HomeOrgel: Interactive Music Box for the Aural Representation of Home Activities

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ABSTRACT

We propose a music-box-type interface, "HomeOrgel", that can express various activities in the home using sound. Users can also control the volume and content using common methods for controlling a music box: opening the cover and winding the spring. Users can hear the sounds of past home activities, such as cooking and the opening/closing of doors with the background music (BGM) mechanism of the music box. We developed the HomeOrgel device and installed it in an actual house. We also verify the effectiveness of our system through evaluation and discussion.

Author Keywords

Auditory display; music box; ubiquitous computing; smart home.

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces – input devices and strategies, user-centered design, Prototyping.

INTRODUCTION

In the near future, it will be common for a large number of computers and sensors to be installed in the home. There have been many research projects on the design of smart homes as test-beds for new technologies in a future environment [2,9,17]. While most projects focused on activity recognition [10,13], representation methods of these activities have also attracted attention in recent years [3,14,16]. To design such representation systems, we need to consider emotional factors: for example, when a user wants to know the status of his/her family member, the presentation method using a picture of the family member [12] is more comforting than a text presentation such as email.

We focused on a music box to present home activities because the music box is familiar to most people, particularly when they look back on their memories. We propose an auditory interface modeled on a music box, "HomeOrgel", which helps users look back on past activities in the home using sounds, imitating the recall of memories using a music box [11].

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First, we introduce the concept and implementation of the HomeOrgel. Next, we explain the installation of our system in an actual home. Then, we report the evaluation method used to verify the effectiveness of our system using actual data. Finally, we provide discussion and present future works.

HOMEORGEL

The HomeOrgel presents various activities in the home using sounds. Users can control the HomeOrgel using common methods for controlling a music box: when a user winds the spring and opens the cover, he/she can hear the sounds of home activities (e.g., conversations and the opening/closing of doors) with the background music (BGM) mechanism of the music box. The user can easily perceive the home activities by listening to these sounds in the same manner as listening to music from a common music box (Figure. 1).

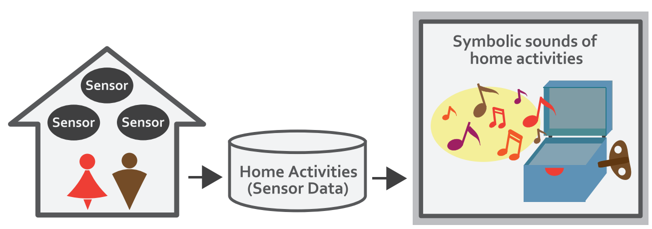

Figure 1. Concept of the HomeOrgel.

Usage

The basic usage of the HomeOrgel is shown in Figure 2. The HomeOrgel provides three main interactions similar to general music boxes by simply using the cover and spring. The procedures are as follows:

1. The user winds the spring on the back of the HomeOrgel by a half-turn.
2. When the user opens the cover, the HomeOrgel starts to play BGM and sounds of past activities (e.g., from 1 hour ago).
3. Sounds of past activities are compressed into a certain length (e.g., 20 sec).

4. The user can change the volume by adjusting the angle of the cover: the volume is increased (decreased) according to the degree to which the cover is opened (closed).
5. When the user closes the cover, the music stops.

When the user winds the spring through more cycles, the HomeOrgel will play the sounds of activities further back in the past. For example, when the user winds the spring three times, he/she can hear sounds of home activities for the past 3 hours. These sounds are compressed into short length to help users look back on past activities more effectively.

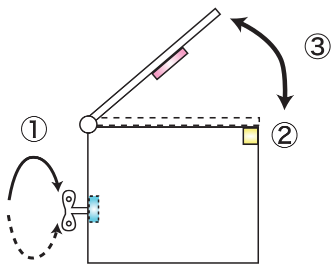

Figure 2. Usage of the HomeOrgel: (1) winding a spring to rewind to past activities, (2) opening/closing the cover to play/stop music, and (3) adjusting the tilt of the cover to control volume.

Design of sounds

There are several research projects that express activities in the real world using sounds [6, 15]. In such systems, users' activities are expressed by changing the rhythm and pitch of music; however, users often have difficulties in finding meaning in these changes since they must learn the mapping between musical changes and activities in advance. To avoid these difficulties, the HomeOrgel adopts "symbolic sounds" to express home activities

Symbolic sounds of home activities

The HomeOrgel adopts "symbolic sounds" to present home activities for the following reasons:

- Clear mapping between sounds and activities
- Protecting privacy of users

The "symbolic sound" is similar to Blattner's concept of "representational sound" [1] and that of "iconic sound" reported by Gaver [5]. These approaches help listeners understand the meaning of sounds without learning them in advance by mapping sounds directly to events in the real world. Similarly, the HomeOrgel helps users recognize the meaning of sounds using pre-recorded symbolic sounds corresponding to home activities. For example, when someone opens/closes an entrance door in the home, the HomeOrgel plays the sound of a door opening/closing (e.g., "bang"). Although we could also record sounds each time using a microphone attached near the entrance, such "raw" sounds may become difficult for users to hear due to surrounding noises. In particular, users may have difficulty in understanding multiple raw sounds at once. Moreover, raw sounds may cause privacy problems since they may include unintentionally captured sounds (e.g., conversations around the entrance). For these reasons, we basically applied pre-recorded symbolic sounds. The HomeOrgel generates various symbolic sounds based on home activities detected by sensors at various locations inside the home: entrance, living room, kitchen and so on. When multiple events occur within a short period, the HomeOrgel generates symbolic sounds corresponding to these events simultaneously.

Music length

We discuss here the total length of music generated by the HomeOrgel. We decided to limit the length of the music to several minutes in consideration of the basic usage of the HomeOrgel: casually looking back over daily activities. Since the system needs to present many activities within a limited time, we compress activities into shorter sounds. The details of this are shown in the Implementation section.

BGM

The HomeOrgel play symbolic sounds in combination with the BGM of music boxes for following reasons: (1) enhancing the attraction of the music and (2) informing the user of the state of the music. When the system plays symbolic sounds without BGM, the music becomes quite boring for listeners after several minutes. Moreover, it is difficult for listeners to distinguish the end from the rest of the music.[1]

Usage scenarios

We introduce several scenarios using the HomeOrgel.

- Scenario 1: A father living away from his family comes home at midnight every day since he is quite busy at his business, meaning he cannot call his family as often he wants. One midnight, he thinks about his family and uses the HomeOrgel. He opens the cover after winding the spring. He can catch up with the activities of his family by hearing the music on the HomeOrgel: his children left home in the morning; his wife cooked before children came home. This allows the father to feel at ease.
- Scenario 2: Grandparents live in the country apart from other family members. They always want to see their grandchildren who just started primary school. On Sunday afternoon, they think about their grandchildren: "are they are at home or out?" The grandparents winded the spring and open the cover of the HomeOrgel. First, the HomeOrgel plays the chimes of the intercom, then plays many more sounds than they had expected. They guess that their

[1] The rest of the music here indicates the absence of any home activities for a period.

grandchildren's friends have come for a small party. Thus, they call their grandchildren later to ask about the event.

- Scenario 3: A daughter studying in her room happens to open the HomeOrgel after winding the spring a little. She hears several sounds: cutting vegetables on the board and sautéing in a pan. She can recognize that her mother just started cooking and leaves for the kitchen to help her mother.

IMPLEMENTATION

We developed a HomeOrgel prototype with the above features. The HomeOrgel device consists of several sensors and a speaker in a ready-made music box (Figure 3).

We attached a rotation sensor on the spring to measure its rotation angle, a magnetic sensor on the edge of the box to detect the opening/closing of the cover, and an acceleration sensor inside the cover to detect its tilt angle. These sensors are connected to a host PC (Windows XP) via a Phidgets Interface Kit. [2]

The HomeOrgel software can control the above sensors using the PhidgetServer[3] via the Phidget Interface Kit. The software controls the playing of the music based on the magnetic sensor, and adjusts the volume of music based on the value of the acceleration sensor; the system increases the volume when the cover is opened more widely. The software can extract past events in chronological order. The recall period is determined by number of time the spring is wound.

As mentioned in the previous section, the software compresses home activities into a shorter period as shown in Figure 4. First, we prepared symbolic sounds of home activities lasting no more than 5 seconds in consideration of the balance between simplicity and expressiveness.

There are three variables for the compression process: "rewind interval", "music interval" and "compression threshold of each event" (Table 1). Next, we explain these variables.

[2] http://www.phidgets.com/

[3] PhidgetServer: middleware for easy control of Phidget devices.

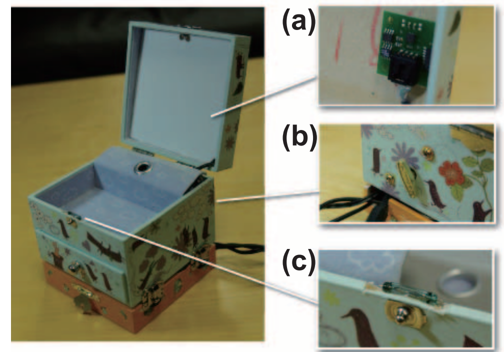

Figure 3. The HomeOrgel prototype: (a) acceleration sensor, (b) knob with a rotation sensor, (c) magnetic sensor.

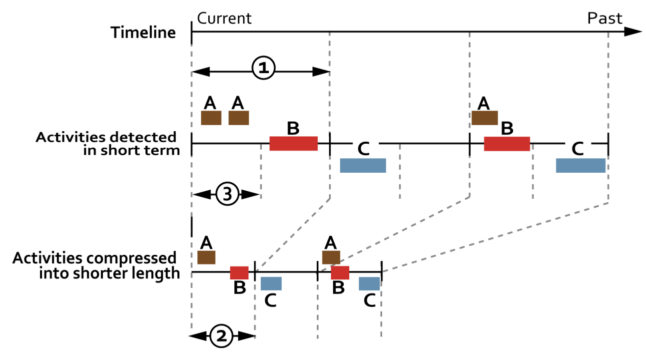

Figure 4. Activity compression procedure: (1) rewind interval of past activities (e.g., 1 h), (2) Music interval (e.g., 10 sec), (3) Compression threshold of each activity (e.g., 30 min).

Variable name	Range of value	Setting value
Rewind interval	1 minute —24 hours	1 hour
Music interval	1 seconds—1minutes	10 seconds
Compression threshold of each activity	1 minute —24 hours	30 minutes

Table 1. Variables of the HomeOrgel software.

Rewind interval

When a user winds the spring by a half-turn, the target activities presented by the HomeOrgel are recalled for a certain time interval, the "rewind interval" (Figure 4-1). We set the rewind interval at 1 hour in the prototype in consideration of its use to recall activities for approximately one day.

Music interval

When the HomeOrgel generates music, activities in the rewind interval are compressed into a shorter length, the "music interval". We calculated the music interval using the following formula: "music_interval = music_length/ (waking_hours/rewind_interval)".

We assumed the music length to be no more than several minutes (e.g., 2.5 minutes) and the waking hours per day as 16 hours. To present the home activities for a day within 2.5 minutes, we set the music interval at 10 seconds in the prototype.[4]

Compression threshold of each activity

When many activities are detected in a short term, the system needs to summarize them to avoid complicated aural presentations. The HomeOrgel functions to pack the multiple activities occurring within the "compression threshold" and generate the corresponding sounds simultaneously. We set the compression threshold at 30 min based on the following formula: "compression_threhold = rewind_interval/(music_interval / sound_length)". The length of the symbolic sounds is up to 5 seconds.[5]

SYSTEM INSTALLATION

We installed a simple activity recognition system in an actual house "Ocha House"[6] to verify the effectiveness of the HomeOrgel using actual data. We report the installation details in this section.

Sensor modules

First, we explain the installation of wireless sensor modules in Ocha House. Each module consists of a wireless communication module (Digi International XBee[7]) and a human detection sensor (Panasonic Electric Works NaPiOn) to detect user movements (Figure 5). We installed the sensor modules in various locations in Ocha House, including the entrance, passage, kitchen, dining room, living room, bedroom and bathroom (Figure 6 and Figure 7).

Ocha House has frames and catwalks suited to the installation of sensor modules and computers (Figure 5, left). Therefore, we attached sensor modules on the frame and catwalk to keep people's attention from the sensors. Figure 6 shows the sensor positions on the frames and their detection area: A (bedroom), B, C (living room) and D, E (dining room). Sensors on the catwalks detect users in J (entrance), K (passage), L (changing room) and M (bathroom). We also installed four sensor modules under the cooking table in the kitchen. These sensors can detect users in F (in front of the stove), G, H (in front of the cutting board) and I (in front of the sink) as shown in Figure7.

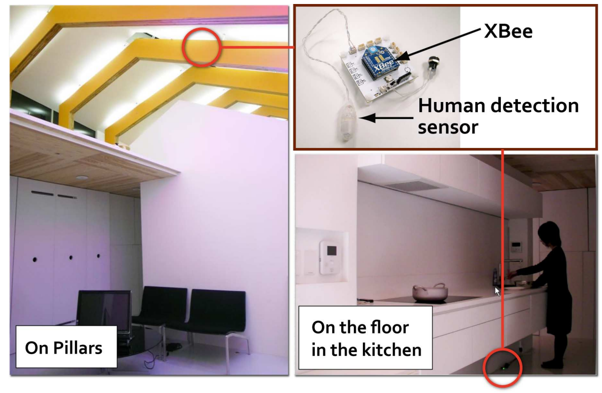

Figure 5. Installation of wireless sensor modules in Ocha House.

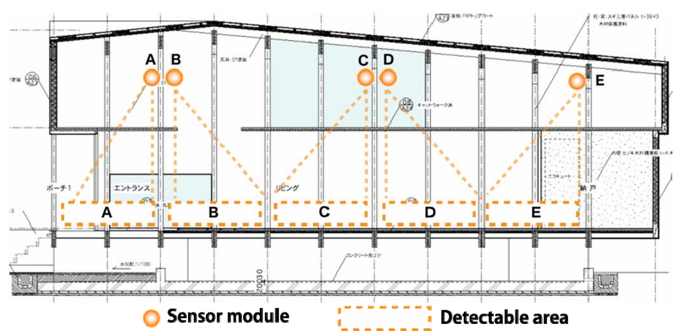

Figure 6. Sensor modules on frames and their detection areas.

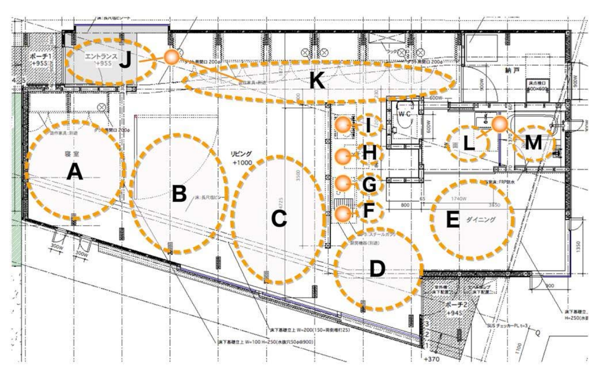

Figure 7. All sensor module detection areas.

[4] 150/ (16/1) = 9.375 (sec)

[5] 60/ (10/5) = 30 (min)

[6] Ocha House: an experimental smart house for evaluating ubiquitous computing applications in Ochanomizu University.

[7] XBee: a wireless communication module based on the 802.15.4/ZigBee standard.

Middleware

We developed two types of middleware, "XBeeServer"[8] and "OchaHouseManager", to control the above sensor modules. Figure 8 shows our system architecture. The XBeeServer collects sensor data from XBee modules (XBeeEndPoints) and translates them into simple messages. The OchaHouseManager receives these messages from the XBeeServer via TCP Sockets and converts them into location/status parameters (e.g., living room/motion, entrance/open) and saves them to the database (Microsoft SQL Server).

The HomeOrgel software determines the recall period by the number of times the spring is wound and extracts the relevant past data from the database. The HomeOrgel estimates the activity (or "event") from the detection areas of sensors. The mapping of detection areas and events is as follows: "working" (in the living room: B~C shown in Figure 7), "eating" (in the dining room: D~E), "cooking" (in the kitchen, in front of the stove: F), "cutting vegetables" (in the kitchen, in front of the cutting table: G~H), "washing dishes" (in the kitchen, in front of the sink: I), "coming home/going out/receiving a guest" (in the entrance: J).

Since the motion sensors continuously react for a while after detecting human motion, our system distinguishes activity from noise using the "activity threshold"; that is, activities are recorded only when they continue beyond the threshold. We set the activity threshold at 15 seconds because a user tended to perform activities at the same location for more than 15 seconds in our preliminary observations.

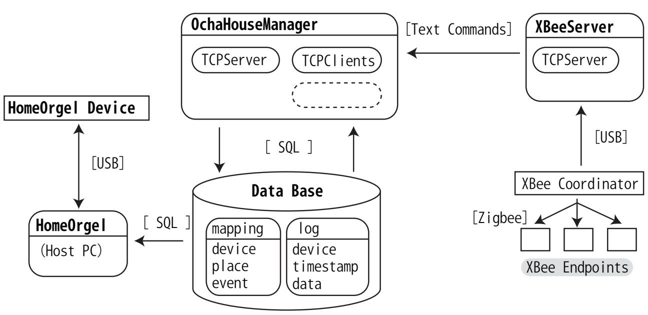

Figure 8. Sensor modules on frames and their detection areas.

EVALUATION

To verify the performance of aural representations by the HomeOrgel, we undertook an evaluation from two perspectives: (1) performance in informing users about home activities by sounds alone" and (2) attractiveness of the HomeOrgel music.

That is, the goal of the evaluation was to explore the two following questions: (A) "Can the subject understand the content of activities by hearing sounds from the HomeOrgel?" and (B) "Did the subject receive a favorable impression from the HomeOrgel music?"

Method

First, an experimenter spent seven hours in Ocha House as shown in Table 3 and used the system to create activity data. Next, the experimenter had each test subject listen to the HomeOrgel music generated from these activities. We selected 7 test subjects (1 male and 6 females, age 22-27). None of them had ever heard the HomeOrgel. Before starting the experiment, we explained the basic functions of the HomeOrgel to the subjects as follows:

- The HomeOrgel represents past home activities using sound.
- The recall period is about 7 hours a day.
- The home activities occurring in 1 hour are compressed into 10 seconds of music.

Next, we obtained feedback from the subjects both by questionnaires and oral discussion. First, the experimenter asked the subjects to answer the two following questions while listening to the HomeOrgel music:

- Q1: "Please write all sounds you hear?"
- Q2: "Please write all events you imagine occurring from the sounds?"

After hearing the HomeOrgel music, the subjects were asked to answer the three following questions:

- Q3: "Please write the time period in which activities most frequently occurred?"
- Q4: "Please write all sounds that you cannot understand?"
- Q5:"Do you experience a pleasant feeling while listening to the HomeOrgel music? (1: not at all - 5: very pleasant)"

Table 2 shows the mapping of activities, symbolic sounds and locations. Table 3 shows actual data for home activities and generated symbolic sounds in chronological order. Figure 9 shows the detailed transitions between activities and the generated sounds.

[8] XBeeServer: middleware for easy control of XBee devices.

Location	Activity	Symbolic Sound
Living room	Reading a book	Flipping through a book
Dining room	Eating	Dish clatter, munching food
Kitchen (stove)	Cooking using a stove	Igniting a stove, shaking a pan
Kitchen (cooking table)	Cooking using a cutting table	Cutting veggies slowly/quickly
Kitchen (sink)	Cooking using water, washing dishes	Running water, washing dishes
Entrance	Coming/leaving home, Welcoming a guest	Intercom

Table 2. The mapping of activities, symbolic sounds, and locations.

Time	Actual activity	Symbolic sound
14:30~15:30	Coming home, working in living room	Intercom, flipping a book
15:30~16:30	Working in living room, opening refrigerator door	Flipping through a book, cutting veggies slowly, shaking a pan
16:30~17:30	Working in living room	None
17:30~18:30	Working in living room	Flipping through a book
18:30~19:30	Working in living room, opening refrigerator door	Igniting a stove
19:30~20:30	Going to shopping, coming home, cooking	intercom, cutting veggies quickly, igniting a stove
20:30~21:30	Having guests, cooking, eating	Igniting a stove, running water, cutting veggies slowly, dish clatter, munching food

Table 3. The actual data for home activities and generated symbolic sounds in the experiment.

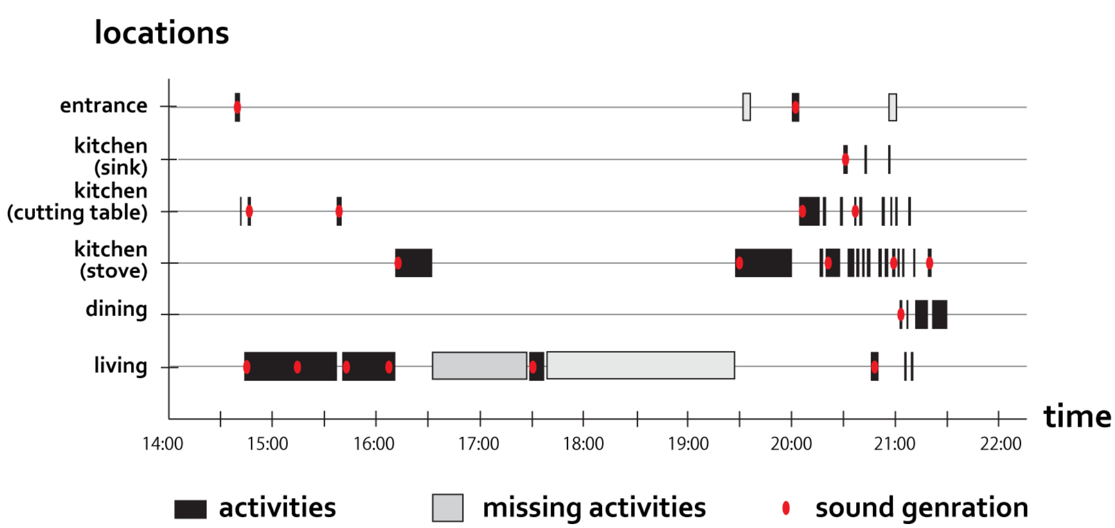

Figure 9. Detailed transitions between activities and generated sounds in the experiment.

Result and Consideration

The results of Q1 - "Please write all sounds you hear?" - are shown in Table 4. All subjects wrote symbolic sounds related to entrance and water, and six subjects wrote the sounds related to cutting/cooking.

Next, the results of Q2 - "Please write events you imagine occurring from the sounds" - are shown in Table 5. All subjects wrote "cooking", six subjects wrote "coming home/receiving guests". Since these answers include expressions such as "cutting vegetables using a kitchen knife" and "washing dishes", some subjects seemed to imagine the details of the cooking events. Although the experimenter did not indicate subjects to write activities in chronological order, one subject answered with almost the exact order: "First, someone comes home, next he/she starts cooking, and finally he/she eats something". As shown in Table 3, this answer corresponds with actual data of home activities. These results suggest that subjects could understand the activities just by hearing the sounds from the HomeOrgel. In contrast, some subjects could not understand the precise activities from the sounds in several cases. For example, although all subjects could recognize "water sounds" in Q1, they imagined different activities, such as "washing dishes" or "running a bath," in Q2. In addition, three subjects answered in Q4 that the water sounds were difficult to understand as they imagined many candidate events (Table 6). Considering this feedback, we saw the need to provide more concrete aural presentations for activities related to water.

Similarly, the intercom sounds were interpreted as multiple activities: "Someone came home" and "Having guests" in Q2. However, since both activities are related to entering the house, the current mapping may be sufficient to represent an "entrance event".

Next, in Q3 - "Please write the time period in which the activities most frequently occurred "- six subjects answered "the last three hours". This result corresponds with the experimenter's behavior as shown in Table 3.

In Q 5 - "Do you experience a pleasant feeling while listening to the HomeOrgel music? (1: not at all - 5: very pleasant)"- five subjects answered "5: very pleasant" or "4: rather pleasant" (M: 3.71, SD: 0.88). Additional comments were as follow: "I had fun imagining the behavior of the person" and "the representation of home activities using sounds like a music box is comforting". These results suggest that most subjects had a favorable impression of the HomeOrgel music.

Evaluation summary

In this evaluation, subjects could understand the correct activities and their frequency of occurrence. Moreover, most subjects had a favorable impression of the HomeOrgel music. These results indicate that the HomeOrgel performs sufficiently well for users to look back on home activities casually.

Category	Raw Answers (number)
Sound of entrance	"Ding Dong"(3), "sound of intercom"(1), "chime"(3)
Water sound	"water sound"(3), "sound of flowing water"(1), "splash"(1), "sound of bathroom"(1),
Sound of cutting	"cutting using knife"(4),"cutting something on cutting board"(1), "thock-thock-thock (cooking)"(1)
Sound of using fire in the kitchen	"sound of frying"(4), "sizzling"(1), "sound of burning"(1)
No sound	

Table 4. The categorized answers to question (1): Please write all sounds you hear?

Category	Raw Answers (number)
Cooking	"cooking"(7), "cutting veggies with knife"(1), "pan frying something"(2), "washing dishes"(1)
Coming home or receiving a guest	"someone came home"(3), "having guests"(1), "someone visited"(1), "someone visited or the resident came home"(1)
Eating	"eating something"(1), "having food"(1)
Others	"turning on taps"(2), "running a bath"(2)

Table 5. The categorized answers to question (2): "Please write all events you imagine occurring from the sounds? "

Sound	Answer number	Reason
Water sound	3	I don't know the difference between bathroom sounds and cooking sounds.
Rest of sounds	2	I don't know the difference between absence and sleeping.
Intercom sound	1	I don't know the difference between the sound of receiving guests and coming home.
Others	1	The volume was not loud enough to hear clearly.

Table 6. The categorized answers to question (4): "Please write symbolic sounds that you cannot understand?"

DISCUSSION

We discuss the HomeOrgel based on the results of the evaluation in following aspects: " Extension of sound expression", "Extension of sensors" and "Controlling variables".

Extension of sound expression

As mentioned above, our system used symbolic sounds in consideration of sound quality and privacy issues. However, some subjects wanted more realistic, sounds such as conversation, laughter, footsteps and the sound of typing on a PC keyboard. Here, we discuss the possibility of applying such sounds to the HomeOrgel.

First, we discuss the possible improvement of the HomeOrgel in terms of the "improvement of symbolic sounds" and "expression based on the frequency of activities." Next, we discuss the advantage of using "family voices" and its potential problems. We also discuss the possibility of designing additional sounds to capture the "characteristic sounds of each family".

Improvement of symbolic sounds

In the evaluation, subjects could generally understand the activities taking place and their frequency of occurrence. This indicates that the symbolic sounds are effective in representing home activities.

However the results of the evaluation also reveal limitations to the symbolic sounds with the subjects having difficulty in understand the activities based solely on water sounds. To avoid these limitations, we need to provide more concrete aural presentations for activities related to water. To this end, we plan to use a combination of symbolic sounds. For example, we would express the activity of "washing dishes" by combining several sounds sequentially: "water flowing", "dish clatter" and "dish cleaning". Similarly, we would express the activity of "taking shower" by combining the sounds of "turning on the faucet" and "water droplets falling like rain".

Expression based on activity frequency

Our current system applied fixed parameters (e.g., volume and pan) for each activity. We plan to vary these parameters based on the frequency of activities for further expressiveness. For example, the system would increase the volume of sounds when (1) the same activity occurs more than once in a short period or (2) a "rare" activity occurs after a long interval (e.g., someone comes into an area which is seldom frequented).

Since excessive changes to the sound parameters may cause difficulties for users to actually hear the music and recognize the activities, we should consider the balance between simplicity and expressiveness.

Using "family" voices.

Since some subjects wanted family voices (e.g., conversation and laughter) in the evaluation, we also considered the possibility of using family voices. By hearing the voices of their family members, listeners can feel the presence of their families and become familiar with the system. Additionally, listeners may recognize the family status more accurately from voice tones. However, the system requires the attachment of many microphones in the home to record the voices.

Moreover, these raw voices may cause privacy issues. To avoid these problems, we consider limiting the recording locations (e.g., only at the entrance and living room).and modifying the recorded voices (e.g., playing voices backwards).

Characteristic sounds of each family.

Each home has its own characteristic sound depending on each family's habits (e.g., child's hobby). These sounds may help listeners recall their family members more directly. For example, when a user has a piano at home, he/she can imagine that his/her daughter is practicing the piano from piano sounds. Moreover, when a user has a cat at home, he/she may imagine the cat's status (e.g., eating and playing) by hearing the cat's voice based on its status. However, these extensions need additional sensors to detect each event (e.g., installing a magnetic sensor on the cover of a piano). We will discuss this point in greater detail in the following section.

Extension of sensors

In this evaluation, the activities the system detected were occasionally incorrect because we applied a simple detection method based on location. For example, when the experimenter went to the refrigerator to get a drink, the HomeOrgel generated the sound of "cutting vegetables" because the refrigerator was located in front of the cooking table. This problem can be solved by attaching additional sensors at various locations (e.g., installing a magnetic sensor on the refrigerator).

Moreover the system occasionally failed to detect activities. For example, the system failed to detect the activity for "16:30-17:30" when the experimenter was working in the living room (Table 3). This problem is caused by the characteristic of motion sensors in only detecting human "movement". Therefore, the sensor could not detect the experimenter because she hardly moved while working on the PC at "16:30-17:30" (Figure 9). Similarly, the current system cannot distinguish staying at home without movement (e.g., sleeping) from going out from home. To solve these limitations, we plan to apply a recognition method based on historical data of user's movements between locations For example; the system may estimate the user's status using the "final location" before movement ceased: when the final location is an entrance, the user probably left home, since he/she hardly stays at entrance for long periods. Similarly, when the final location is a bedroom, the user is probably sleeping. As mentioned above, the system needs additional sensors to extend sound expression. For example, we need to attach a magnetic sensor into the cover of the piano to detect the activity of "playing a piano". However, we should take into consideration the difficulties associated with installation in an everyday household environment. The results of this evaluation verified that the current system is effective to some degree because the subjects could understand the correct chronological order of the experimenter's activities. We should improve the system further through consideration of the trade-off between the accuracy of event detection and the number of sensors.

Controlling variables

We discuss here some variables of the HomeOrgel: "rewind interval" and "music interval". In the current system, the home activities for a 1-hour period (=rewind interval) are compressed into 10 seconds (=music interval) of music to help users recall activities from approximately one day. However, we may need to change these settings based on situations. For example, a shorter rewind interval (e.g., 10 minutes) is appropriate in the case of scenario 3 because the user here wants to check current home activities. Although these variables can be changed by software settings, we plan to provide more intuitive methods to control them. For example, when we attach a RFID reader inside the device and RFID tags onto small objects, the user can select settings simply by placing the object[9] into the device.

RELATED WORKS

Bottles[7] is an interface to access digital information using glass bottles as "containers" and "controls". Although this system focuses on different applications from our system, the basic approach of using familiar objects for representing sound information is similar.

Several research projects have adopted visual content to represent home activities. For example, Video Window System [4] records the users' rooms using video cameras, and shares the data among users via a permanent connection. Although this system allows users to provide and receive complete information, it may cause privacy problems. Additionally, users need to focus on the display to obtain the information.

There have been several research projects that represent home activities using ambient information. Digital family portrait [12] provides qualitative visualizations of a family member's daily life. Leveraging a familiar household object, the picture frame, this system populates the frame with iconic imagery summarizing for several weeks. The ambientROOM [8] is an interface to information for processing in the background of awareness. This information is displayed through various subtle displays of light and sound. Although these ambient displays can solve problems of privacy and user disturbance, users may have difficulty in understanding multiple simultaneous activities as they need to learn the mapping between activities and representations in advance. In contrast, our system can provide clear mappings between sounds and activities using symbolic sounds.

There have also been several research projects that represent home activities using sounds. Music Monitor [15] illustrated how music can be used to balance attention between two active rooms in a home, with an initial focus between the kitchen and living room. InPhase [16] proposed a new method of communicating the "happy coincidences" between a pair of remote locations using sounds. While these systems represent rather limited activities, HomeOrgel represents a wide range of activities in the home using symbolic sounds. Moreover, a user can understand most activities simply by listening to the corresponding sounds without any advance study of the mapping. Additionally, our system can help users look back on past activities easily using techniques common to the control of a music box.

CONCLUSION

This paper proposed a music-box type interface, "HomeOrgel", which can express various activities in the home using sound. We developed the HomeOrgel prototype, which consisted of several sensors and a speaker in a ready-made music box, and installed a simple activity recognition system in an actual house, "Ocha House". Based on the actual data collected in Ocha House, we performed an evaluation study to verify the performance of the aural representations of the HomeOrgel. Results showed that subjects could understand most activities correctly as well as their frequency of occurrence just by listening to the HomeOrgel music. Moreover, most subjects had a favorable impression of the music. These results indicate that the performance of the HomeOrgel was adequate for the users to review and recall home activities on a casual level. Our current aim is to further improve the HomeOrgel system in terms of sounds, sensors, and interaction.

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