Electronic paper provides a solution for distributed signage

Robert Sprague

Bistable displays combined with a wireless communication system enable low-power battery-operated signs to be updated automatically.

Signs provide several functions in public buildings, campuses, offices, and stores: they help people find their way, show the schedules of classrooms or conference rooms, and indicate the price of merchandise. With the proliferation of digital information, there are many potential benefits to making signs that can be tied to a database and electronically changed. Difficulties in achieving such displays include the cost of the signs, the cost of installation, the need to supply a source of power to each sign, and the need for software and systems to control the information sent to each sign. Part of the problem can be solved using electronic-paper displays that are inexpensive, easy to read, and lightweight. These signs can run on batteries for months or years because they don’t consume power to maintain an image, and they are easy to install because they use reflected light for illumination. Here I describe one electronic-paper system that uses the Gyricon rotating-ball display technology implemented into a commercial distributed signage system. A single computer and software system controls all the signs via a wireless connection, and all the signs run on batteries.

The basic Gyricon\1,2 display technology consists of a sheet of silicone elastomer in which many round spheres are embedded. The spheres are smaller than the eye can see and are made so that one hemisphere is one color and the other is a contrasting color. In addition to a different color, each hemisphere also has a different electronic charge. Every ball floats in its own small cavity, which is filled with silicone fluid. An electric field across the sheet can cause the ball to rotate. When the field is turned off, the ball settles against the cavity wall. Electrostatic forces maintain that state of rotation until an opposite electric field is applied, thus achieving bistable operation. Patterned electrodes allow us to rotate balls in selected areas, thus creating an image on the display. This is achieved by laminating the sheet between an electronic backplane and a transparent top electrode.

The performance of this display depends upon how closely the beads are packed, how well they rotate within their individual cavities, and how well the bichromality can be produced. At my previous company, Gyricon, we manufactured these displays via a spinning-disk technology that uses surface tension to generate bichromal droplets of molten polyethylene. After the balls solidify, they are coated in a silicone elastomer sheet, and then swelled with silicone oil to free up a cavity around each ball, which allows it to rotate. We used an average bead size of about 90\(\mu\)m in diameter, although we also made electronic paper sheets with beads as small as 30\(\mu\)m. Our devices achieved reflectivity as high as 27%, a contrast ratio as high as 12:1, a rotation speed of about 200ms, and an indefinite image-storage lifetime. Although it was designed for indoor use, there has been promising work to show that this technology can be extended to outdoor use in full sunlight.

In order to apply an image to the Gyricon display, we used two types of electronic backplanes, depending on the size of the display (see Figure 1). For larger signs, we employed a circuit board with the top metallization layer patterned into segments, each with its own driver, as shown in Figure 1(a). The segments are shaped so that within a given rectangular region on the sign, any alphanumeric character can be generated. To make good-looking characters, we use a 64-segment font of our own design, rather than the simpler 7-segment font typically used, for example, on digital watches. For smaller signs that need greater flexibility in font and image, we use a 100-dot-per-inch pixilated active-matrix backplane of amorphous-silicon transistors, much like the backplanes that drive conventional laptop displays, but operating at 50V. Although battery life depends on how often the display is updated each day, we normally expect batteries to last six months.

For situations in which the user needs central control of signs spread around a building or campus, these displays can be updated via a wireless router as shown in Figure 2.\3 One piece of software can control hundreds or thousands of signs if the designer assigns each sign its own network address and stores

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Figure 1. (a) Large 15×17in. bistable Gyricon signs on the left use segmented printed circuit board backplanes. (b) The smaller 5.5×7in. bistable Gyricon signs on the right use active-matrix backplanes instead.

Figure 2. A single computer equipped with scheduling software can communicate via a wireless router with battery-operated signs showing retail prices, wayfinding directions, and scheduling or other business messages.
each sign’s layout in the software scheduler. This program looks like commonly available scheduling software: any message can be scheduled for any time slot. Once programmed into the scheduler, the appropriate message appears on the sign at the appropriate time, whether it is a one-time message or a recurring message programmed far in advance. Wireless control of these signs is achieved using the 802.11b wireless communication standard, the same ‘Wi-Fi’ system already in use in many locations.

For applications in which the sign content is linked to other databases—such as in retail pricing—the software enables links from each sign to the appropriate set of data in the store’s software, so that the two are always consistent. Whenever the price is updated in the point-of-sale database for the store, the new price will be represented on the sign at its next update. Such systems have great potential value to retail stores because they save labor, enable both price integrity and timely pricing updates, and provide manageable levels of local or remote control.

In conclusion, we showed a practical implementation of the Gyricon electronic-paper display technology in a commercial network of centrally controlled battery-operated wirelessly connected distributed signs. Such systems enable simple message updating and eliminate labor costs associated with paper signs for the same applications.

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References