

Smart ARbnb: Smarthome Interface for Airbnb with Augmented Reality and Visible Light Communication

Tomas Gecevičius, Yaliang Chuang *, Jingrui An

Dept. of Industrial Design, Eindhoven University of Technology, Eindhoven, the Netherlands

tomas@gecevicus.lt, y.chuang@tue.nl, j.an@tue.nl

ABSTRACT

Peer-to-peer rental services are continuously growing in the sharing economy era. There also are more and more houses with smarthome system added into the market. The hosts originally designed the automation system to improve the comfort and convenience of their own lives, but also shared it with guests for enhancing their experiences while the hosts were away from home. However, due to the lack of communication, the guests might encounter negative experiences when the automation took place without perceptible in-situ feedforward and feedback in advance. In this study, we developed a web-based application that combines augmented reality and visible light communication to control smart home devices. The tool uses a mobile camera to scan IoT communicators, let users change connected devices' settings, and visualizes the current set automation. Additionally, guests can use presets to change the atmosphere, creating a wonderful experience. Our user study shows users preferred the web-based system rather than installing new apps. The interaction experience was easy to use and overall positive. Our AR interface provided direct controls of the appliances and clear explanations of the functionalities. While users recognized the usefulness of the physical feedforward shown with LED interfaces, some users could not interpret the meanings initially, and sometimes the blinking lights were distracting. We highlighted several design considerations for improving the understandability and guest experiences for staying in smart accommodations.

CCS CONCEPTS

• **Human-centered computing** → *User interface design; Empirical studies in interaction design; Ubiquitous and mobile computing design and evaluation methods.*

KEYWORDS

Automation, Smarthome, Feedforward, Situational Awareness, User Experience, Mental Model

1 BACKGROUND

Smarthome recently becomes increasingly ubiquitous with the popularity of Internet of Things (IoT) technology and products. It brings comfort, energy efficiency, and security to homeowners [7] by letting them control the devices through their smartphone or self-operated with automation rules. These features can provide superior user experiences in simplifying daily routines, such as automatically switching off appliances when users left home or adjusting the home temperature in advance to when users are on the way back home. Furthermore, when users are away from home for a business trip or vacation, the system can also give users peace of mind by monitoring the house for users and simulating people's presence with random lights to scare away intruders.

Smarthome is also a life-changing tool for Airbnb hosts to ensure the safety of the rental accommodations and cut off the energy costs. Hosts can remotely let guests enter by using the smart lock or give access only for a limited amount of time. They can also remotely check the temperature with a smart thermostat and switch off the system when guests are not staying inside. One of the reasons hosts are using smart devices is to monitor the Airbnb property and guests' activities, for example, by installing outdoor cameras or noise sensors, hosts are checking if the visitors are not creating big parties in their place and are not bothering neighbors with the noise [4]. In addition, 60% of people would pay more if the listed rental place has a smarthome system [5].

Customer satisfaction is an important factor when providing a service as it delivers useful behavior after the purchase, for example, helpful word-of-mouth or repeat visitations, resulting in growing profits [10]. For the guests who do not have a smarthome system at their home, this kind of technology in Airbnb rented apartments brings an innovative experience. From accessing the property without a physical key to getting a fresh cup of coffee when they wake up it makes the stay in the rented accommodation special [8]. The smarthome system in hosting brings profits and saves energy costs, while also provides a unique experience that guests prefer.

2 RESEARCH QUESTIONS

While smarthome provides significant benefits for the hosts, the guests might lack a corresponding understanding of the systems. Guests usually feel uncomfortable around smart devices regarding privacy and do not understand how everything works. Very often, hosts are not always present to help guests check in the property and explain how the system works. The lack of guests' experience and understanding of the smarthome system can lead to unexpected losses of time, money, and complaints [9].

3 METHODS

We applied the research through design methodology[12] to explore the "Smart ARbnb" system we developed for solving the abovementioned problems and improve guests' experiences in a smart accommodation. It consists of multiple devices equipped with tangible IoT communicators [3] (Fig. 1) and a web-based interface that could be used on various mobile devices.

Web Application of the Smart ARBnB

The first part of the prototype is a web application. The website is a tool that uses a mobile camera to detect smart appliances in the environment by reading IoT communicators' light patterns (Fig.2). In the Airbnb context, the guests should have a quick and simple way how to interact with

the smarthomes. To avoid creating additional mobile applications that guests would need to download and install, a different approach was selected - to create a website that could be accessible only in the local home network with the ".local" domain or by tapping the IoT communicators' integrated NFC tag with your phone. After reading the visual light pattern the web interface gets the control from the smarthome system and gives access to the settings of the devices.

The other functionality of the web application is atmosphere selection (Fig.2b). A list of automation presets that the host could create and guests could choose to execute, for example, "Romantic time", "Dinner with friends", "Dance party", could create a perfect setting for unforgettable memories. The shown atmosphere should be relevant to the user's current context - showing options that control only the room devices the user is in and based on time of the day. Moreover, the interface could show suggestions that are connected with the scanned device, for example, when controlling music speaker, it could suggest local traditional or popular music playlists, or when interacting with motorized blinds in the morning, it could offer to use "Morning routine" automation. In addition, the UI should indicate upcoming automation that is linked with the current scanned device, issues if something goes wrong, for example, the battery is low, the device lost connection to the network, etc. Besides that, the host could attach a notification or a message to the devices, informing the guests that they changed the device settings remotely or telling other relevant information (Fig.2c).

In addition, during the research it was found that hosts prefer to control the smart appliances remotely by themselves in order not to let the guests set the settings too high,

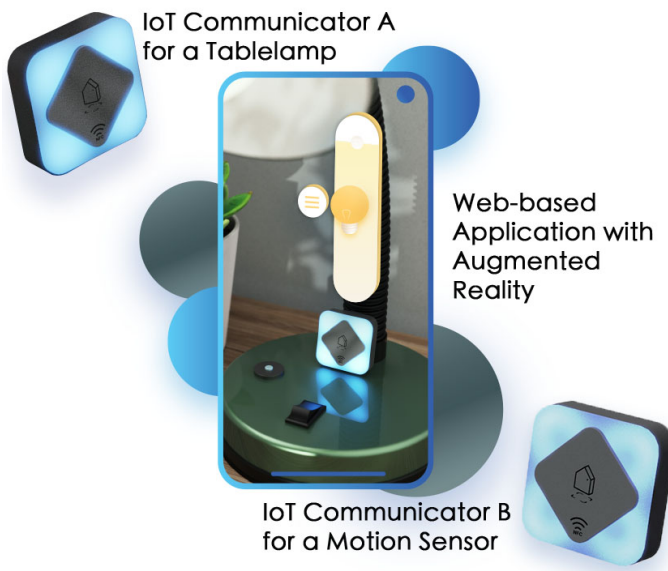


Figure 1: The "Smart ARbnb" system developed in this study. It consists of tangible IoT communicators with visible LED lights and a web-based interface with Augmented Reality feature.

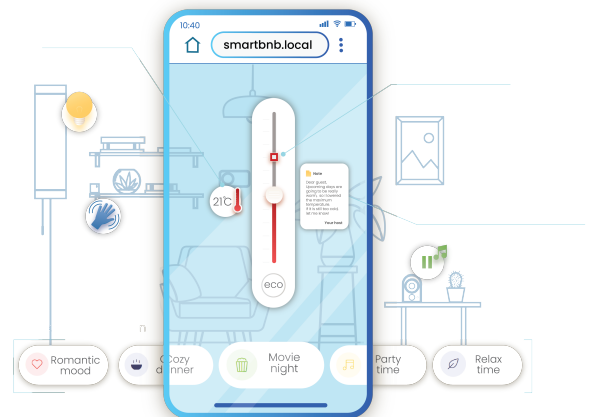


Figure 2: The user interface of the web application.

for example, with thermostat increase the temperature, thus rising the energy consumption costs. For this reason, many hosts are not letting the guest access the smarthome interface at all. To find a compromise, the maximum or minimum value could be set by the host for each of the device settings (Fig.2d). In this case, the host can be sure, that the guests will not heat the accommodation too much or will not play music or TV in the night too loud, thus disturbing neighbors.

Furthermore, guests who come to the new accommodation are not aware of the current set automation in the smarthome system. This web application should show the automation overview and if needed, visualize which devices belong to selected automation (Fig.3). For a smarthome system, especially in the Airbnb context, privacy is important, therefore people prefer to have a smarthome server locally rather than cloud-based[11]. Our Smart ARbnb system could be fully operated with the local network.

Physical IoT Communicators

The second part is the IoT communicator which is a battery-powered coin size device (Fig.4) that is attached to each smart appliance in the home. Each also has connected to the smarthome system and equipped with integrated LED lights for providing feedback and feedforward to users. This device uses visual light communication, a specific, morse code inspired, light pattern to broadcast the identification number of the smart appliance. While the smart appliance market is rapidly growing[8], guests might not be able to understand which devices are smart and which are not, so the IoT

communicator light also acts as a visual indicator of the placement of networked devices. In addition, smarthome systems are not expressive, they do not visualize what is happening with the system or smart devices. The IoT communicator’s lights can be used as a “Peripheral interaction” display [1], indicating the feedforward or feedback from smarthome automations, showing issues or notifications from the devices and messages from hosts. Light patterns are shown in Fig.5. This device’s most important part is a LED light, so this functionality can be easily incorporated into the smart device itself and no extra devices would be needed to have near each smart appliance. Nevertheless, when different smart appliances and home systems still do not have standardized network protocol to increase the compatibility with different brand devices, it is highly unlikely that this kind of proposed AR interface would be incorporated inside of them, thus separate IoT communicators are needed.

In the Airbnb context, the guests should have a quick and simple way how to interact with smarthomes. To eliminate the hassle of forcing guests to download and install a new application on their devices, a different approach was selected - to create a website that could be accessed only in the local home network with the ".local" domain or by tapping the IoT communicators’ integrated NFC tag with your phone. After reading the visual light pattern, the web interface gets control from the smarthome system and gives access to the devices’ settings. Research showed that Airbnb guests have some difficulties with controlling appliances [6], like the oven, dishwasher, or washing machine. In addition, in the Airbnb accommodation, guests can come from different countries, so the interface should be multilanguage and also focus

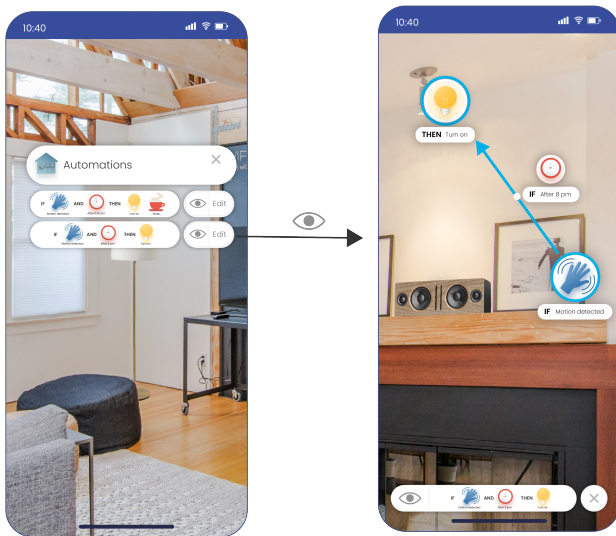


Figure 3: After the system detects the devices with the camera, a user can switch to the automation overview to see the explanations of related rules set for the devices.

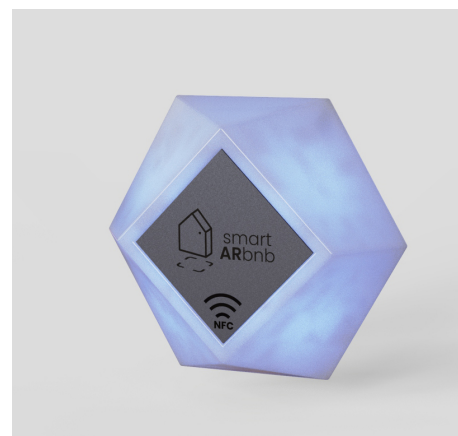


Figure 4: The physical IoT Communicator. It could be linked to a smart appliance and allocated aside. It can display alternative LED lighting patterns for serving two purposes: (1) for Smart ARbnb system to detect its location and status, (2) giving user corresponding feedforward and feedback.

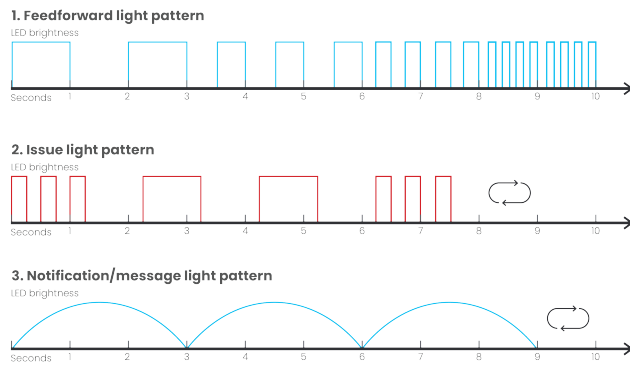


Figure 5: The three different lighting patterns designed for the IoT Communicators to notify users the particular system behaviors with users' peripheral perceptions.

more on the visual elements, like icons to indicate what is needed. By providing a simple and informative interface (Fig. 3), guests should avoid usability or misuse issues.

User Study

A user study is conducted with five participants to evaluate the design concept and the usability of the prototype. The research was performed in a studio-type apartment that has a working smarthome system with few smart devices - two Philips light bulbs, a Philips hue light strip, a connected speaker, a motion sensor, and a thermostat. In total, six IoT communicators were used and scattered in the studio. The smart device and IoT communicators' placement can be seen in Fig.6. We adapted the experimental setup used in [2] to collect users' interpretations and user experiences of our design concept with thinking aloud approach. After completing the testing, we also conducted a semi-structured interview to collect their feedback on improving our design.

4 FINDINGS

The results indicate that participants look positive about this concept. Users value the exciting experience it creates - "I can imagine if I use this in every place, I would first just try out everything. Yeah, so it's like quite exciting" (P2) and also the gamified feeling: "It was a nice experience. I really liked that scavenger hunt feeling, that you are walking with your phone and searching for the sensors, you don't know what you are going to find. It's really fun" (P3). Furthermore, users liked that it is easy to use application - "It's incredibly easy to learn it's the procedure" (P4), "Aesthetically pleasing, easy to understand, allows to avoid using voice commands" (P3), "That's the power of this (product), like, you only need to learn once, and once you've seen it, then you know it's quite

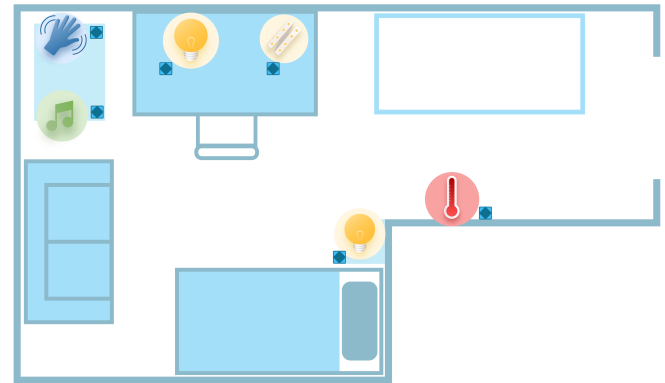


Figure 6: The layout of the studio apartment and positions of the six devices used in the user study.

easy" (P1). In addition, participants favored that the interface is in a website - "Everything looks cool and quite cute, but I don't like to install any apps, but if it is made on the website, then it is awesome" (P3). Moreover, the atmosphere selection was an appreciated feature - "...the ambient settings are super nice when you want the right settings in a second" (P4), "But still, like the Ambient setting it's really cool. You just come in, feel like this and 'pop'. That's really the best" (P1). In overall, participants are positive about this project because it is easy to use, creates an exciting experience, it is quickly accessible and it helps them quickly change the environment to their needs.

The important factor of satisfaction with this concept is the experience of being around the lighted up IoT communicators. The user study showed that the opinions about it are contrasting. Three out of five participants felt the physical interface was very helpful. The lights create a feeling that the smarthome wants to interact - "They're blinking. They try to tell me something" (P2), "It seems that they want my attention all the time" (P3). The IoT communicators also bring curiosity and help to find the smart devices in the accommodation - "The feeling was quite nice, it was intriguing" (P3), "But it is very good to find them because if it didn't light up, I wouldn't have found them [i.e., smart appliances]." (P1). On the other hand, two participants said that the blinking IoT communicators lights might be annoying and overwhelming - "They neutral well with the slightly negative though, because there's still a bit distracting" (P4), "I feel like these lights might be a bit too much might be a bit overwhelming. When you're being confronted by lights at the sudden from every direction" (P5).

Besides the interpretations, we also noticed that the light color could be adjusted to enhance the specific meanings of the message. For instance, P4 mentioned that "Notification

should be more direct, it is too calm for it." Similarly, P1 also said, "I would use more 'Blink Blink' solution." Since the notification light pattern color was connected more to the thermostat functionality rather than to the pattern itself, the color should be changed to more neutral, like white or violet.

5 CONCLUSION AND FUTURE STUDY

After researching the smarthome systems in the Airbnb context, the main problems as confusion and misuse of appliances, unawareness about the current set automation, and lack of expressiveness of the smarthome system. Among them, the accessibility to the smarthome interface are found, which can outweigh the benefits like energy, cost savings, and pleasing home automation that could create a nice atmosphere or experience for the guests. To overcome those challenges, we developed a Smart ARbnb system for guiding guests' onboarding process and facilitating them to use the smart system properly.

We conducted a user study with five participants to evaluate the usability and design concept. Their overall experience of the interaction and system appears to be positive, and all users would like to see the "Smart ARbnb" system inside the next Airbnb accommodation place. While users recognized the usefulness of the physical feedforward shown with visible LED lights, the information was not intuitive to some users. Sometimes the blinking lights were distracting.

In future work, the user interface and lighting patterns can be improved and evaluated regarding the understandability of the automation overview and better balance between notifying users and distracting their attentions.

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