Printerface: Screen Printed Electroluminescent Touch Interface

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Abstract
Printerface proposes a visual design technique to create customized and interactive icons that may be applied to paper or textile substrates. The icons are screen printed electroluminescent (EL) and conductive inks. Research in the field of printed electronics traditionally uses either dot-matrix or multiple capacitive buttons for interaction. Current low-resolution interfaces limit customizability and user interaction. The *Printerface* demo suggest a new method which allows a designer visual freedom over low-resolution displays.

The graphical nature of the screen print process allows a series of communicative icons to follow a defined visual language. Special steps were taken during the design process to create icons that illuminate from a single layout of segments. A microcontroller illuminates specified segments of EL to display each icon of a music playback interface: play, pause, back, and skip (figure 1a). Each electrode of the display additionally acts as a capacitive sensor to interpret user interaction. The capabilities of this technology allow new notification and interactive possibilities for low-resolution, flexible interfaces.

Author Keywords
Dynamic icon; electroluminescent; pervasive interface; printed electronics; visual design.

Figure 2: Silkscreen used to create printed circuit. Yellow mesh with photo emulsion.

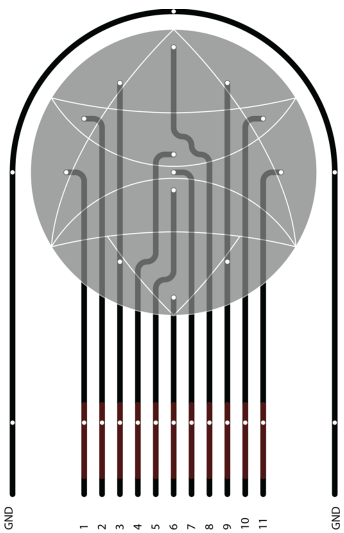

Figure 3: Electrode segments (gray), leads to electrodes (black), substrate VIA (white dots).

ACM Classification Keywords

H.5.2. User Interfaces

Introduction

Publications in recent years show the field of printed electronics is growing in parallel to the development of paper and textile-based user interfaces [4, 5]. Advances in materials science have allowed screen printing to be a scalable method of production for circuitry. The method allows for customized shapes of flexible light. Current screen printed EL interface research shows two main methods of output: EL dot matrix or individual EL capacitive buttons [8]. Dot matrix displays are able to show a user multiple different icons on a single grid, but it is difficult for a designer to customize the symbols [6]. The designer is limited to pixelated imagery (figure 1b). Individual capacitive buttons can be customized to display any shape and are touch interactive, but they do not support gestures.

This demo proposes a segment-based icon touch interface. A user may interact with the icons using touch and swipe gestures to control music playback. For this *Printerface*, music, each icon is constructed from illuminating segments of an unconventional grid. A screen printed rear electrode (figure 3) illuminates a particular area of a continuous layer of phosphor. Each electrode additionally acts a capacitive sensor [2].

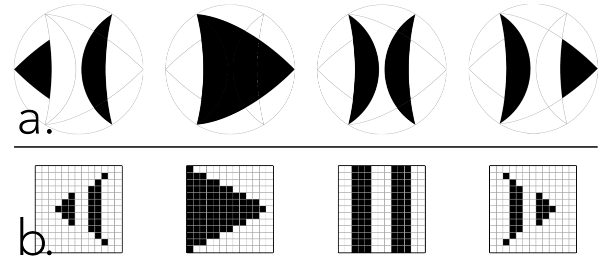

Figure 1: back, play, pause, skip icons; a. stylized segment-based icons (uses 11 leads); b. dot-matrix pixel-based icons (uses 26 leads).

Icon Design

The set of icons was designed based on three criteria. Each icon first follows two conventional heuristics of symbol design: the icons should share a visual language and follow grid guidelines [2]. The icons created for this EL interface share a third parameter; each icon must be a combination of illuminated discrete segments [10]. The shape of each segment (figure 2) is determined by the overlapping areas of the icon set.

An initial grid was created based on the shape of standard music control icons [11]. The design process was used to simultaneously alter the grid, segments, and icons, so the defined visual language was achieved. The set is designed to feel friendly, playful, and kinetic, by using curved lines of ellipses with either 1:1 or 1:2 proportions.

Interaction

This interface features two conventional interactions used for smartphones: taps and swipes. Tapping any individual segment plays or pauses the music (figure 1a). The print production method allows each segmented electrode to act as a capacitive touch sensor [8]. If the microcontroller recognizes segments 6-5-7-4-8 are touched in quick succession, the system will recognize the user swiped right, and skip to the next song. If segments 8-4-7-5-6 (figure 3) are touched in succession, a left swipe is recognized, and the previous song plays. The *Printerface* described here acts as a conceptual example of a dynamic ambient icon-based interface for paper or wearable substrates [3, 4, 7].

Printing

The silkscreened interface uses silver nanoparticle conductive ink on paper and cloth substrates to create a layer of electrodes in the shape of the segmented design. The phosphor, dielectric, transparent electrode (excluding silver particle bus bar), and acrylic insulation, are stacked, continuous layers of ink, printed as circles. The interface takes advantage of the screen print process to precisely illuminate sections of phosphor to create the icon designs. The screen mesh openings are 62 microns with a thread diameter of 48 microns. Silver ink leads were printed to connect each electrode to the power through a triac.

The microcontroller (logic) circuit illuminates segments of the print based on a program that interprets capacitive input from the electrodes. The logic circuit controls eleven channels of high voltage AC using triacs. A 3 volt DC to ~200 volt AC inverter is continuously providing a high frequency signal that is connected to one terminal of the triac. When the logic circuit activates the triac, the AC current illuminates the phosphor between the selected electrode and a common, transparent top electrode. When activated, each electrode creates an electromagnetic field with the transparent electrode, due to the presence of the dielectric. An electromagnetic field builds on the rise of the AC signal. When the field collapses on the amplitude drop, the phosphor particles emit photons [9]. Each segment is additionally connected between an digital input and output on the microcontroller to register capacitance [1, 12]. The logic and inverter circuits must be powered by separate sources and grounds to avoid shorting.

Further Developments

Printerface could be applied to most surfaces that can be screen printed, including bicycling windbreakers, so a cyclist could swiftly control music playback. Screen printed EL's unique flexible, touch interactive, and customizable properties could allow for future dynamic icon development. The segmented icon would allow for a single print to display multiple types of visual notifications (message, email, phone, etc.) in a user's periphery. Other interactive icons could also be used in children's books to create an enriched reading experience.

Screen printing is already a ubiquitous technique of clothing customization. The process could easily be integrated into existing large-scale production systems.

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