

Everyday Life ToDo Display on Ceiling for Smart Living Space

Shigeyuki Hirai
Faculty of Information Science and Engineering
Kyoto Sangyo University
Kyoto, Japan
hirai@cse.kyoto-su.ac.jp

Michi Takamura
Faculty of Computer Science and Engineering
Kyoto Sangyo University
Kyoto, Japan

Abstract—Many commonly used household appliances and equipment include refrigerators, washing machines, intercoms, telephones, air conditioners, microwaves, and ovens; they communicate various information to the users by providing notifications using auditory displays. However, an occupied user may not pay attention to the notifications and/or cannot recognize simultaneous auditory alerts. Therefore, in this study, we propose a ceiling display system that displays information depending on the location of the users. This display system utilizes house ceilings as overhead visual displays that can update the users with various information simultaneously. This paper describes the different situations where appliances notify the users on completing a task; subsequently, we propose a concept for the ceiling display system in a smart house that will be introduced in the near future. In addition, the expected effectiveness of this system, some useful scenarios, and initial verifications of the visual notifications on the ceiling are described.

Keywords—ceiling display, smart house, smart home, to-do list

I. INTRODUCTION

In everyday life, various task notifications are overflowing in houses owing to the auditory alerts from household appliances and residential facilities. However, these notifications may not be heard if the family members are not in the vicinity of the appliances, the notifications occur simultaneously, or all members are occupied. Therefore, the notification should be managed as short-term ToDo with family members. Recently, home appliances are being synced with smartphones or Internet services. In the near future, it is assumed that smart houses will be able to notify users with audio/visual alerts as in a ubiquitous environment. In fact, many Bluetooth loudspeakers and small or pico-sized projectors that can project information on the ceilings and walls have been released recently. This use of projectors is described as a type of augmented reality display in everyday life [1], and various visualization systems are proposed to realize smart spaces with walls or tabletops [2–6]. However, with regard to visual notification, it should be noted that there are numerous items in a house, such as furniture, calendars, and posters. Therefore, it is difficult to utilize walls and floors as valid displays. On the other hand, most areas of the ceiling are blank spaces, other than those occupied by lighting equipment, and hence, it is considered effective to utilize it as a visual display for notifications.

Interactive Ceiling [7] is one study that utilizes such a ceiling, where users face upward and access information, such as weather reports or some other information, on an ambient display. Wimmer, et al. [8] investigated human perception and ergonomic attributes when using the ceiling as a visual display and proposed concrete example applications concerning convenience and satisfaction.

In this study, we propose a ceiling display system specialized for ToDo tasks and their notifications from household appliances used in everyday life. This paper describes the outline of the system and design of the notification method. We also describe the results of the initial verification for notifications considering the peripheral visual field on the ceiling.

II. CONCEPT OF CEILING TODO DISPLAY

Figure 1 shows an overview of our system that displays the updates of the ToDo lists as notifications on the ceiling above the user along with auditory alerts. A child can notice that washing is completed in one room while the parent near the front entrance can notice that there is a visitor; both can be done simultaneously via the ceiling display. The visual design of the ToDo display can be represented in various ways. Figure 2 shows an example of the visual design.

To confirm the notification of a home appliance, it is necessary to be in the vicinity of the appliance; you cannot see the face of the visitor unless you are in front of the interphone. Even in such situations, it is possible to receive notifications irrespective of where the user is via the ceiling ToDo display.

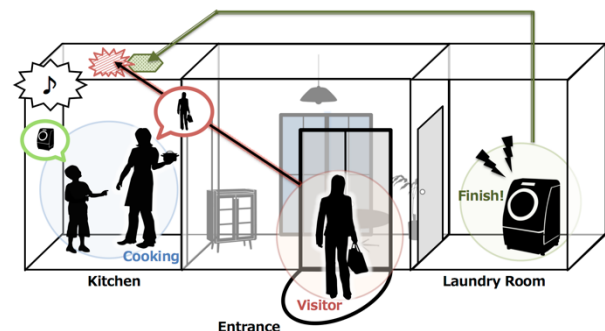


Fig. 1. Overview of ceiling ToDo display in a smart house.

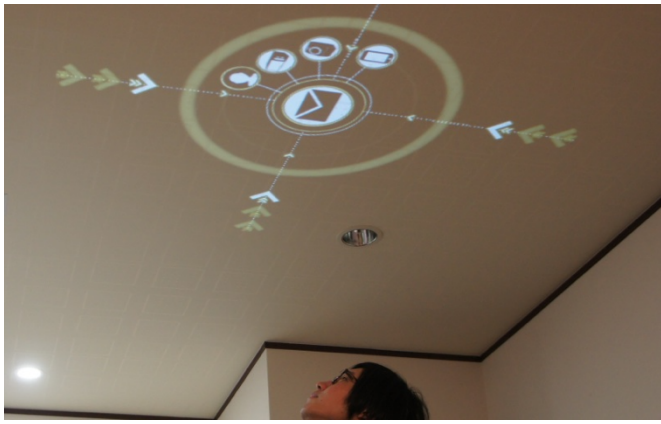


Fig. 2. Example ToDo list display on the ceiling.

Using the ceiling to display notifications, it is possible for families in the same room to share the displayed information. By allowing families to see each other's notifications, it is possible to communicate with each other via the ceiling. Because ToDo and its notifications are displayed in the ceiling around people, there is no need to always have a terminal, such as a smartphone or cellphone, to receive the notifications. In addition, it can be used as a means to notify the elderly or children; it is highly unlikely they will have such terminals.

When presenting the contents of ToDo visually, the display can adopt expressions corresponding to various requirements, such as the type and importance of information, simultaneous notifications, and continuous display of incomplete tasks. This means that the visual representation is more free compared with the conventional instant notification sounds.

III. SUPPOSED INFORMATION TO DISPLAY AND USE CASE

This chapter describes various information and notifications that can be displayed on the ceilings of homes (Table I). Furthermore, typical cases of the ToDo display on a ceiling are described.

A. Microwave Oven

Consider placing a dish in a microwave to warm it. If we are not in the kitchen, we cannot hear the finish alarm go off. If we are occupied with some other work at the same time, for example, if a visitor rings the doorbell or we are looking after kids, we may forget that a dish is being warmed in the microwave. When we remember it later, the food is already getting cold. Using this system, however, the notification of the microwave oven is projected on the ceiling in an entrance or a kid's room and is displayed until the dish is taken out of the microwave. It reminds us that a dish has been warmed in it.

B. Washing Machine

Next is an example of a laundry scene. We may go out having forgotten clothes are being washed in a washing machine, and we may remember it after returning. It must be getting us to wash clothes again. Even in this case, this system can notify the users through a display on that ceiling at the entrance that clothes are being washed. This will give us a chance to think about whether we should wait for the laundry

to finish and then hang the clothes to dry before going out or to wash them later as there is no time.

C. Intercom/Doorphone

When the doorbell rings, someone goes to the indoor unit of the doorphone, checks the monitor image, and confirms who the visitor is. If the visitor is a friend of a mother, the mother is called out. Here, we have to go to the entrance to check who the visitor is on the monitor of the indoor unit and then notify the concerned family member. However, using the proposed system, the intercom sends a notification to all the family members, and the image of the visitor is displayed on the ceiling overhead for each family member. This way, the concerned person then greets the visitor at the entrance.

D. Phone call, SNS message and App Notification

Here we mention about phone calls or Social Network Service (SNS) messages, various app notifications at home. Mobile phones notify users about various updates including incoming calls, emails, and SNS messages. In addition, various updates from other application, such as weather information, news headlines, schedule reminders, and to-do lists, are also received based on the users' settings. However, if users are not around their phones, they will not notice these notifications. This system displays these various notifications as well for the user on the ceiling.

TABLE I. INFORMATION AND NOTIFICATION EXAMPLES AT HOME.

Category	Information Source	Information/Notification
Infrastructure and Environment	Electricity	Power Consumption Power Generation
	Gas	Gas Consumption Gas Leak
	Water Supply	Water Consumption Water Flow Water Temperature
	Air Condition	Room Temperature Humidity
Appliances	Wash Machine	Finish Alert
	Robot Cleaner	Finish Alert
	Rice Cooker	Finish Open Alert
	Refrigerator	Open Alert
	Microwave Oven	Finish Alert
	Intercom/Doorphone	Call
Computers	Mobile Phones/PC	Program Start Start / Stop Recording News Headlines
		Phone Call Email / SNS messages Schedule ToDo list Weather Information News Headlines (Apps Various Info.)
Other	Emergency Alert	Earthquake Tsunami Fire Tornado Typhoon / Hurricane / Cyclone

IV. INITIAL VERIFICATION OF VISUAL NOTIFICATION ON CEILING

In the ToDo display system using the ceiling, there are two ways to notify users: Visual and auditory presentations. Although the auditory indication depends on the degree of the influence of the environmental sound in the room, it is an effective method because people can hear the sound without having to look toward a particular direction. However, because we do not pay attention to the ceiling in everyday life, it is necessary to devise an effective visual presentation for the notifications. We focused on the fact that the ceiling is a place that enters the peripheral visual field. The peripheral visual field is superior to central vision as it included the perception of brightness and motion. Therefore, we design visual notifications that can be displayed as motion graphics in the peripheral visual field on the ceiling. Furthermore, we conducted an initial experiment to verify the visual notification as shown in Figure 3. In this experiment, a short throw projector was installed on the floor toward the ceiling. We made three motion graphics—Patterns A, B, and C—shown in Figure 4, and made a pattern that appears suddenly above subject's head as Pattern D. These animations were drawn with Processing and projected three times at random for a certain period of time for each subject. Subjects were signaled when they notice the visual notification in the movie viewing task. In this verification, we surveyed 12 subjects—those in their early twenties (10 males and 2 females).

According to this experiment, the result noticed for each pattern is presented in Table II. This result shows that some type of motion pattern viewed in the peripheral visual field is effective, according to the comparison Patterns A, B, C, and D. Furthermore, this result shows these motion graphics cannot be noticed perfectly, but they are valid to some extent. These motion patterns and their circle objects were designed tentatively. It is necessary to experiment with various shapes and motions of objects.

In addition, we conducted another experiment by flashing the entire ceiling of a room for emergency alerts with white and red colors. As a result, all subjects were able to notice the flash of both colors perfectly. We interviewed them about these flash notifications after the experiment. They answered that they noticed not only the flash on the ceiling but also the light reflected on the walls. These comments suggest that when the entire ceiling is flashed, the notifications are effective. However, if we use only this flash method, there will be a constraint that variations of visual design of notification cannot be made much. Therefore, we plan to design various visual notifications that combine the flash and motion object approaches.

V. CONCLUSION

In this study, we propose a ceiling ToDo display system for a smart living space that projects ToDo information and their notifications on the ceiling based on the location of the user. In this system, because the ceiling is used as a display, which is different from the conventional display systems, we devised a visual presentation of notifications and verified their effect. In the future, we plan to draft several visual designs of ToDo and develop a multi-projector system that supports wide ceiling areas covering an entire room. Furthermore, we will confirm if

the users are comfortable looking for ToDo information and their notifications on the ceiling.

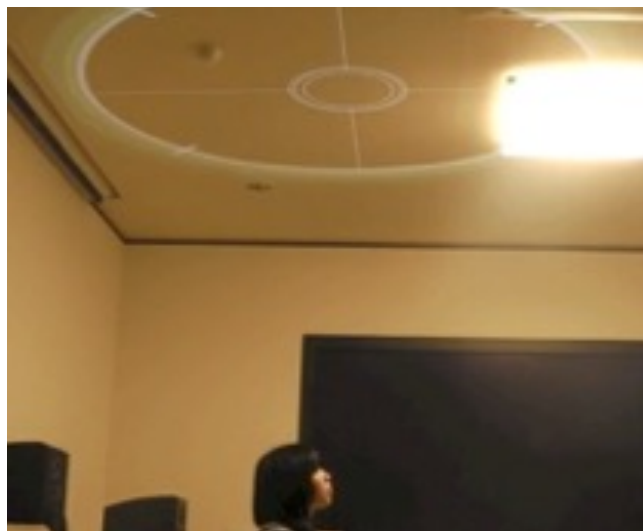


Fig. 3. Scene of verification of visual notification on ceiling.

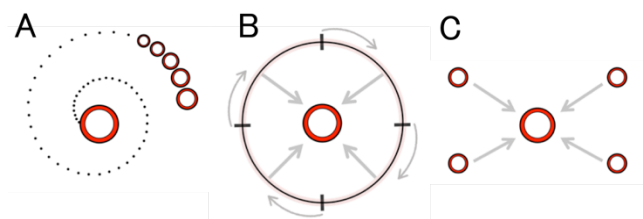


Fig. 4. Motion patterns of visual notification in initial verification.

TABLE II. RESULT OF RATIO FOR NOTIFYING TO VISUAL NOTIFICATION ON CEILING FOR EACH PATTERN.

Patten	Rate
Pattern A	83 %
Pattern B	72 %
Pattern C	78 %
Pattern D	6 %

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