Ambient Lamp Display in the ActiveHome Ubiquitous Computing Environment for Relaxing and Mediation

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Abstract

This paper describes the design and implementation of Tea Place. Tea Place is an ambient lamp display placed above a tea table in the ActiveHome ubiquitous computing environment. This ambient display system is intended to enhance a traditional tea table with multimodal interfaces for user relaxation and mediation. It detects user context (such as the color of tea in a cup) and displays abstract animation images using LED array reflected on the surface of tea, ambient sounds and wind blowing. It makes users to concentrate on drinking and increasing their intimacy on the table at home.

1. Introduction

Smart Home is the environment with a set of intelligent home appliances that is adaptive to resident's needs. The sensors embedded in the house are used to recognize the resident's behaviors, and the environment controls the home appliances and tools that are connected with the home network to provide the interactive responses to the residents. The ubiquitous system provides adequate information to users at the desired moment [1].

There are many ambient display and tangible media in Smart Home environment. They have shapes of house appliance of furniture. Smart home appliances are not only computer based digital device in the home but also ambient interface system. The fundamental human issues (such as attention, perception and metal representation) are the key factors for developing Smart Home user interfaces [2].

Home is a space not just for living. Many modern people get stressed from their company and society. They want to take a rest. Home should be a place for rest and relax. Tea place is a swing lamp ambient display to make users to be in the nature by providing them abstract LED animation images, sounds and winds. People at home often drink a cup of tea or coffee on the table and relax their body. This ambient display system detects the color of tea and gestures of people.

Tea Place is currently installed in the bedroom of the ActiveHome ubiquitous computing environment (Fig 1). ActiveHome is a smart home testbed operated by the Digital Media Laboratory at the Information and Communications University, to support design and development of intelligent tools for better life. Fig 2 shows ActiveHome, which is a 1200-square feet apartment-looking residential space that consists of a bedroom, a bathroom, a kitchen, and a living room. It is an on-going project dedicated to exploring ubiquitous computing technology integration.

Fig 1: The Tea Place, an ambient lamp display installed in the ActiveHome ubiquitous computing environment, designed for people relaxing and meditation

Fig 2: Active Home : A ubiquitous Computing Environment by Digital media laboratory at information and communication University

Tea Place is implemented with a LED array, a camera module and a micro-controller unit embedded in a lamp shade, connected with a computer. This paper presents the motivation, hardware and software system architecture, user interaction scenarios, and current uses of TeaPlace in the ActiveHome ubiquitous computing environment.

2. Related Works

Smart home project [1] propelled by Interaction software group of Samsung electronics Co. Ltd. It aims to build a ubiquitous home environment and smart home appliances to improve people's life while being as non-invasive as possible with regards to their home life. This project introduced many appliance designs, such as Smart pen, Gia, Smart wardrobe, Smart dressing table, Smart bed, Smart pillow and Smart mat, Gate reminder, Smart table, Smart picture frame, Smart refrigerator, Smart green house, Smart sofa, Digi flower, Smart universal remote control, Electronic paper, and Smart projector.

Ambient display is an "interface between human and digital information in cyber space[2]." The term is introduced by Tangible media group at MIT Media Lab as a part of the "tangible bits" project. Ambient display resides in the background as a periphery and envisions the information using ambient media. It extends the concept of conventional GUI-based display to make the physical environment as an interface to digital information.

3. System Architecture

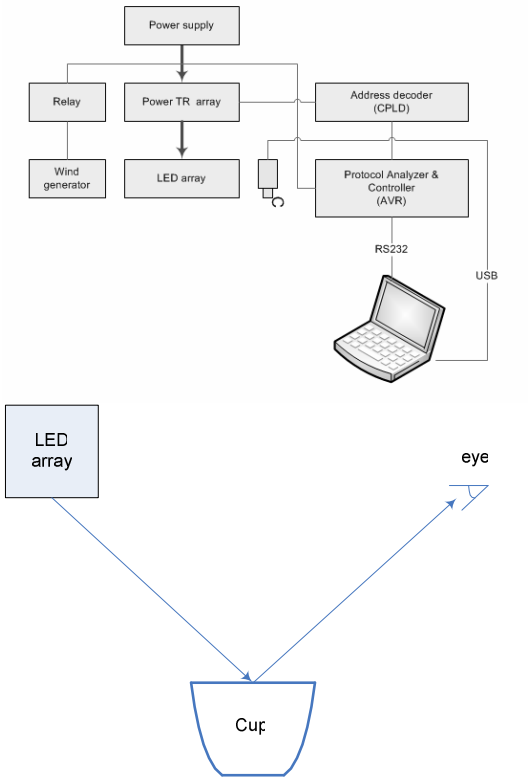

Fig 3: The Tea Place System Architecture (top) and the conceptual diagram of LED display images reflected over the surface of tea to be shown to people (bottom)

3. 1 System Overview

Tea Place is intended to design a seamless and natural interface for relaxing and meditation in a residential environment. The Tea Place ambient lamp display can be installed in any tea table and cup (preferably a large cup). In this system, a surface of tea on the cup gives the private display for each user. Users can enjoy taste, smell and warm feeling while drinking tea.

Fig 3 shows the overall system architecture of Tea Place. The system recognizes the kinds of tea that the user drinks (by detecting its color). It then displays additional visual, auditory and tactile patterns on the tea surface by the dynamic LED patterns, the sounds, and the wind generated by a fan embedded in the lamp. The LED patterns are reflected on the surface of tea. The Tea Place system consists of three main modules: context recognition, interaction control, and ambient display.

3. 2 System Modules

The context recognition module uses the camera module which captures the tea place area and detects

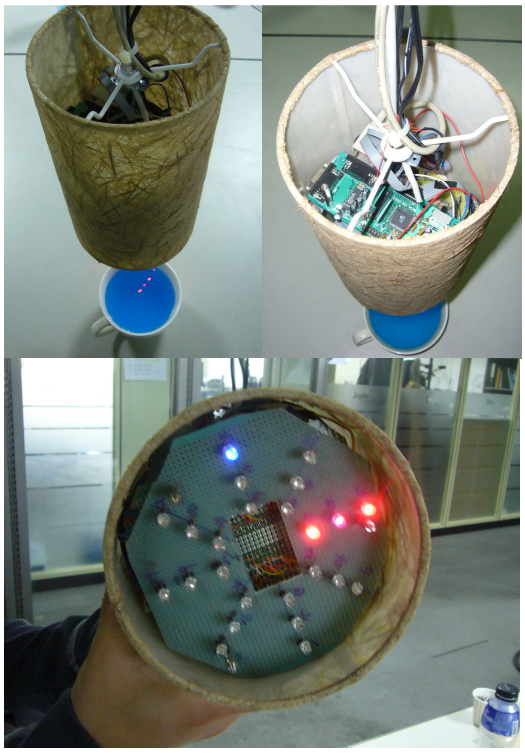

Fig 4: The hardware structure of Tea Place: Reflected image on the surface of Poweraid drink (top left), Electric core unit (top right), LED array (bottom)

the color of the tea that people drink and user's gesture. During idle time the camera detects idle marker on the table. To make this task easy, there is a cross at the center of camera image. The user interaction is triggered by placing a cup on the marker. The camera module reads the center image of 10×10 RGB pixel data and converts it to HIS data (which is more robust to light intensity) followed by averaging HIS data to classify the kind of tea (i.e., the color of tea). This information is used as one of contexts of user. Once user interaction is started, the camera module also detects user's gestures.

The control module continuously gets user's context information (such as the kind of tea) and determines whether user interaction can be started. As soon as it detects the change of color of the marker, the control module combines the user context with the environment information (such as time, season, weather and temperature) and then determines the user interaction scenario. The interaction scenario consists of LED patterns, sound files, and winds operated in a sequence. While a user drinks, the control module continuously reads predefined interaction scenarios, sends display patterns and sounds to the display module via a USB communication channel.

The display module creates the LED display patterns, ambient sounds and winds according to user-context interaction scenario. The module consists of a μ-controller hardware driver, a LED display array, a sound speaker and an electric fan. The controller analyzes the interaction scenario data received from the control module. Then, it sends multiplexed LED patterns to a demultiplex and latch module built using three XC9636 Xilinx Complex Programmable Logic Devices (CPLDs). Each CPLD is programmed by Verilog HDL as a two-to-twenty four demultiplexer and latch. Each LED has three RGB color and needs three input terminals to display all color elements and the three input signals are demultiplexed to control eight LEDs. The number of LEDs is 3×8, and 24 LEDs aligned in a polar coordinate to countermove the orientation problem that is often confronted by the table-top display system.

Users can see the reflected pattern of the LED array on the surface of tea. In addition, the micro controller directly operates an electronic fan embedded in the lamp to generate ambient wind blowing. The wind represents context-matched ambient as well as makes wave on the tea surface to distort the reflected image. As mentioned it earlier, the reflected image only displayed on the surface of tea in the cup, which allows users to experience private moments. Fig 4 shows the hardware structure of Tea Place. The top left image shows the reflected image shown on the surface of Poweraid drink, the top right image shows the actual electric core unit, and the bottom image shows the LED array.

4. Design Considerations for Relaxing and Meditation

Many people spend much time at home. They want to take a rest at home and relax their body and mind. Many people spend time on the table reading some books, talking with friends and drinking tea or coffee. Table is usually become the place for communication and relaxation. The Tea Place system makes people to concentrate relaxing. With this design consideration, the system provides an abstract form of images and sounds with the context-based user interaction rather than displaying actual information naively. This system does not give any text or visual icons. Hence, users can interpret the abstract form in many different ways.

4. 1 Interaction Scenario

Table. 1. Interaction Generating List

Color of Tea	Type of Tea	Image of LED	Sound Effect	Wind
Green	Green Tea	Leaf, Warm	Bird Singing	Wind
Red	English Tea	Water Melon	Flame Sound	
Blue	Poweraid	Wind Wheel, Rain Drop	Water Sound	Wind
Yellow	Barley Tea Puer Tea	Constellation, Moon	Frog Sound	

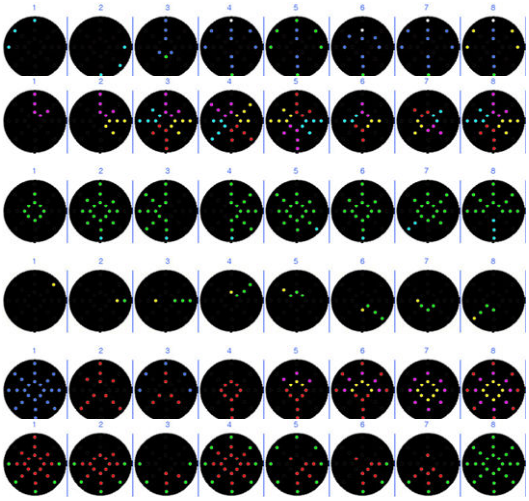

Fig 5: The example of LED displaying patterns: RainDrop, Wind, Leaf, Warm, Flame, Watermelon (from top to bottom)

The user interaction design is based on the tea colors. The system consists of simple scenarios which give different experiences by variation of color of tea. The color of the tea is a critical factor for user interaction scenario. Table 1 show the description of interaction scenarios generated according to the color of tea. User will get the feedback from the system with light, sound and wind. Fig. 5 shows the sequence of animation images to be shown on the LED array. The LED patterns we created are more than fifteen animation images. Users can also affect the image on the LED array with their gesture. For example, they can push and pull their different colored area on the LED array. It can help to maintain and mediate their common attention.

Fig 6 shows a LED display pattern editor, an authoring tool for generating the animation data for

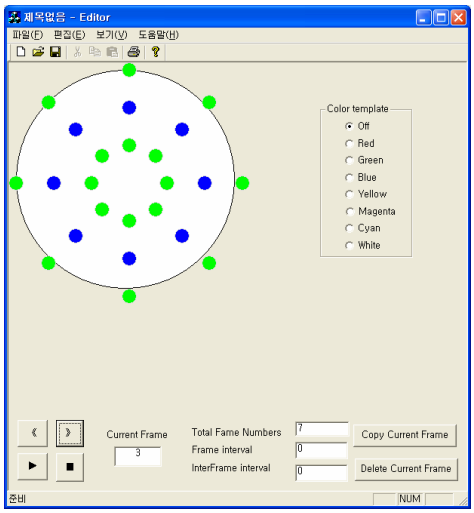

Fig 6: The LED display pattern editor

LED array. This program is designed for the administrators of Tea Place system. The pattern designers simply click and give a color to generate the LED image patterns on the editor. For each frame, the designers can add a new LED pattern or modify existing ones. When the setting is done, the sequence of LED patterns specified by the designers is saved as a text data file, to be used for animation playing.

As shown in Fig. 7, twenty-four LEDs are aligned in three concentric curricles. Currently, three LED input pins can be on and off, thereby generating eight different colors (i.e., Red, Green, Blue, Yellow, Cyan, Magenta, White, Turn off).

4.2 Context-based User Interaction Controls

Fig 7 shows the main control module and the position marker (in red color) placed on the table where the cup of tea will be located. The main control program gets video data from the camera through a USB connection. It keeps monitoring the marker area and decides the context-based user interaction controls.

The interaction session is started when the color of idle marker is changed. That is, the system is activated when people drinks a cup of tea or coffee. When the control module detects the change of the marker color, it combines the user's context with the environmental context (such as indoor temperature, outside weather condition, current time and season, etc) gotten from the internet to determine the interaction scenario. As discussed earlier, the interaction scenario contains the

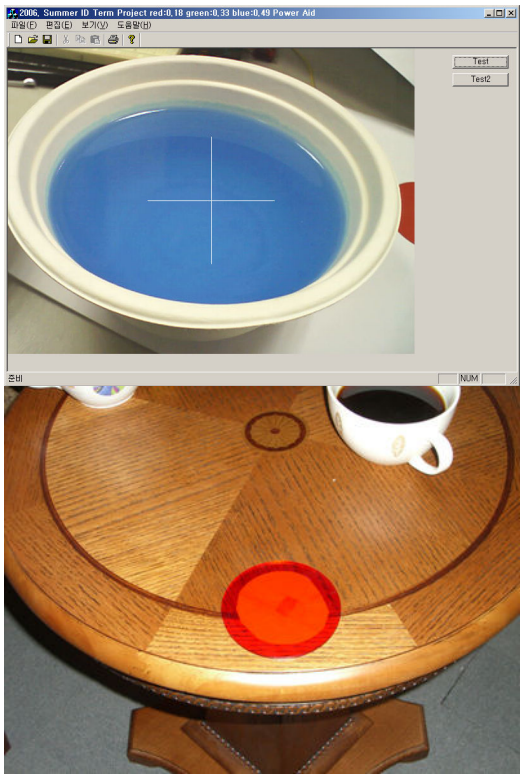

Fig 7: The main control module program (top) and the position marker on the table of Tea Place in the Active Home (bottom)

information about LED patterns, sounds, and winds to be sent to the display module. Once the interaction session is started, the camera also detects user's gestures, such as whether user drinks a cup of tea or not. Then, the interaction session ends when the cup being taken off from the marker area.

5. Conclusion

This paper described Tea Place, a lamp style ambient display system designed for the ActiveHome ubiquitous computing environment. It is currently set up on a tea table in the ActiveHome bedroom. In the past, most Smart Home environments focus on developing technology for efficiency and user convenience [1][2]. However, we wanted to make an ambient device that helps people be more relaxing and mediation at home.

Tea Place is designed to provide the ambient nature using abstract images, sounds, and winds to arouse emotional moods. We display LED image patterns in an abstract form rather than a text or specific visual icons. In this design, we intend to arouse users with many different notions. Tea Place presents the use of electronic and computer technology to enhance relaxation or mediation in a Smart Home environment.

Over the past year, many people have visited and experienced Tea Place. We noticed that most of them were immersed in watching the images displayed on the surface of tea on the cup. They tried to find out the meaning of image and enjoy the interaction. We found that ambient nature sounds really helped them to get more immersed. Interestingly, many people tried to find out the relationship between sounds and images. Some people said that LED images were like a reflected constellation. This system makes the emotional mood as if they are in the middle of nature, such as mountain, ocean, stream or lake.

For the future, we plan to extend this system to multi user networked system. Users are connected in different locations. They interact with this local system and commutate with other people coincidently.

6. References

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