional microscopes, and why they are not well adapted for imaging 3D samples. The course material will provide information to assist the student to determine the adequate microscope for a given application. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Bahram Javidi (PhD) is Board of Trustees Distinguished Professor at the University of Connecticut. Prof. Javidi is fellows of eight professional societies, including IEEE, OSA and SPIE. He has more than 700 books, chapters, refereed published articles, and conference papers with over 10000 citations according to WEB of Science [h-index=54].

Manuel Martinez-Corral is Full Professor of Optics at the University of Valencia (Spain) where he regularly teaches courses on Diffractive Imaging and 3D Microscopy. In 2010 he was elected Fellow of the SPIE. He is the leader of the 3D Imaging and Display Laboratory (3DID). He has published more than 70 articles in major journals, which have received about 1100 citations.

Introduction to Night Vision

SC1068

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

Night vision devices have become ubiquitous in both commercial and military environments. From the very high end systems used for aviation, to the low-performance systems sold for outdoorsmen, these devices have changed the way their users operate at night. This course explains the basic principles behind night vision and discusses the different types of night vision devices, both “analog” and “digital”. In addition to a survey of night vision devices, we also examine the inner workings of night vision systems and explain them in an easy to understand manner. We will discuss the design of night vision systems, both handheld and head mounted.

Although we will talk briefly about SWIR and thermal devices to differentiate them from night vision devices, this course is primarily aimed at visible and near infra-red (NIR) imagers. Imagery from both night vision cameras as well as thermal imagers will be presented and the differences between them will be compared/contrasted.

LEARNING OUTCOMES

This course will enable you to:

- identify the three basic components of a night vision imager: the sensor, the amplifier and the output component
- specify input optics (objective lenses) and output optics (eyepieces) for both analog and digital night vision devices
- explain the difference between VIS/NIR night vision, SWIR, MWIR and LWIR sensors as well as when each should be chosen
- differentiate the different generations of night vision goggles
- define appropriate light levels for night vision device testing
- describe new digital night vision devices and their advantages and disadvantages
- explain the important attributes of night vision systems and how they should be specified for “best value” performance
- predict night vision performance using NVESD models

INTENDED AUDIENCE

Scientists, engineers, technicians, procurement personnel or managers who wish to learn more about night vision devices. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Michael Browne is the Vice President of Product Development at SA Photonics. He has a Ph.D. in Optical Engineering from the University of Arizona’s Optical Sciences Center. Mike has been involved in the design, test and measurement of night vision systems since 1986. At Kaiser Electronics, he led the design of numerous head mounted night vision systems including those for the RAH-66 Comanche helicopter and the USAF NVS program. He leads SA Photonics’ efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. His current research includes investigations into the design of wide field of view night vision devices, binocular rivalry in head mounted displays, and smear reduction in digital displays.

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $560 Members | $655 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:

- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

GPU for Defense Applications

SC1069

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course teaches the basics of utilizing modern programmable graphics processing units (GPUs) for military applications. The modern GPU is a fully programmable parallel programming environment that performs computations an order of magnitude faster than the modern CPU. In this course, we will learn broadly about the architecture of the GPU, the appropriate situations where speedups may be obtained and gain an understanding of the tools and languages that are available for development. Programming is not a part of the curriculum.

We will also discuss the available GPU platforms, with an emphasis on rugged, deployable, and low-power offerings. Lastly, the bulk of the course will center on applications and case studies, with emphasis on applications we have produced, including: real-time image processing for the reduction of atmospheric turbulence, applied accelerated linear algebra, image enhancement via super resolution, computational fluid dynamics, and computational electromagnetics.

LEARNING OUTCOMES

This course will enable you to:

- summarize how a graphics processing unit functions
- describe the architecture of a modern compute-capable GPU
- describe which types of applications can be improved by the GPU, and to what degree
- determine the suitability of your algorithm for the GPU
- purchase a system well suited to your application
- assess the tools and languages available to the GPU programmer
- appreciate the applicability of the GPU to many defense industry applications via case studies

INTENDED AUDIENCE

Scientists, engineers, mathematicians, and management who are evaluating the graphics processing unit as a candidate to reduce computational time or costs. We will cover both large scale (e.g. clusters) and small-scale (e.g. low-power, deployable) applications.

INSTRUCTOR

John Humphrey is a member of the Accelerated Computing Solutions group at EM Photonics. He earned his MSEE degree from the University of Delaware studying the acceleration of electromagnetics algorithms using custom hardware platforms. At EM Photonics, he launched a GPU research effort in 2005 with a GPU-based FDTD solver based on OpenGL methods and then later explored working in CUDA. Since then, he has worked on accelerated algorithms in a variety of fields, including linear algebra solvers and computational fluid dynamics engines.

Understanding Diffractive Optics

SC1071

Course Level: Introductory
CEU: 0.65 $550 Members | $645 Non-Members USD
Monday 8:30 am to 5:30 pm

The course will cover the fundamental principles of diffraction phenomena. A qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics, as well as the unique properties associated with the diffraction of laser beams during propagation. The instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics
- describe diffraction phenomena associated with the propagation of laser beams
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and resonant domains, diffraction efficiency, and the blazing condition
- receive an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was published in 2011 by SPIE Press.

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics* , FG21 (SPIE Press, 2011) by Yakov Soskind.

Unmanned, Robotic, and Layered Systems

Methods of Energy Harvesting for Low-Power Sensors

SC1075

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course focuses on the transformation of mechanical energy into low-power electricity with an emphasis on vibration-based energy harvesting. A primary goal is to describe the methods of mechanical energy harvesting to use in low-power sensors. Piezoelectric, electromagnetic, electrostatic and magnetostrictive conversion mechanisms will be discussed along with the use of electroactive polymers. Special focus will be placed on piezoelectric materials due to their substantially large power density and ease of application at different geometric scales. System-level modeling and analysis, power density levels, storage devices, deterministic and random energy harvesting, kinetic energy harvesting, flow energy harvesting from aeroelastic and hydroelastic vibrations, acoustic energy harvesting and nonlinear energy harvesting for frequency bandwidth enhancement will be addressed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental principles of mechanical energy harvesting from ambient vibrations
- explain the characteristics and relative advantages of different energy harvesting methods
- identify the concept of power density and differentiate the concepts of input power and the power density of an energy harvester
- distinguish between resonant and non-resonant energy harvesting as well as deterministic and random energy harvesting
- compare linear and nonlinear energy harvesting and classify their characteristics to construct the optimal energy harvester given the input energy characteristics
- combine other sources of energy input (e.g., wind or wave energy, kinetic energy in walking) with mechanical energy harvesting devices for multi-physics problems
- distinguish between the characteristics of conventional and unconventional storage components
- become familiar with recent advances and other methods in energy harvesting

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers from industry and academia who wish to learn about the fundamentals and recent advances in low-power energy harvesting. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Alper Erturk is an Assistant Professor of Mechanical Engineering at Georgia Institute of Technology. Over the past five years, he has published more than 70 articles in refereed international journals and conference proceedings on smart materials and dynamical systems, and a book titled Piezoelectric Energy Harvesting. He is an elected member of the ASME Technical Committee on Adaptive Structures and Material Systems and ASME Technical Committee on Vibration and Sound, and a member of ASME, AIAA, IEEE, SPIE, and SEM. Dr. Erturk received his Ph.D. in Engineering Mechanics at Virginia Tech.

Introduction to Night Vision

SC1068

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

Night vision devices have become ubiquitous in both commercial and military environments. From the very high end systems used for aviation, to the low-performance systems sold for outdoorsmen, these devices have changed the way their users operate at night. This course explains the basic principles behind night vision and discusses the different types of night vision devices, both "analog" and "digital". In addition to a survey of night vision devices, we also examine the inner workings of night vision systems and explain them in an easy to understand manner. We will discuss the design of night vision systems, both handheld and head mounted.

Although we will talk briefly about SWIR and thermal devices to differentiate them from night vision devices, this course is primarily aimed at visible and near infra-red (NIR) imagers. Imagery from both night vision cameras as well as thermal imagers will be presented and the differences between them will be compared/contrasted.

LEARNING OUTCOMES

This course will enable you to:

- identify the three basic components of a night vision imager: the sensor, the amplifier and the output component
- specify input optics (objective lenses) and output optics (eyepieces) for both analog and digital night vision devices
- explain the difference between VIS/NIR night vision, SWIR, MWIR and LWIR sensors as well as when each should be chosen
- differentiate the different generations of night vision goggles
- define appropriate light levels for night vision device testing
- describe new digital night vision devices and their advantages and disadvantages
- explain the important attributes of night vision systems and how they should be specified for "best value" performance
- predict night vision performance using NVESD models

INTENDED AUDIENCE

Scientists, engineers, technicians, procurement personnel or managers who wish to learn more about night vision devices. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Michael Browne is the Vice President of Product Development at SA Photonics. He has a Ph.D. in Optical Engineering from the University of Arizona's Optical Sciences Center. Mike has been involved in the design, test and measurement of night vision systems since 1986. At Kaiser Electronics, he led the design of numerous head mounted night vision systems including those for the RAH-66 Comanche helicopter and the USAF NVS program. He leads SA Photonics' efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. His current research includes investigations into the design of wide field of view night vision devices, binocular rivalry in head mounted displays, and smear reduction in digital displays.

Ocean Sensing and Monitoring

SC1077

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 8:30 am to 12:30 pm

This course covers basic principles and applications of optical oceanography. The course is aimed to provide background information for those interested in exploring oceanography using optical techniques, including sensing and monitoring via remote sensing (passive and active), as well as traditional in situ sampling approaches. Ocean optics principles including absorption, scattering by both particles and optical turbulence, polarization and impacts on underwater imaging and communication are presented in theory and through examples. Typical sensors and platforms including unmanned underwater vehicles are introduced. Topics associated with data collection, processing, analysis, fusion and assimilation to ocean models are also discussed. This course can also be used as a refresher for recent advances in related areas. Anyone who wants to answer questions such as, “what are the issues oceanographers working on these days (that can benefit from our technology)?”, “what does the ocean color tell us?”, or “how far can we see in the water?” will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- grasp core concepts and fundamentals of oceanography, including major processes such as mixing and mixed layer depth, upwelling, red tide, currents, waves, euphotic zone, primary production, turbulence, SST, wind, altimetry, boundary layers and resuspention. The background information provided is the key to the understanding and appreciation of ocean sensing techniques and instrumentation developed.
- assess the basic principles and challenges associated with ocean sensing and monitoring with optical methods, including remote sensing and in situ sampling methods
- identify recent advances in sensing platforms including unmanned aerial/ underwater vehicles, and monitoring networks
- gain new understanding of visibility theory from a MTF perspective, which can be easily incorporated to imaging system design and evaluation
- calculate underwater visibility ranges under different turbidity and turbulence conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn how to apply their technology to monitor 70% of the earth surface, to know more about how to quantify visibility, ocean color and other oceanic phenomenon such as currents, waves, temperature, wind and salinity. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Weilin (Will) Hou has been working on research and engineering projects in optical oceanography for the past twenty years, with primary focus on underwater visibility theories and imaging application, in situ and remote sensing of ocean phenomenon. He is currently an oceanographer and the head of the Hydro Optics Sensors and Systems Section at the U. S. Naval Research Laboratory. He earned his PhD in Optical Oceanography at the University of South Florida in 1997. He developed and co-chairs the SPIE Ocean Sensing and Monitoring conference and is the editor of 3 SPIE proceedings. He has 2 patents and numerous publications. He serves as a panel expert on underwater imaging for NATO and defense technology export control.

This course includes content from the upcoming text *Ocean Sensing and Monitoring: Optics and other methods* (SPIE Press, 2013) by Weilin Hou.

Applications of Detection Theory

SC952

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a “target.” In this case the term “target” may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the “Receiver Operating Characteristic” (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind “Decision Tree Analysis” culminating with an in class exercise. Decision tree analysis allows one to “fuse together” multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:

- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a “Spider Chart” from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years’ service; his decorations include the “Defense Superior Service Medal” from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

Sensor Data and Information Exploitation

Precision Stabilized Pointing and Tracking Systems

SC160

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Monday 8:30 am to 5:30 pm

This course provides a practical description of the design, analysis, integration, and evaluation processes associated with development of precision stabilization, pointing and tracking systems. Major topics include stabilized platform technology, electro-mechanical system configuration and analysis, and typical pointing and tracking system architectures.

LEARNING OUTCOMES

This course will enable you to:

- acquire the terminology of stabilization, pointing, and tracking systems and understand the common system architectures and operation
- define typical electro-mechanical configurations and key subsystems and components used in precision stabilization and laser pointing systems
- describe the primary systems engineering tradeoffs and decisions that are required to configure and design stabilization, pointing and tracking systems
- distinguish the performance capabilities of specific design configurations

INTENDED AUDIENCE

This material is designed for engineers and managers responsible for design, analysis, development, or test of electro-optical stabilization, pointing and tracking systems or components. A minimum BS degree in an engineering discipline and familiarity with basic control systems is recommended.

INSTRUCTOR

James Hilkert is president of Alpha-Theta Technologies, an engineering consulting firm specializing in precision pointing, tracking and stabilization applications for clients such as Raytheon, General Dynamics, Northrop Grumman, DRS, Atlantic Positioning and the U.S. Navy. Prior to founding Alpha-Theta Technologies in 1994, he spent 20 years at Texas Instruments Defense Systems (now Raytheon) where he designed inertial tracking and pointing systems for a variety of military applications and later managed the Control Systems Technology Center. He received the Dr. Engineering degree from Southern Methodist University and MSME and BSME degrees from Mississippi State University, is a member of ASME, AIAA and SPIE, and lectures on control systems at The University of Texas at Dallas.

Predicting Target Acquisition Performance of Electro-Optical Imagers

SC181

Course Level: Advanced
CEU: 0.65 $570 Members | $665 Non-Members USD
Wednesday 8:30 am to 5:30 pm

This course describes how to predict and evaluate electro-optical (EO) imager performance. Metrics that quantify imager resolution are described. The detection, recognition, and identification tasks are discussed, and the meaning of acquisition probabilities is explained. The basic theory of operation of thermal imagers, image intensifiers, and video cameras is presented. This course describes how to quantify the resolution and noise characteristics of an EO imager. The theory and analysis of sampled imagers is emphasized. Image quality metrics are described, and the relationship between image quality and target acquisition performance is explained. The course provides a complete overview of how to analyze and evaluate the performance of EO imagers.

LEARNING OUTCOMES

This course will enable you to:

- describe what a target acquisition model does
- describe the operation of thermal sensors, video cameras and other EO imagers
- analyze the impact of sampling on targeting performance
- evaluate the targeting performance of an EO imager

INTENDED AUDIENCE

This course is intended for the design engineer or system analyst who is interested in quantifying the performance of EO imagers. Some background in linear systems analysis is helpful but not mandatory.

INSTRUCTOR

Richard Vollmerhausen recently retired from the Army's Night Vision and Electronic Sensors Directorate. He is currently consulting. Mr. Vollmerhausen is the developer of the current generation of target acquisition models used by the Army.

COURSE PRICE INCLUDES the text *Analysis and Evaluation of Sampled Imaging Systems* (SPIE Press, 2010) by Richard H. Vollmerhausen, Ronald G. Driggers, and Don Reago.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of automatic target and object detection and its applications in Hyperspectral Imagery (HSI). The primary goal of this course is to introduce the well known target detection algorithms in hyperspectral imagery. Examples of the classical target detection techniques such as spectral matched filter, subspace matched filter, adaptive matched filter, orthogonal subspace, support vector machine (SVM) and machine learning are reviewed. Construction of invariance subspaces for target and background as well as the use of regularization techniques are presented. Standard atmospheric correction and compensation techniques are reviewed. Anomaly detection techniques for HSI and dual band FLIR imagery are also discussed. Applications of HSI for detection of mines, targets, humans, chemical plumes and anomalies are reviewed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental concepts of target detection algorithms as applied to HSI
- learn the procedure to use the generalized maximum likelihood ratio test to design spectral detectors
- describe the fundamental differences between different detection algorithms based on their model representations
- develop statistical models as well as subspace models for HSI data
- explain the difference between anomaly detection and classification
- distinguish between linear and nonlinear approaches (SVM and Kernel learning techniques)
- develop anomaly detection techniques for different environmental scenarios
- describe linear models and unmixing techniques for abundance measures
- plot ROC curves to evaluate the performance of the algorithms

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about target detection in hyperspectral, multispectral or dual-band FLIR imagery. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a senior research scientist (ST) at US Army Research Laboratory (ARL). He is also an adjunct professor in the Electrical and Computer Engineering Department at the Johns Hopkins University. He is actively engaged in research in image processing, neural networks, automatic target recognition, and video compression and its transmission over high speed networks. He has published over 200 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing,IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

Multispectral and Hyperspectral Image Sensors

SC194

Course Level: Advanced
CEU: 0.35 $375 Members | $425 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

This course will describe the imaging capabilities and applications of the principal types of multispectral (MS) and hyperspectral (HS) sensors. The focus will be on sensors that work in the visible, near-infrared and shortwave-infrared spectral regimes, but the course will touch on longwave-infrared applications. A summary of the salient features of classical color imaging (human observation) will also be provided in an appendix.

LEARNING OUTCOMES

This course will enable you to:

- understand many of the applications and advantages of multispectral (MS) and hyperspectral (HS) imaging
- describe and categorize the properties of the principal MS / HS design types (multi-band scanner, starers with filter wheels, dispersive, wedge, and Fourier transform imagers with 2D arrays, etc.)
- list and define the relevant radiometric radiometric quantities, concepts and phenomenology
- understand the process of translating system requirements into sensor hardware constraints and specifications
- analyze signal-to-noise ratio, modulation-transfer-function, and spatial / spectral sampling for MS and HS sensors
- define, understand and apply the relevant noise-equivalent figures-of-merit (Noise-equivalent reflectance difference, Noise-equivalent temperature difference, Noise-equivalent spectral radiance, Noise-equivalent irradiance, etc.)
- describe the elements of the image chain from photons-in to bits-out (photon detection, video signal manipulation, analog processing, and digitization)
- list and review key imager subsystem technology elements (optical, focal plane, video electronics, and thermal)
- formulate a detailed end-to-end design example of a satellite imaging scanning HS sensor
- provide an appendix that summarizes color imaging principles and sensor associated elements for human observation applications (e.g. color television, still cameras, etc.)

INTENDED AUDIENCE

Engineers, scientists, and technical managers who are interested in understanding and applying multispectral and hyperspectral sensors in advanced military, civil, scientific and commercial applications.

INSTRUCTOR

Terrence Lomheim holds the position of Distinguished Engineer at The Aerospace Corp. He has 34 years of hardware and analysis experience in visible and infrared electro-optical systems, focal plane technology, and applied optics, and has authored and co-authored 63 publications in these technical areas. He is a Fellow of the SPIE.

COURSE PRICE INCLUDES the text *CMOS/CCD Sensors and Camera Systems, 2nd edition* (SPIE Press, 2011) by Terrence Lomheim and Gerald Holst.

Multisensor Data Fusion for Object Detection, Classification and Identification

SC994

Course Level: Introductory
CEU: 0.65 $585 Members | $680 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course describes sensor and data fusion methods that improve the probability of correct target detection, classification, and identification. The methods allow the combining of information from collocated or dispersed sensors that utilize similar or different signature-generation phenomenologies. Examples provide insight as to how different phenomenology-based sensors enhance a data fusion system.

After introducing the JDL data fusion and resource management model, sensor and data fusion architectures are described in terms of sensor-level, central-level, and hybrid fusion, and pixel-, feature-, and decision-level fusion. The data fusion algorithm taxonomies that follow provide an introduction to the descriptions of the algorithms and methods utilized for detection, classification, identification, and state estimation and tracking - the Level 1 fusion processes. These algorithms support the higher-level data fusion processes of situation and threat assessment.

Subsequent sections of the course more fully develop the Bayesian, Dempster-Shafer, and voting logic data fusion algorithms. Examples abound throughout the material to illustrate the major techniques being presented. The illustrative problems demonstrate that many of the data fusion methods can be applied to combine information from almost any grouping of sensors as long as they can supply the input data required by the fusion algorithm. Practitioners who want to identify the input quantities or parameters needed to implement data fusion will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify multisensor data fusion principles, algorithms, and architectures for new and existing systems
- describe the advantages of multisensor data fusion for object discrimination and state estimation
- select appropriate sensors for specific sensor and data fusion applications
- identify potential algorithms for target detection, classification, identification, and tracking
- formulate sensor and data fusion approaches for many practical applications
- compare the detection and classification ability of many data fusion algorithms to those available without data fusion
- acquire the skills needed to develop and apply data fusion algorithms to more complex situations

INTENDED AUDIENCE

Engineers, scientists, managers, systems designers, military operations personnel, and other users of multisensor data fusion for target detection, classification, identification, and tracking of airborne, ground-based, and underwater targets will benefit from this course. Undergraduate training in engineering, science, or mathematics is assumed.

INSTRUCTOR

Lawrence Klein specializes in developing multiple sensor systems for tactical and reconnaissance military applications and homeland defense. His interests also include application of sensor and data fusion concepts to intelligent transportation systems. While at Hughes Aircraft Company, Dr. Klein developed missile deployment strategies and sensors for missile guidance. As Chief Scientist at Aerojet ElectroSystems TAMS Division, he was responsible for programs that integrated active and passive millimeter-wave and infrared multispectral sensors in satellites and smart “fire-and-forget” weapons. At Honeywell, he designed passive millimeter-wave midcourse missile guidance systems and millimeter-wave sensors to trigger land mines. In addition to the course text, Dr. Klein has authored Millimeter-Wave and Infrared Multisensor

Design and Signal Processing (Artech House, 1997), Sensor Technologies and Data Requirements for ITS (Artech House, 2001), and the Traffic Detector Handbook for the Federal Highway Administration (2006).

COURSE PRICE INCLUDES the text *Sensor and Data Fusion: A Tool for Information Assessment and Decision Making* (SPIE Press, 2004) by Lawrence A. Klein.

Analog-to-Digital Converters for Digital ROICs

SC1076

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course surveys structure and operation of analog-to-digital converters (ADCs) implemented on digital readout integrated circuits (ROICs) and digital image sensors. Attendees will learn how to evaluate ADC architectures using basic figures of merit for use in different sensor formats. We will cover a wide range of cutting edge architectures and see published examples without delving into transistor level theory. We will survey both academia and industrial ADC architectures. From this survey attendees will discover the industrial design evolution convergence down to a few workhorse architectures and what lessons it imparts to the image sensor community. If you are interested in the digital ROIC revolution or if you ever interface with designers or evaluate digital ROIC proposals, then you will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify analog-to-digital architectures used for creating digital ROICs and image sensors
- calculate ADC architecture figures of merit important to image sensors
- evaluate ADC architecture compatibility with image sensor format and requirements
- infer the direction in which state-of-the-art digital image sensors are headed
- name the top ADC architectures used by commercial industry and explain how this knowledge benefits the image sensor industry
- stimulate your own creativity and help you develop new ideas and applications for digital ROICs and digital image sensors

INTENDED AUDIENCE

This course is intended for engineers and physicists with a background in basic electrical theory (electrical stimuli, resistors, capacitors and block diagramming) who wish to learn about analog-to-digital converter architectures and how they are applied to digital ROICs and digital image sensors. An undergraduate degree in science or engineering is assumed, and basic knowledge of electrical engineering will be particularly helpful.

INSTRUCTOR

Kenton Veeder is a ROIC design engineer, systems engineer, and part time detector physicist. He has been in the defense and commercial image sensor field for over 12 years and is the president of Senseeker Engineering Inc. in Santa Barbara, California. He has nine patents and several publications, one of which earned the MSS Detectors best paper award in 2006. While working for Raytheon he was awarded recognition as Raytheon's 'Father of the Digital Focal Plane Array' and he and his team were given the company wide 'Excellence In Technology' award. Kenton earned his M.S. in electrical engineering from the Analog-and-Mixed Signal Center at Texas A&M University. Kenton is a member of SPIE and IEEE.

GPU for Defense Applications

SC1069

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course teaches the basics of utilizing modern programmable graphics processing units (GPUs) for military applications. The modern GPU is a fully programmable parallel programming environment that performs computations an order of magnitude faster than the modern CPU. In this course, we will learn broadly about the architecture of the GPU, the appropriate situations where speedups may be obtained and gain an understanding of the tools and languages that are available for development. Programming is not a part of the curriculum.

We will also discuss the available GPU platforms, with an emphasis on rugged, deployable, and low-power offerings. Lastly, the bulk of the course will center on applications and case studies, with emphasis on applications we have produced, including: real-time image processing for the reduction of atmospheric turbulence, applied accelerated linear algebra, image enhancement via super resolution, computational fluid dynamics, and computational electromagnetics.

LEARNING OUTCOMES

This course will enable you to:

- summarize how a graphics processing unit functions
- describe the architecture of a modern compute-capable GPU
- describe which types of applications can be improved by the GPU, and to what degree
- determine the suitability of your algorithm for the GPU
- purchase a system well suited to your application
- assess the tools and languages available to the GPU programmer
- appreciate the applicability of the GPU to many defense industry applications via case studies

INTENDED AUDIENCE

Scientists, engineers, mathematicians, and management who are evaluating the graphics processing unit as a candidate to reduce computational time or costs. We will cover both large scale (e.g. clusters) and small-scale (e.g. low-power, deployable) applications.

INSTRUCTOR

John Humphrey is a member of the Accelerated Computing Solutions group at EM Photonics. He earned his MSEE degree from the University of Delaware studying the acceleration of electromagnetics algorithms using custom hardware platforms. At EM Photonics, he launched a GPU research effort in 2005 with a GPU-based FDTD solver based on OpenGL methods and then later explored working in CUDA. Since then, he has worked on accelerated algorithms in a variety of fields, including linear algebra solvers and computational fluid dynamics engines.

Laser Lab Design - Laser Safety and Practicality

SC1106

New

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Monday 1:30 pm to 5:30 pm

This course presents and reviews lessons learned on how to layout and set up a Research & Development laser laboratory in a university or technology research facility. There will be an initial review of laser safety concepts, and lab design requirements. The rest of the class time will be spent on items to be aware of in setting up a laser lab and solutions to problems. A number of good and bad scenarios will be covered.

LEARNING OUTCOMES

This course will enable you to:

- describe and understand the fundamentals of Laser Safety
- comprehend laser hazard classification and its relationship to laser safety

- use real world considerations in putting together an R&D laser lab
- develop proper signage, access control measures and visual barriers for your lab
- avoid common laser lab set up problems
- effectively communicate your laser safety needs to a facility or construction project manager overseeing your space

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn about laser safety and how to avoid problems when setting up a laser lab.

INSTRUCTOR

Ken Barat has been involved in laser safety for over 30 years, including serving until 2013 as the Laser Safety Officer at Lawrence Berkeley National Laboratory, the LSO for the National Ignition Facility and laser safety advisor for LIGO. He is Chair of ANSI Z136.8 Standard, Safe Use of Lasers in the Research, Development or Testing, Chair and originator of the LSO Workshop Series, and first chair of DOE Laser Safety Officers Working Group. He has authored three texts on laser safety, numerous articles, speaker at national and international conferences and Universities. Recognition for his work in this field includes Laser Institute of America Fellow, Rockwell Award for both Education and Laser Safety Contributions, IEEE Senior member and a CLSO.

Basic Laser Technology

SC972

New

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Friday 8:30 am to 12:30 pm

If you are uncomfortable working with lasers as “black boxes” and would like to have a basic understanding of their inner workings, this introductory course will be of benefit to you. The workshop will cover the basic principles common to the operation of any laser/laser system. Next, we will discuss laser components and their functionality. Components covered will include laser pumps/energy sources, mirrors, active media, nonlinear crystals, and Q-switches. The properties of laser beams will be described in terms of some of their common performance specifications such as longitudinal modes and monochromaticity, transverse electromagnetic (TEM) modes and focusability, continuous wave (CW) power, peak power and power stability. Laser slope and wall-plug efficiencies will also be discussed.

LEARNING OUTCOMES

This course will enable you to:
- describe the overall inner workings of any laser
- describe the functionality of the key laser components
- know the difference between how acousto- and electro-optic Q-switches work
- explain how each key component in a laser may contribute to laser performance
- intelligently engage your clients or customers using proper laser terminology
- build stronger relationships with clients and customers by demonstrating product knowledge
- obtain the technical knowledge and confidence to enhance your job performance and rise above the competition, inside and outside your company

INTENDED AUDIENCE

Managers, engineers, technicians, assemblers, sales/marketing, customer service, and other support staff. This workshop will help cultivate a common/standardized understanding of lasers across the company.

INSTRUCTOR

Sydney Sukuta is currently a Laser Technology professor at San Jose City College. He also has industry experience working for the some the world’s leading laser manufacturers in Silicon Valley where he saw first-hand the issues they encounter on a daily basis. In response, Dr. Sukuta developed prescriptive short courses to help absolve most of these issues.

Signal, Image, and Neural Net Processing

Fundamentals of Electronic Image Processing

SC066

Course Level: Introductory
CEU: 0.65 $585 Members | $680 Non-Members USD
Monday 8:30 am to 5:30 pm

Many disciplines of science and manufacturing acquire and evaluate images on a routine basis. Typically these images must be processed so that important features can be measured or identified This short course introduces the fundamentals of electronic image processing to scientists and engineers who need to know how to manipulate images that have been acquired and stored within a digital computer.

LEARNING OUTCOMES

This course will enable you to:
- describe image storage, acquisition, and digitization
- become familiar with image transforms such as Fourier, Hough, Walsh, Hadamar, Discrete Cosine, and Hotelling
- explain the difference between the types of linear and non-linear filters and when to use each
- learn the difference between types of noise in the degradation of an image
- apply color image processing techniques to enhance key features in color and gray scale images
- recognize image segmentation techniques and how they are used to extract objects from an image
- explain software approaches to image processing
- demonstrate how to use the UCFImage image processing software program included with the course.

INTENDED AUDIENCE

This course will be useful to engineers and scientists who have a need to understand and use image processing techniques, but have no formal training in image processing. It will give the individual insight into a number of complex algorithms as it applies to several different applications of this very interesting and important field.

INSTRUCTOR

Arthur Weeks holds an associate professor position with the Dept. of Electrical and Computer Engineering at the Univ. of Central Florida. He recently left his position as a vice president of corporate technology to continue his research in image processing and bio-medical signal processing. He has published over 30 articles and three books in image processing.

COURSE PRICE INCLUDES the text *Fundamentals of Electronic Image Processing* (SPIE Press, 1996) by Arthur Weeks.

Analog-to-Digital Converters for Digital ROICs

SC1076

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course surveys structure and operation of analog-to-digital converters (ADCs) implemented on digital readout integrated circuits (ROICs) and digital image sensors. Attendees will learn how to evaluate ADC architectures using basic figures of merit for use in different sensor formats. We will cover a wide range of cutting edge architectures and see published examples without delving into transistor level theory. We will survey both academia and industrial ADC architectures. From this survey attendees will discover the industrial design evolution convergence down to a few workhorse architectures and what lessons it imparts to the image sensor community. If you are interested in the digital ROIC revolution or if you ever interface with designers or evaluate digital ROIC proposals, then you will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify analog-to-digital architectures used for creating digital ROICs and image sensors
- calculate ADC architecture figures of merit important to image sensors
- evaluate ADC architecture compatibility with image sensor format and requirements
- infer the direction in which state-of-the-art digital image sensors are headed
- name the top ADC architectures used by commercial industry and explain how this knowledge benefits the image sensor industry
- stimulate your own creativity and help you develop new ideas and applications for digital ROICs and digital image sensors

INTENDED AUDIENCE

This course is intended for engineers and physicists with a background in basic electrical theory (electrical stimuli, resistors, capacitors and block diagramming) who wish to learn about analog-to-digital converter architectures and how they are applied to digital ROICs and digital image sensors. An undergraduate degree in science or engineering is assumed, and basic knowledge of electrical engineering will be particularly helpful.

INSTRUCTOR

Kenton Veeder is a ROIC design engineer, systems engineer, and part time detector physicist. He has been in the defense and commercial image sensor field for over 12 years and is the president of Senseeker Engineering Inc. in Santa Barbara, California. He has nine patents and several publications, one of which earned the MSS Detectors best paper award in 2006. While working for Raytheon he was awarded recognition as Raytheon's 'Father of the Digital Focal Plane Array' and he and his team were given the company wide 'Excellence In Technology' award. Kenton earned his M.S. in electrical engineering from the Analog-and-Mixed Signal Center at Texas A&M University. Kenton is a member of SPIE and IEEE.

Applications of Detection Theory

SC952

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a "target." In this case the term "target" may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the "Receiver Operating Characteristic" (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind "Decision Tree Analysis" culminating with an in class exercise. Decision tree analysis allows one to "fuse together" multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:

- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a "Spider Chart" from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years' service; his decorations include the "Defense Superior Service Medal" from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

Multisensor Data Fusion for Object Detection, Classification and Identification

SC994

Course Level: Introductory
CEU: 0.65 $585 Members | $680 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course describes sensor and data fusion methods that improve the probability of correct target detection, classification, and identification. The methods allow the combining of information from collocated or dispersed sensors that utilize similar or different signature-generation phenomenologies. Examples provide insight as to how different phenomenology-based sensors enhance a data fusion system.

After introducing the JDL data fusion and resource management model, sensor and data fusion architectures are described in terms of sensor-level, central-level, and hybrid fusion, and pixel-, feature-, and decision-level fusion. The data fusion algorithm taxonomies that follow provide an introduction to the descriptions of the algorithms and methods utilized for detection, classification, identification, and state estimation and tracking - the Level 1 fusion processes. These algorithms support the higher-level data fusion processes of situation and threat assessment.

Subsequent sections of the course more fully develop the Bayesian, Dempster-Shafer, and voting logic data fusion algorithms. Examples abound throughout the material to illustrate the major techniques being presented. The illustrative problems demonstrate that many of the data fusion methods can be applied to combine information from almost any grouping of sensors as long as they can supply the input data required by the fusion algorithm. Practitioners who want to identify the input quantities or parameters needed to implement data fusion will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify multisensor data fusion principles, algorithms, and architectures for new and existing systems
- describe the advantages of multisensor data fusion for object discrimination and state estimation
- select appropriate sensors for specific sensor and data fusion applications
- identify potential algorithms for target detection, classification, identification, and tracking
- formulate sensor and data fusion approaches for many practical applications
- compare the detection and classification ability of many data fusion algorithms to those available without data fusion
- acquire the skills needed to develop and apply data fusion algorithms to more complex situations

INTENDED AUDIENCE

Engineers, scientists, managers, systems designers, military operations personnel, and other users of multisensor data fusion for target detection, classification, identification, and tracking of airborne, ground-based, and underwater targets will benefit from this course. Undergraduate training in engineering, science, or mathematics is assumed.

INSTRUCTOR

Lawrence Klein specializes in developing multiple sensor systems for tactical and reconnaissance military applications and homeland defense. His interests also include application of sensor and data fusion concepts to intelligent transportation systems. While at Hughes Aircraft Company, Dr. Klein developed missile deployment strategies and sensors for missile guidance. As Chief Scientist at Aerojet ElectroSystems TAMS Division, he was responsible for programs that integrated active and passive millimeter-wave and infrared multispectral sensors in satellites and smart “fire-and-forget” weapons. At Honeywell, he designed passive millimeter-wave midcourse missile guidance systems and millimeter-wave sensors to trigger land mines. In addition to the course text, Dr. Klein has authored Millimeter-Wave and Infrared Multisensor Design and Signal Processing (Artech House, 1997), Sensor Technologies and Data Requirements for ITS (Artech House, 2001), and the Traffic Detector Handbook for the Federal Highway Administration (2006).

COURSE PRICE INCLUDES the text *Sensor and Data Fusion: A Tool for Information Assessment and Decision Making* (SPIE Press, 2004) by Lawrence A. Klein.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course Level: Introductory
CEU: 0.65 $515 Members | $610 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of automatic target and object detection and its applications in Hyperspectral Imagery (HSI). The primary goal of this course is to introduce the well known target detection algorithms in hyperspectral imagery. Examples of the classical target detection techniques such as spectral matched filter, subspace matched filter, adaptive matched filter, orthogonal subspace, support vector machine (SVM) and machine learning are reviewed. Construction of invariance subspaces for target and background as well as the use of regularization techniques are presented. Standard atmospheric correction and compensation techniques are reviewed. Anomaly detection techniques for HSI and dual band FLIR imagery are also discussed. Applications of HSI for detection of mines, targets, humans, chemical plumes and anomalies are reviewed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental concepts of target detection algorithms as applied to HSI
- learn the procedure to use the generalized maximum likelihood ratio test to design spectral detectors
- describe the fundamental differences between different detection algorithms based on their model representations
- develop statistical models as well as subspace models for HSI data
- explain the difference between anomaly detection and classification
- distinguish between linear and nonlinear approaches (SVM and Kernel learning techniques)
- develop anomaly detection techniques for different environmental scenarios
- describe linear models and unmixing techniques for abundance measures
- plot ROC curves to evaluate the performance of the algorithms

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about target detection in hyperspectral, multispectral or dual-band FLIR imagery. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a senior research scientist (ST) at US Army Research Laboratory (ARL). He is also an adjunct professor in the Electrical and Computer Engineering Department at the Johns Hopkins University. He is actively engaged in research in image processing, neural networks, automatic target recognition, and video compression and its transmission over high speed networks. He has published over 200 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing,IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

GPU for Defense Applications

SC1069

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course teaches the basics of utilizing modern programmable graphics processing units (GPUs) for military applications. The modern GPU is a fully programmable parallel programming environment that performs computations an order of magnitude faster than the modern CPU. In this course, we will learn broadly about the architecture of the GPU, the appropriate situations where speedups may be obtained and gain an understanding of the tools and languages that are available for development. Programming is not a part of the curriculum.

We will also discuss the available GPU platforms, with an emphasis on rugged, deployable, and low-power offerings. Lastly, the bulk of the course will center on applications and case studies, with emphasis on applications we have produced, including: real-time image processing for the reduction of atmospheric turbulence, applied accelerated linear algebra, image enhancement via super resolution, computational fluid dynamics, and computational electromagnetics.

LEARNING OUTCOMES

This course will enable you to:

- summarize how a graphics processing unit functions
- describe the architecture of a modern compute-capable GPU
- describe which types of applications can be improved by the GPU, and to what degree
- determine the suitability of your algorithm for the GPU
- purchase a system well suited to your application
- assess the tools and languages available to the GPU programmer
- appreciate the applicability of the GPU to many defense industry applications via case studies

INTENDED AUDIENCE

Scientists, engineers, mathematicians, and management who are evaluating the graphics processing unit as a candidate to reduce computational time or costs. We will cover both large scale (e.g. clusters) and small-scale (e.g. low-power, deployable) applications.

INSTRUCTOR

John Humphrey is a member of the Accelerated Computing Solutions group at EM Photonics. He earned his MSEE degree from the University of Delaware studying the acceleration of electromagnetics algorithms using custom hardware platforms. At EM Photonics, he launched a GPU research effort in 2005 with a GPU-based FDTD solver based on OpenGL methods and then later explored working in CUDA. Since then, he has worked on accelerated algorithms in a variety of fields, including linear algebra solvers and computational fluid dynamics engines.

Information Systems and Networks: Processing, Fusion, and Knowledge Generation

Multisensor Data Fusion for Object Detection, Classification and Identification

SC994

Course Level: Introductory
CEU: 0.65 $585 Members | $680 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course describes sensor and data fusion methods that improve the probability of correct target detection, classification, and identification. The methods allow the combining of information from collocated or dispersed sensors that utilize similar or different signature-generation phenomenologies. Examples provide insight as to how different phenomenology-based sensors enhance a data fusion system.

After introducing the JDL data fusion and resource management model, sensor and data fusion architectures are described in terms of sensor-level, central-level, and hybrid fusion, and pixel-, feature-, and decision-level fusion. The data fusion algorithm taxonomies that follow provide an introduction to the descriptions of the algorithms and methods utilized for detection, classification, identification, and state estimation and tracking - the Level 1 fusion processes. These algorithms support the higher-level data fusion processes of situation and threat assessment.

Subsequent sections of the course more fully develop the Bayesian, Dempster-Shafer, and voting logic data fusion algorithms. Examples abound throughout the material to illustrate the major techniques being presented. The illustrative problems demonstrate that many of the data fusion methods can be applied to combine information from almost any grouping of sensors as long as they can supply the input data required by the fusion algorithm. Practitioners who want to identify the input quantities or parameters needed to implement data fusion will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify multisensor data fusion principles, algorithms, and architectures for new and existing systems
- describe the advantages of multisensor data fusion for object discrimination and state estimation
- select appropriate sensors for specific sensor and data fusion applications
- identify potential algorithms for target detection, classification, identification, and tracking
- formulate sensor and data fusion approaches for many practical applications
- compare the detection and classification ability of many data fusion algorithms to those available without data fusion
- acquire the skills needed to develop and apply data fusion algorithms to more complex situations

INTENDED AUDIENCE

Engineers, scientists, managers, systems designers, military operations personnel, and other users of multisensor data fusion for target detection, classification, identification, and tracking of airborne, ground-based, and underwater targets will benefit from this course. Undergraduate training in engineering, science, or mathematics is assumed.

INSTRUCTOR

Lawrence Klein specializes in developing multiple sensor systems for tactical and reconnaissance military applications and homeland defense. His interests also include application of sensor and data fusion concepts to intelligent transportation systems. While at Hughes Aircraft Company, Dr. Klein developed missile deployment strategies and sensors for missile guidance. As Chief Scientist at Aerojet ElectroSystems TAMS Division, he was responsible for programs that integrated active and passive millimeter-wave and infrared multispectral sensors in satellites and smart "fire-and-forget" weapons. At Honeywell, he designed passive millimeter-wave midcourse missile guidance systems and millimeter-wave sensors to trigger land mines. In addition to the course text, Dr. Klein has authored Millimeter-Wave and Infrared Multisensor Design and Signal Processing (Artech House, 1997), Sensor Technologies and Data Requirements for ITS (Artech House, 2001), and the Traffic Detector Handbook for the Federal Highway Administration (2006).

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Applications of Detection Theory

SC952

Course Level: Intermediate
CEU: 0.65 $515 Members | $610 Non-Members USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a "target." In this case the term "target" may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the "Receiver Operating Characteristic" (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind "Decision Tree Analysis" culminating with an in class exercise. Decision tree analysis allows one to "fuse together" multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:

- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a "Spider Chart" from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years' service; his decorations include the "Defense Superior Service Medal" from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

GPU for Defense Applications

SC1069

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course teaches the basics of utilizing modern programmable graphics processing units (GPUs) for military applications. The modern GPU is a fully programmable parallel programming environment that performs computations an order of magnitude faster than the modern CPU. In this course, we will learn broadly about the architecture of the GPU, the appropriate situations where speedups may be obtained and gain an understanding of the tools and languages that are available for development. Programming is not a part of the curriculum.

We will also discuss the available GPU platforms, with an emphasis on rugged, deployable, and low-power offerings. Lastly, the bulk of the course will center on applications and case studies, with emphasis on applications we have produced, including: real-time image processing for the reduction of atmospheric turbulence, applied accelerated linear algebra, image enhancement via super resolution, computational fluid dynamics, and computational electromagnetics.

LEARNING OUTCOMES

This course will enable you to:

- summarize how a graphics processing unit functions
- describe the architecture of a modern compute-capable GPU
- describe which types of applications can be improved by the GPU, and to what degree
- determine the suitability of your algorithm for the GPU
- purchase a system well suited to your application
- assess the tools and languages available to the GPU programmer
- appreciate the applicability of the GPU to many defense industry applications via case studies

INTENDED AUDIENCE

Scientists, engineers, mathematicians, and management who are evaluating the graphics processing unit as a candidate to reduce computational time or costs. We will cover both large scale (e.g. clusters) and small-scale (e.g. low-power, deployable) applications.

INSTRUCTOR

John Humphrey is a member of the Accelerated Computing Solutions group at EM Photonics. He earned his MSEE degree from the University of Delaware studying the acceleration of electromagnetics algorithms using custom hardware platforms. At EM Photonics, he launched a GPU research effort in 2005 with a GPU-based FDTD solver based on OpenGL methods and then later explored working in CUDA. Since then, he has worked on accelerated algorithms in a variety of fields, including linear algebra solvers and computational fluid dynamics engines.

Business + Professional Development

Complying with the ITAR: A Case Study

WS933

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 1:30 pm to 5:30 pm

In the world of international trade, it's what you don't know that can hurt you. With the U.S. government's focus on homeland security and its increasing reliance on photonics for the development and production of defense-related products and services, your activities may well be subject to the ITAR.

This workshop will begin with a brief contextual overview of U.S. export controls, including the Export Administration Regulations, the ITAR, and special sanction programs administered by the Treasury Department's Office of Foreign Assets Control. We will then transition into a case study focused on the ITAR. Real world situations and lessons learned will be shared. Various aspects of the case study will likely be familiar to you in the context of your own experiences, allowing you to learn effectively how to spot ITAR issues before they negatively impact your business. You will also learn about current enforcement trends and best practices for avoiding violations.

LEARNING OUTCOMES

- determine at least on a preliminary basis whether your products, services and/or technical data are subject to the ITAR
- know when a deemed export might arise and what to do about it
- communicate effectively with government and private contracting entities, including prime and subprime contractors, in order to know when the ITAR may apply
- determine what type of government license or approval must be obtained in particular circumstances
- implement best practices to handle ITAR-controlled products, services or technical data and avoid negative enforcement outcomes

INTENDED AUDIENCE

Owners, executives, managers and engineers engaged in photonics research, development or manufacturing activities.

INSTRUCTOR

Kerry Scarlott Kerry Scarlott is a Director at the law firm of Goulston & Storrs. With an office in Boston, MA and Washington, D.C., Kerry focuses his practice on business law and international trade law, with particular expertise in assisting technology-based companies. He serves as general outside counsel to companies and entrepreneurs, providing guidance in connection with entity formation, debt and equity financings and private offerings, mergers and acquisitions, day-to-day commercial contract matters, strategic alliances, private label manufacturing, and intellectual property protection and utilization. Kerry has particular expertise in counseling technology-based clients in navigating the Export Administration Regulations (EAR) and the International Traffic in Arms Regulations (ITAR). He lectures and writes regularly on international trade matters, including export compliance, foreign distribution and sale of products, and related topics.

Essential Skills for Engineering Project Leaders

WS846

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Thursday 1:30 pm to 5:30 pm

This workshop teaches skills needed to lead technical projects, drive innovation, and influence others. Attendees learn the difference between leadership and management, and how to develop specific leadership skills that are important to technical professionals who lead projects or need assistance from others to get things done. Participants engage in exercises that assess their individual leadership abilities and provide guidance for further skill development.

LEARNING OUTCOMES

This course will enable you to:
- become more influential
- improve your ability to effectively lead projects and teams
- identify leadership development goals specific to your individual needs
- get more support for ideas that will benefit your company
- build rapport with your boss and your peers

INTENDED AUDIENCE

This material is intended for early-career technical professionals who can benefit from improving leadership skills. The course is tailored for engineers and other technical professionals through the use of real-world case studies, exercises and examples pertaining to the experiences of individuals and teams involved in technology projects.

INSTRUCTOR

Gary Hinkle is President and founder of Auxilium, Inc. His experience includes a broad variety of management and staff assignments with small, medium, and large companies involved in the development and manufacturing of high-tech products. Gary led several high-profile projects including the development of a U.S. Army vehicle maintenance system, and he directed the development of 9-1-1 systems used in the majority of Public Safety Answering Points in the U.S. He also served as engineering manager for the world's best selling oscilloscope product line at Tektronix. His design and management experience spans the electronics, mechanical and software engineering disciplines.

Leading Successful Product Innovation

WS951

Course Level: Intermediate
CEU: 0.35 $295 Members | $345 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The fundamental goal of this course is to answer the question: "How do I take an idea off the white-board and turn it into a windfall product?" We will explore and apply the principles of good leadership to create a culture of excellence within your organization-the most basic ingredient for success. A special emphasis will be placed on learning how to develop and construct an effective new project pitch using the instructor's "Disciplined Creativity" concept and framework. We will then describe the "Spiral Development Process" for rapid, effective, and successful prototype development, followed by an in-depth examination of the life-cycle approach to product development. This course will also enable you to conduct a "red teaming" exercise to identify competitive threats, identify weaknesses in your company, and most importantly, develop solution strategies. We will also place an emphasis on how to properly vet an idea and how to ask tough-minded questions designed to ferret out shortcomings.

LEARNING OUTCOMES

This course will enable you to:
- apply the key principles of leadership to create a culture of excellence for your organization
- develop a project "pitch" to champion your idea with venture capitalists, and funding agencies
- construct a "spiral development" process that is executable, manageable, and successful
- identify best practices for the life-cycle approach to product management
- conduct a "red teaming" exercise
- apply the principles of strategic planning to develop a successful technology roadmap
- conduct an "After Action Review" and distill out critical "lessons learned"
- demonstrate how to run an effective meeting
- formulate a "product requirements document"
- demonstrate effective project management skills
- define and list the key elements of "Design for Manufacturing"

INTENDED AUDIENCE

This course designed for R&D managers at all levels. It is also appropriate for other senior department managers with responsibility for aspects of product development (e.g. marketing, manufacturing, business development). Start-up companies, or anyone contemplating starting their own venture will find the material relevant and useful. Scientists and engineers aspiring to management track positions will also benefit from this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years' service; his decorations include the "Defense Superior Service Medal" from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007) and is an SPIE Fellow..

Basic Optics for Non-Optics Personnel

WS609

Course Level: Introductory
CEU: 0.2 $100 Members | $150 Non-Members USD
Tuesday 1:30 pm to 4:00 pm

This course will provide the technical manager, sales engineering, marketing staff, or other non-optics personnel with a basic, non-mathematical introduction to the terms, specifications, and concepts used in optical technology to facilitate effective communication with optics professionals on a functional level. Topics to be covered include basic concepts such as imaging, interference, diffraction, polarization and aberrations, definitions relating to color and optical quality, and an overview of the basic measures of optical performance such as MTF and wavefront error. The material will be presented with a minimal amount of math, rather emphasizing working concepts, definitions, rules of thumb, and visual interpretation of specifications. Specific applications will include defining basic imaging needs such as magnification, depth-of-field, and MTF as well as the definitions of radiometric terms.

LEARNING OUTCOMES

This course will enable you to:
- read optical system descriptions and papers
- ask the right questions about optical component performance
- describe basic optical specifications for lenses, filters, and other components
- assess differences in types of filters, mirrors and beam directing optics
- know how optics is used in our everyday lives

INTENDED AUDIENCE

This course is intended for the non-optical professional who needs to understand basic optics and interface with optics professionals.

INSTRUCTOR

Kevin Harding has been active in the optics industry for over 30 years, and has taught machine vision and optical methods for over 25 years in over 70 workshops and tutorials, including engineering workshops on machine vision, metrology, NDT, and interferometry used by vendors and system houses to train their own engineers. He has been recognized for his leadership in optics and machine vision by the Society of Manufacturing Engineers, Automated Imaging Association, and Engineering Society of Detroit. Kevin is a Fellow of SPIE and was the 2008 President of the Society.

Basic Laser Technology

SC972

New

Course Level: Introductory
CEU: 0.35 $295 Members | $345 Non-Members USD
Friday 8:30 am to 12:30 pm

If you are uncomfortable working with lasers as "black boxes" and would like to have a basic understanding of their inner workings, this introductory course will be of benefit to you. The workshop will cover the basic principles common to the operation of any laser/laser system. Next, we will discuss laser components and their functionality. Components covered will include laser pumps/energy sources, mirrors, active media, nonlinear crystals, and Q-switches. The properties of laser beams will be described in terms of some of their common performance specifications such as longitudinal modes and monochromaticity, transverse electromagnetic (TEM) modes and focusability, continuous wave (CW) power, peak power and power stability. Laser slope and wall-plug efficiencies will also be discussed.

LEARNING OUTCOMES

This course will enable you to:

- describe the overall inner workings of any laser
- describe the functionality of the key laser components
- know the difference between how acousto- and electro-optic Q-switches work
- explain how each key component in a laser may contribute to laser performance
- intelligently engage your clients or customers using proper laser terminology
- build stronger relationships with clients and customers by demonstrating product knowledge
- obtain the technical knowledge and confidence to enhance your job performance and rise above the competition, inside and outside your company

INTENDED AUDIENCE

Managers, engineers, technicians, assemblers, sales/marketing, customer service, and other support staff. This workshop will help cultivate a common/standardized understanding of lasers across the company.

INSTRUCTOR

Sydney Sukuta is currently a Laser Technology professor at San Jose City College. He also has industry experience working for the some the world's leading laser manufacturers in Silicon Valley where he saw first-hand the issues they encounter on a daily basis. In response, Dr. Sukuta developed prescriptive short courses to help absolve most of these issues.

Just Outgoing Enough: Public Speaking, Networking, and Getting What You Want for Scientists and Engineers

WS1108

New

Course Level: Introductory
CEU: 0.3 $50 Members | $100 Non-Members USD
Wednesday 1:30 pm to 5:00 pm

A scientist or engineer needs to be able to make individual connections with other people to communicate ideas, get access to resources, and gain opportunities for advancement. Yet many of us who go into science would never be called "a people person", and a good proportion of us are not particularly interested in becoming one.

This workshop will focus on how to acquire the skills necessary for public speaking, networking, and presenting yourself to others. You don't have to become the life of the party to be successful in science. The trick is to learn to be just outgoing enough to make connections—whether with individuals or with an audience— and keep them open enough to achieve what you want to get done. This lively and interactive session will help attendees develop strategies for finding their own comfort zones.

LEARNING OUTCOMES

This course will enable you to:

- launch a conversation with someone who doesn't know you, is senior to you, and has something you need
- learn to be comfortable when making contact with other people
- sketch out a description of your work/research quickly for discussion with technical and non-technical people
- communicate with a room full of people when you are the center of attention
- use talks, from the sixty second introduction, to the dissertation and the job talk, to spread your ideas and advance toward your goals
- overcome networking anxiety and how to make it a more natural behavior
- figure out what you want out of your work and life, and how to communicate your goals to your supervisor, manager, informal and formal mentors, and others who can help you get to where you want to go

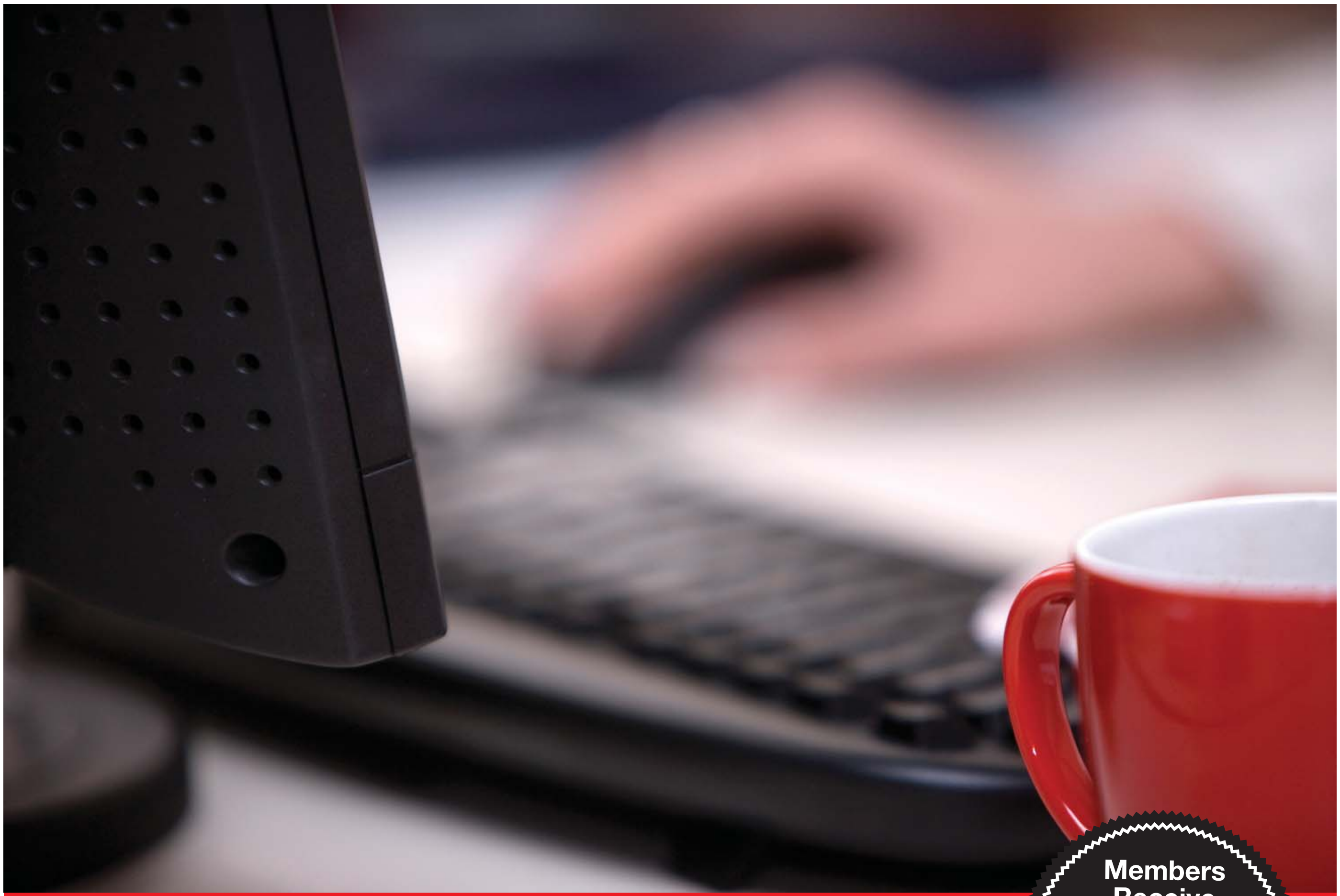
INTENDED AUDIENCE

Students, early career professionals, and anyone who wishes to develop their networking and communication skills.

INSTRUCTOR

Victoria McGovern Ph.D. is a biochemist interested in how organisms bring in information from the environment and use nucleic acid shape to act on that information, is a Senior Program Officer at the Burroughs Wellcome Fund, a foundation that supports basic research in the health sciences in the United States and Canada. She runs the Fund's infectious disease program area and population science program area. She is an established science writer, a frequent speaker on communications and scientific career development, and a lifetime member of TechShop, America's first nationwide open access public workshop.

This course is free to SPIE Student Members, but **you must register to attend.**



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