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# A Miniaturized Display Network for Situated Glyphs

Gerd Kortuem<sup>1</sup>, Fahim Kawsar<sup>1,2</sup>, Phil Scholl<sup>3</sup>, Michael Beigl<sup>3</sup>, Adalberto L. Simeone<sup>1</sup>, and Kevin Smith<sup>1</sup>

<sup>1</sup> Lancaster University, UK,  
kortuem@comp.lancs.ac.uk, {a.simeone, k.smith}@lancaster.ac.uk

<sup>2</sup> Bell Labs, Belgium.

fahim.kawsar@alcatel-luncet.com

<sup>3</sup> Karlsruhe Institute of Technology (KIT), Germany  
{scholl,michael}@teco.edu

**Abstract.** We demonstrate a novel approach for building situated information systems using wirelessly connected miniaturized displays. These displays are spatially distributed in a physical work environment and present situated glyphs - human-readable abstract graphical signs - to provide activity centric notification and feedback. The demo will showcase how such miniaturized display networks can be used in dynamic workplaces, e.g., a hospital to support complex activities.

## 1 Introduction

In the field of information visualization, a *glyph* is a single graphical unit designed to convey multiple data [1]. Different parts of the representation or different visual attributes (e.g., shape, size, colour) are utilized to encode different values. In one early example Chernoff used different attributes of human faces (e.g.: the shape of the nose or eyes) to represent multidimensional data [2]. In contemporary literature, researchers have used glyphs to represent different attributes of documents [3] or for visualising software management data [4].

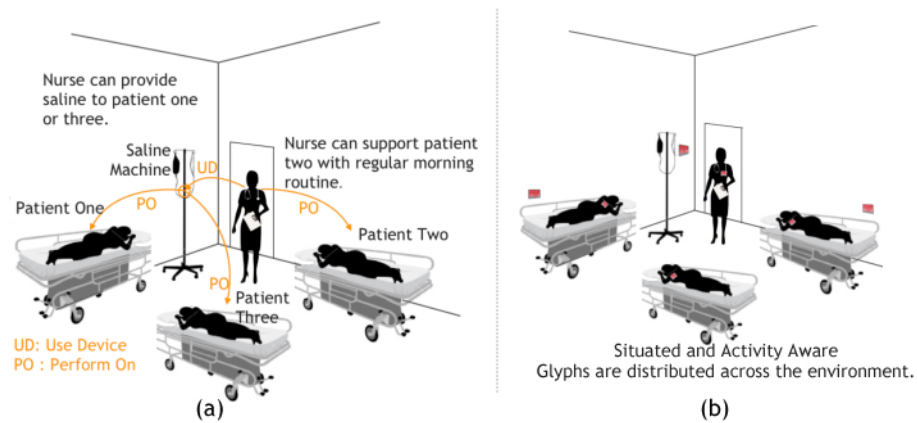
Up until now glyph-based systems have primarily been used for desktop-based visualization. In contrast, we are interested in how glyphs can be embedded in the built environment (walls, doors, etc) and in digital equipment (machines and medical devices) to build situated work-place information systems [5]. The use of glyphs in the built environment has some similarities to ambient displays [6]. Ambient Displays are often distributed across the environment and provide a constant stream of peripheral information. These devices present information within a space through subtle changes in light, sound, and movement, which can be processed in the background of awareness [7–9].

Due to their intrinsic capability of representing multiple variables with a single graphical representation, we see opportunities to use glyphs for exposing salient information in dynamic workplace environments such as hospitals. Our work on situated glyphs and situated information systems differs in a number of important aspects from previous work on ambient displays:

- Situated glyphs encode actionable information that directly influences actions of human actors in the environment.

- The information display of a situated glyph is highly place and time-dependent and relates to the real-world context of where the glyph is located.

This is exemplified by the hospital environment depicted in Fig. 1. In this example, a number of miniaturized displays are distributed throughout a patient room. Glyphs visible on these displays encode information that is relevant to the devices or patients they are next to. For example a glyph next to a patient might displays task information for nurses (“next check-up for this patient at 14:00”) or represent the quality of the care of the patient (“patient has been visited and interacted with 6 times over the last 12 hours”). One of the key functions of situated glyphs is to help people (in our case nurses) discover the activities that can or should be performed in a given space, at a given time with the devices and objects at hand. Another use of glyphs is to enable nurses and other personnel to reflect upon the overall quality of care they provide.



**Fig. 1.** Situated Glyphs in Hospital Setting

Fig. 2 shows two variations of glyph design for the hospital domain. In the image on the left, text is used to describe a task while the numbers in the lower part define the target patient (left) and the assigned nurse (right). Background color represents the urgency of the task (from blue to red). In the image on the right, the same task is rendered as the combination of a bed icon and a task icon (a pill). In this case this glyph is supposed to be displayed in close proximity and aimed at all nurses, so those values are no longer required. Finally, urgency of the task is encoded in the bed icon colors (from green to red, for better contrast on black background). In this work we present the technical foundation for building glyph-based situated information systems. In particular, we present the design and system architecture of a display network that connects miniaturized, wireless display units into a coherent system.

Small wireless displays are gaining popularity and have been proven to be useful in consumer products such as Apples iPod Nano. These miniature displays, due to their



**Fig. 2.** Two different glyph designs for Hospital Scenario

form factor afford us to utilize them as placeholders for spatially distributed situated glyphs. However, currently available displays are not capable of providing all functionality required for our situated information system. These requirements are:

- Programmability to integrate the functionality of a situated glyph as discussed above.
- A two-way wireless connection to peer glyphs and to a central application server to control status of the glyphs remotely using a standardized low power protocol.
- Low power consumption to survive at least a day.
- High display resolution (matrix display) with good visibility from all angles.
- Minimal interaction support through touch or buttons.

## 2 Miniaturized Display Networks for Situated Glyphs

There are some display systems already on the market that would fulfill a part of the above requirements (e.g., TI's Silicone Watch provides decent power consumption and wireless connection, but no high-resolution matrix display). However, to our best knowledge there is no display system in the literature that supports all the requirements above. Consequently, we have developed a custom designed connected display system from off-the-shelf modules.

As mentioned above, our major design issues are low energy consumption and wireless connectivity. For high-resolution display devices that are always on, power consumption of the display is the crucial parameter. Organic LED display technology features low energy consumption, wide viewing angles and improved brightness when compared to other display technologies and has therefore been chosen as the basis for ambient displays. Wireless connectivity is provided by a separate microcontroller with embedded ZigBee -IEEE



**Fig. 3.** Micro display prototype with a physical size of 51mmx30mm

802.15.4 capabilities. Based on this low-power wireless network TCP/IP functionality is provided by the Contiki operating systems. Accordingly, our prototype as shown in Figure 3 consists of four modules:

- A OLED-160-G1 display module manufactured by 4DSYSTEMS, featuring a resolution of 160x128 pixels at 65k colors and consuming 110mA at maximum and 14 mA at minimum, with an average of about 20 mA at 4 V. Consumption depends on contrast which is regulated by environmental conditions.
- The core module is made of a Jennic JN5139 wireless microcontroller that integrates memory, CPU and IEEE 802.15.4/ZigBee connectivity. It has a wireless operating range of about 30m indoors and consumes 45mA during wireless operation. A port of Contiki to the Jennic JN5139 provides IPv6 communication capabilities. Wireless networking is based on the IEEE802.15.4 standard, which targets low-power wireless sensor networks and in our case is geared towards single-hop, reliable, high-speed operation. A sustainable throughput of 8 kb/s through a TCP-connection is achievable
- A rechargeable lithium-polymer battery of the same physical size as the display with a capacity of 1000mAh and associated power conversion unit.
- User interaction support with a touch panel.

On startup each ambient display assigns itself a unique IPv6-address. Applications on the Application Server connect to the TCP server on the display. The system is able to run at least for 6 hours with full bright display, constant wireless transmission and constant usage of input. In average settings, runtimes of 3 or more days are expected which fits our need.

In the demo, we will showcase this custom-made display network presenting situated glyphs designed to support complex dynamic activities in a hospital environment.

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