Communicating with Space and People

Smart Interface Design for Enhancing User Awareness and Interactions

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Smart space design has become an important research paradigm because of the emerging information and communication technology, smart materials, and sensory technology. A space equipped with human-computer interfaces, communicates not only with space but also with its occupants. In previous researches, the focus was on developing smart houses which made decisions for its occupants on controlling the condition of space. However, the human tends to make choices and the subtle psychological changes of occupants may derive exceptional decisions. Therefore, this paper aims to propose smart interfaces in house design, i.e., the "Individual Sense" concept is introduced by examining the assumptions and cases. This research probed into how the interface is characterized by individual actions. The "Individual Sense" is implemented on the basis of commonsense for reasoning potential interactions and demonstration and discussion are reported.

Keywords: *Smart space; human computer interaction; interface design; house sense; commonsense.*

Introduction

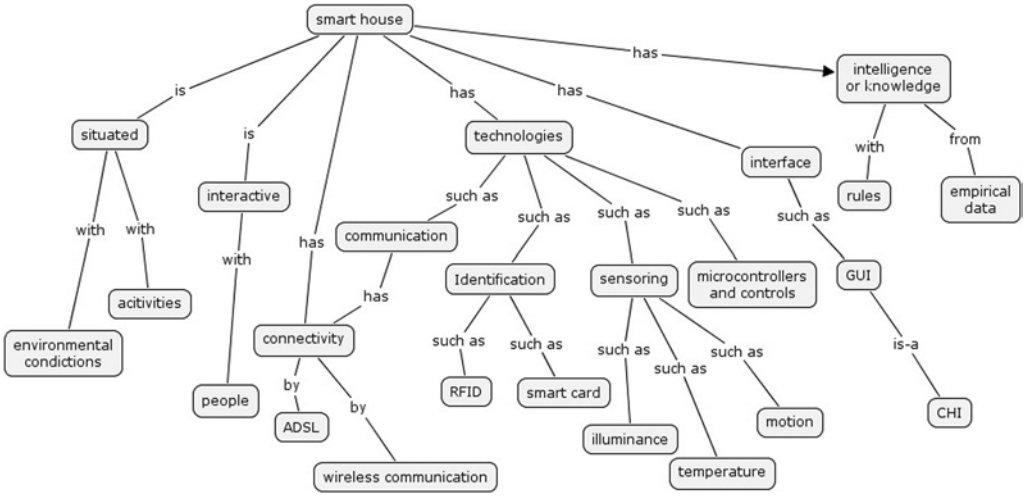
The emergence of ubiquitous computing and smart technologies become the impetus for novel spatial design in the information era. Smart space design has become an important research paradigm. In previous research, the major advancement in smart house design by a world-wide survey of smart environments is summarized in a concept map, illustrated in Figure 1 (Chiu et.al., 2006). The findings indicate that most researches focused on the adoption of technologies and its applications in daily activities and not addressing sufficiently user needs. It is critical to reconsider the house design from the user and environmental point of views.

A smart space is no longer a static container of living objects, but an information interface for facilitating living conditions. Therefore, this paper aims to propose smart interfaces in house design, i.e., the "Individual Sense" concept by examining certain assumptions and cases. The aim of this research is focusing on communicating with space and people by smart interface design. Smart living interfaces are introduced, demonstrated and discussion.

Methodology

Because the human body is situated with various conditions, obtaining "sense" (such as touch, vision, smell, taste, hearing, and balance) is the basis to maintain human body or buildings. Smart houses present an analogy to the human body in terms of functionality. Communicating with space and people is an important research issue for smart space

Figure 1
The concept map of a smart house



design. The design concept of "House Sense" is previously proposed to form an analytic framework to study the relationship between information, user and activities, and consequently to create computational supports; and finally discover patterns built up by users' behaviors and actions. Therefore, smart interface design is proposed for enhancing user awareness (of status, events and preferences) and interaction. Smart house design should be integrated with "House Sense" that is capable to gain a general conscious awareness about the living activities surrounded by occupants in a house embedded with sensors, space locators, and Radio Frequency Identification (RFID). House Sense reasoning mechanism is applied to preliminary implementation as shown in Figure 2. Therefore, the "House Sense" and later "Individual Sense" are capable of reasoning and generalizing the future possible actions of users and gives out different modes for user's choices.

Based on the notion of House Sense, Individual Sense is further developed. In this paper, different scenario-based design simulation are presented to describe the possible situations that will occur is a housing unit and how the HCI system communicate with its users. Furthermore, the simulation can envision the scenarios by adding interfaces for enhancing user awareness. And the interactive devices proposed in the living scenes can bring out the appropriate "cues" for reminding users and respond to users' needs. The details are depicted in the following sections.

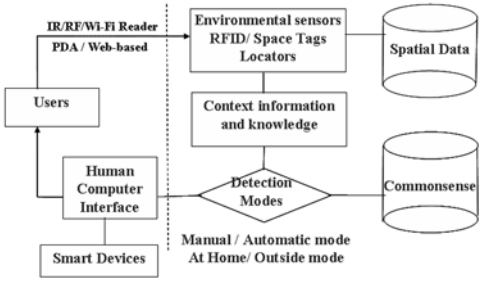


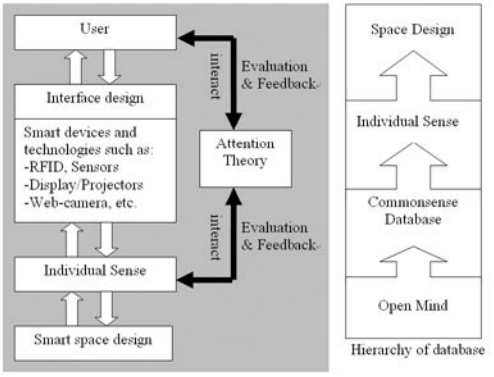
Figure 2
The System Framework of House Sense

Commonsense-based smart space interface

Previous research focused on developing a smart house where computers can made the decisions for its occupants. However, the psychological statistic revealed that due to the human nature, users still prefer to make decisions by themselves and control the situations which occur to them. Users enjoy the

convenience brought by the technology yet hope to have choices. Instead of making decisions for them, users show favors of suggestions and modes that computer gives to them for their free choices. The study builds the basic scheme based on the Commonsense database. Later the behavioral study is combining the Attention theory. As shown in the system framework in Figure 3, the visual attention theory is applied to examine the effectiveness of how to communicate with space and people, new approach for smart house design is therefore proposed.

Meanwhile, common sense is being commonly used for reasoning daily activities. Programs with Common Sense was first initiated in McCarthy (1959) and becomes the impetus for interface design (Minsky, 2000). Commonsense-based technologies enable an entirely new type of applications, ones that are actually "smart" in the sense of understanding the user's situation and goals somewhat like a real person would (Commonsense, 2006). It acquires large amounts of commonsense knowledge automatically from such sources as the Web, from observing people through speech and sensors as they live their lives, and by interacting with simulated worlds. Recently, some system prototypes are applied to smart space design. For instance, Kitchen Sense was developed by the MIT Media Lab based on the Commonsense database and ConceptNet (Lee, et al, 2005). It provides the potential direction for smart space design.



Individual Sense

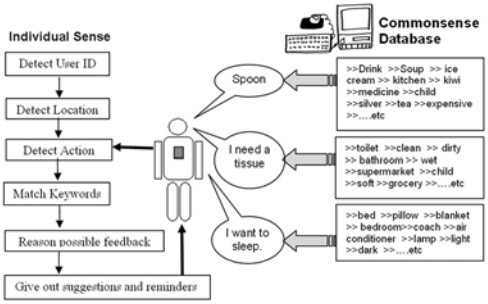
Individual Sense is presented to picture how the system controls the individual information in a space. Figure 3 shows not only the hierarchy of database but how the interactive interface design triggers new space design. The basic scheme of the interface was deriving from the Commonsense database that collected over millions of keywords including actions, locations, items, and verbal sentences. Individual Sense uses commonsense database to do the keyword matching. While a single question sentence is brought up by users, Individual Sense match keywords and gives its users the result of text-reasoning for analogy making. Furthermore, it reasons the next possible action of users and listed all the possible choices for users. Later the behavioral study is combining the visual Attention theory to examine the effectiveness of how to communicate with space and people.

The smart house which is equipped with Individual Sense is able to provide different information and analogy-making feedback to users, Figure 4. Individual Sense uses metaphors, such as cues and symbols to remind users about what they may need to notice and give users options for next steps. Within this process, Attention Theory is applied in Individual Sense to draw the attention from users. The cues are visual or audio designed under the manipulation of Attention Theory that helps to evaluate the reaction of users. In different spaces and assorted scenarios, Individual Sense differentiates the level of privacy and displays the information for a certain user appropriately. In different scenarios, the simulated conditions describe how the smart space and user interact. By using Individual Sense as an interface between the house and users, a user wears a device which is communicating with the HCI system of this space enters a room, the system is recognizing user's identification and monitoring his physical sign. It speculates on user's actions and living pattern, then, provides

Figure 3
Framework of Individual Sense and the Hierarchy of Database

Figure 4
Diagram of how Individual Sense works

Figure 5
The process to determine clues for awareness



its user the information or reminders by giving out cues and symbols, Figure 5.

While the user is performing a certain kind of actions regarding his preference about accessibility, mobility, or privacy, the attribute of the space is transforming. While the physical condition and background of a user changes, the attribute of the space transforms and the smart space makes appropriate feedbacks to users. Individual Sense database will function in according with the following procedure:

1. Detect user's Identification - To access user's preference & schedule
2. Detect the location of user - To detect possible actions
3. Detect the actions of user - To reason possible intention
4. Match the keywords - To give out more precise feedbacks and suggestions
5. Give out feedbacks

Information Interface Design for Privacy Concerns

In environmental psychology, the definition of privacy is that an individual has the control of deciding what information of himself is released to others and under a specific circumstances, how he interacts with others (Westin, 1970). Privacy is categorized as linguistic privacy and visual privacy. The former means conversations cannot be heard. The latter means subjects cannot be seen (Sundstorm, 1986). With the help of new materials, sensory technology and the human-computer interaction, a space is no longer a static room. The relationship between space and information are classified into 4 categories (Table 1). While designing an interactive space

to enhance living conditions, the privacy is an issue that should never be neglected. However, the definition of the attribute of a space remains the same, the dichotomy: a space is defined as either private (individual) or public (shared). Unlike traditional space, people used to categorized the attribute of space into public, semi-pubic and private, the attribute of a smart space is not fixed and the space should be adaptive to various users' needs. Therefore, the attribute of a smart space should be defined by users' actions and behaviors.

	Private Space (Individual Space)	**Un-Private Space (Shared Space)**
Private information (for individual)	Scenario I e.g. Bathroom	Scenario II e.g. Living room
Un-Private (shared) information	Scenario III e.g. Bathroom	Scenario IV e.g. Living room

Table 1
Information vs. Space

In this research, user's need for privacy can be detected in a smart space which is adaptive to different users for enhancing the user's awareness in his diary life. The interactive device is capable of determining the privacy level of the information which is going to be released. And it transforms the information to appropriate cues to present to the specific user. There are several solutions for privacy control:

1. Plan Layout – the plan layout can reach the privacy control by designing winding circulations or multi-stories of floor plans. The access of each room is controlled by the user who owns the key. This is the most common solution for privacy control. This method controls the accessibility of the space but the disadvantage is that once user's demand of the space changes it requires money, labor and time to remove fixed walls.
2. Vision Boundary – use wither solid or movable partitions to obstruct others' views to maintain user's privacy. The partition can be opaque or flexible.
3. Access Control – partitions are not necessarily opaque but are able to stop others' access or to stop the content of conversation from leaking. This method is mainly focusing on information control.
4. Metaphor – the transmission of information is not ascertainable for every single user. Although information is showed in public, the information is implied by hints, cues, and symbols. Only a certain user or a group of users who have access to the information understand the content of information.

The above solutions will be integrated and applied in the following smart space and interface design. Human activities rely on accessing information for interaction, and these are related to 6W (who, where, what, when, why, and how). Different kinds of scenario simulations explain the communication of the space and its occupants, Figure 6. For example, in scenario II, the owner of the house wears a portable device that Individual Sense can detect his/her identity and immediately inform him/her the condition of the house, including if there is incoming messages or unusual events occurred in the house. If the user is not alone, Individual Sense detects the other occupant's identity and determines if the information which is about to release is concerning the user's privacy. If the reasoning is positive, the system switch its mode to "Private" and displays the information where only the user can access.

Although some information is private and needs to be concealed from the public or others, there are also exceptional case that the system addresses. For instance, the information regarding user's medical records is private and confidential. Only the user himself and authorized persons can access the data.

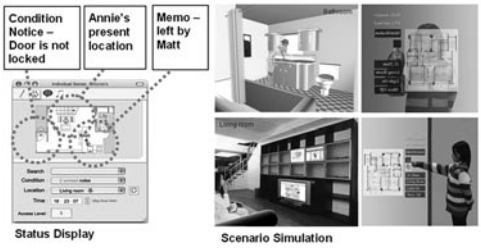
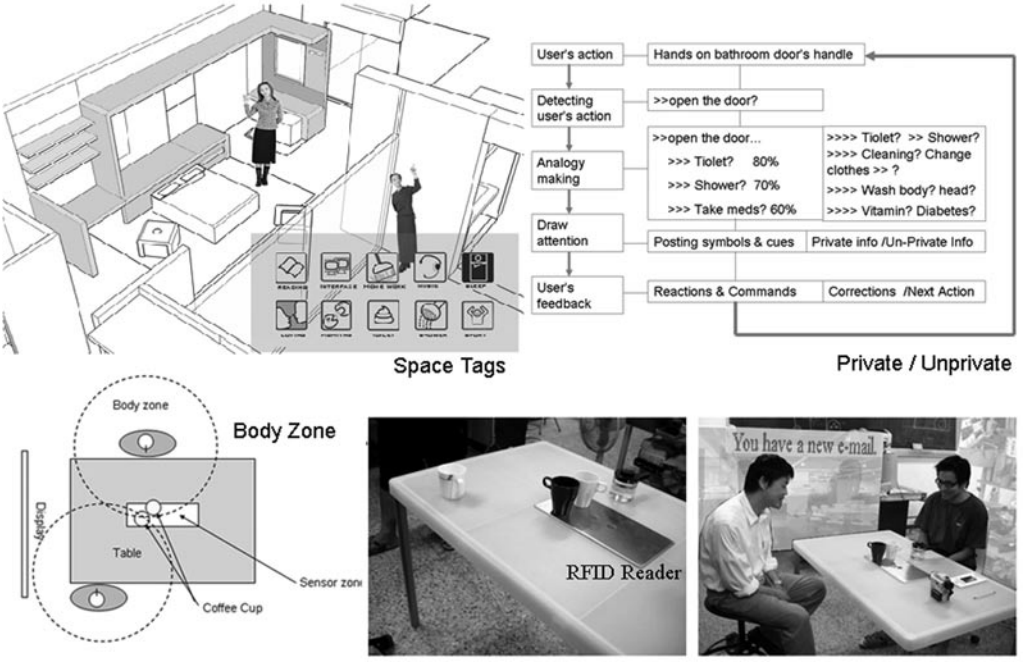


Figure 6
Scenarios-based Simulation

Figure 7
Information revealed for privacy concerns



Yet, if the user is an elderly person living alone, this designed space with Individual Sense is programmed to be aware of the living safety. In case of emergency, the system detects the user's physical conditions and decides when the user cannot handle the emergency and successfully help himself out. It reacts by calling for help by notifying the medical system and user's family. How and when is the right time for the system to give the authorization of accessing a person's private information is the next issue to study.

Discussion

For users, the capability to react, interact with smart objects are important for interface design. The above findings provide the foundation for further discussion.

Interface Design for Communicating with People and Space

The study had proposed three prototypes of interfaces (namely - Body zone, Space tags, Privacy /Un-private) to demonstrate that smart houses are capable of enhancing sense of places with smart design concepts, Figure 7 (Chiu, 2006). In addition to Private/Un-Private, Body zone has defined the working area for wireless communication and the sensor zone for RFID reader. Space tags are physical or virtual objects that can be used to retrieve spatial information for reminding events or triggering displays and controls. Individual Sense integrated these three prototypes of interface and enhances users' awareness of a smart living space. The study findings indicate that designers' role is no longer just to apply state-of-the-art technologies into design, but rethink the space and user requirement smartly in the future house design. Smart house will be human-centric, not building system or electronic

devices oriented. In responds to various user needs, human computer interfaces can be integrated with sensor technologies and smart devices for easy accessibility and privacy. For instance, the interactive device is capable of determining the privacy level of the information which is going to be released. And it transforms the information to appropriate cues to present to the specific user.

Future Individual Sense Development

Common senses are generally used for daily living activities. With data mining and reasoning in Individual Sense, the system employs the common sense database to reason the next possible activities, related tools, and locations that the user may be, and gives its user some choices and suggestions to remind user. In particular, when users are patients, elderly people or young children who need help to perform certain activities in their daily life, Individual Sense offers them some useful reminders. For example, patients sometimes forget to take their medicine on time, with the help of Individual Sense, they can easily find where the medicine is, when is the right time to take it, any necessary preparation and the dosage in order to prevent an overdose. For young children, Individual Sense helps them to stay away from dangerous items, such as stoves, and helps parents to be aware where the children are and what the children may need.

Awareness of Social and Psychological Aspects

In previous smart space designs, most of them focused on how the electronics works in a space, however, users' backgrounds and the reactions to the space are neglected. While obtaining personal needs, there may have some conflicts. There are psychological and social issues mainly related to personal privacy.

Psychologically, human beings have complicated characters and no two are the same. But there is one thing similar and that is everyone is looking for a secure and comfortable space. The gender shows the differences between women and men when they are facing the same situation. A bathroom without a lock may not cause any insecure feeling to a male, but it does cause insecure feeling to a female. It is concerning the privacy demand of female. Female usually concern higher level of privacy. Individual Sense is adaptive to each user basing on its data mining and documentation of users' preference.

Socially, an old grandfather may not be eager for the stylish design of the house, but some interactions with his sons and grandchildren. By using personal familiar pictures as cues and space tags, Individual Sense tries to be customized for each occupant of the house, and creates a tender interaction for family and also the space.

Conclusion

In this paper, a smart space equipped with Individual Sense is capable of responding the users' need based on reasoning users' behaviors and actions. The goal is to develop a better living space for different users with different physical conditions. The attribute of the space is not fixed but constantly transformed with the demand of its user. The adaptive space is not only interacting with it users but also enhances users' awareness.

Afterward, the aim of this research is toward simulating the scenarios based on privacy or other concerns for different user groups such as patients, elder people, young kids, and who needs memory aids. The feasibility of the prototype system and interface design reveals the potential direction for the future development. A new way of designing interface is to integrate the ubiquitous computing technologies and smart space interface. These raise the importance of computer-enhanced interface design, and preference controls (individual vs. group) in future smart space design.

Acknowledgements

This study is partial supported by the NSC Grant 94-2211-E-006-063. The authors want to thank Jackie C.H. Lee for his advice and supports in developing Individual Sense.

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