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Colley, Ashley; Gröhn, Willehardt; Häkkilä, Jonna

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CleanLeaf Table: Preventing the Spread of COVID-19 through Smart Surfaces

ASHLEY COLLEY, University of Lapland, Finland
WILLEHARDT GRÖHN, University of Lapland, Finland
JONNA HÄKKILÄ, University of Lapland, Finland

Fig. 1. The CleanLeaf table. Left: Electrochromic version. Right: LED version indicating available for use state (clean) and requiring cleaning

One mechanism for the spread of the COVID-19 virus is through contaminated surfaces, e.g. tables in cafes, trains or public libraries. This mechanism may be prevented by cleaning the table surface between each use. In practice, this can be optimized by directing arriving users to clean tables and highlighting to staff which surfaces require cleaning. One approach to achieve this is through making the table surface itself smart and indicate its clean or dirty status. In the *CleanLeaf* table we demonstrate two approaches to integrating indication in a table surface, LEDs under a thin wood veneer and electrochromic displays. Rather than explicit light emitting display based signage, the design demonstrates calm computing with the display forming an integral part of the surface design.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**.

Additional Key Words and Phrases: Smart surfaces, pervasive displays, calm computing, electrochromic displays, COVID-19.

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1 INTRODUCTION

The management of the COVID-19 pandemic in 2020 saw the introduction of a variety of practices to reduce the spread of the virus, such as social distancing, the use of face masks and hand sanitizer and the closure of spaces such as restaurants and libraries. As public spaces reopened measures were taken such as distancing between used tables and frequent sanitizing of surfaces. Space owners used various temporary, and often homemade, signs and adhesive tape based solutions to direct customers movements and seating selection.

One mechanism for the spread of the COVID-19 virus is through contaminated surfaces, e.g. tables in cafes, trains or public libraries. This mechanism may be prevented by cleaning the table surface between each use. In practice, this can be optimized by directing arriving users to clean tables and highlighting to staff which surfaces require cleaning. One approach to achieve this is through making the table surface itself smart and indicate its clean or dirty status. In the *CleanLeaf* table we demonstrate two approaches to integrating indication in a table surface, LEDs under a thin wood veneer and electrochromic displays. Rather than explicit light emitting display based signage, the design demonstrates calm computing [7] with the display forming an integral part of the surface design.

As a contribution, we present an artifact implementing an aesthetic functional surface and demonstrating a possible solution to pandemic related challenges. Whilst calm computing is an often used term, practical examples are relatively rare.

2 BACKGROUND

Rather than presenting as a computational device, our work is positioned towards Weiser's vision of calm computing [7], where computational interfaces are seamlessly embedded in the world around us. Within this direction there is a large body of work focusing on ambient displays, defined by Mankoff et al. [5] as "... aesthetically pleasing displays of information which sit on the periphery of a user's attention". Examples range from, e.g., Fogarty et al.'s information collages [2], to Wakita and Shibutani's textile mosaic [6] and Colley et al.'s plant shadow based display [1].

The two technology approaches to we have applied to create our table surface display have been demonstrated in a range of applications in prior work. For example, creating an ambient display by placing LEDs behind a thin layer of wood veneer, has been demonstrated in the Living Wood display [4]. The construction of electrochromic displays, as well as some example applications, is demonstrated by Jensen et al. [3]

3 CONCEPT

Fig. 2. CleanLeaf table use case flow (LED version)

To provide indication if a table has been cleaned and is available to use we developed the *CleanLeaf* prototype table (Figure 2). The table followed the style of a typical circular standing cafe table. Two PIR sensors were integrated at

Fig. 3. The two states of the electrochromic display integrated into the table's wooden surface

the top of the table leg, facing 180° apart. An NFC reader was embedded in the center of the table, under the surface such that it was not visible, but was close enough to the tables surface to read an NFC tag placed on the surface. The system was controlled by an Arduino microcontroller located under the table surface. When the PIR sensors detected an object in range for more than a minimum time, the table was considered *dirty*. After cleaning, the table state could then be reset to *clean* by placing an NFC tag in the center of the table, in the area of the reader. A delay of 5 seconds was provided such that the cleaner could exit from the range of the PIR sensors.

A key target for the design of the table surface was that it should follow the principles of calm computing, with its display elements seamlessly integrated as part of the overall aesthetic design of the surface. Two versions of the table were developed one based on LEDs and the other utilizing electrochromic displays. In the LED version (Figure 2), the table surface was constructed from a thin layer of wood veneer, glued to a Plexiglas substrate. The light from LEDs located under the Plexiglas was then visible through the thin wood veneer. To create aesthetic patterning a masking layer with cutouts in the shape of leaves was placed between the LEDs and the Plexiglas. The colors of the LEDs were switched to indicate the clean (green illumination) or dirty (red) state of the table. The second version of the table used electrochromic display technology. The electochromic displays were designed following a leaf motif and placed in shaped cutouts in the table surface (Figure 3. The entire table surface was then coated in a layer of epoxy resin to create a seamless display surface.

4 DISCUSSION AND CONCLUSION

The two technologies we have demonstrated as having potential for making ambient displays each have advantages and disadvantages. The electrochromic approach, encased in epoxy is non light emitting, capable of displaying intricate patterning, has minimal depth, and especially when covered with a layer of epoxy, is robust enough for the majority of smart surface applications. However, because the electrochromic display does not emit any light it may be difficult to notice in an everyday environment and a solution based on LEDs may be preferable for some applications. As future work we plan to evaluate the functionality and user perception of the two versions of the table when deployed in a cafe environment.

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