Contextual Bricks

Creating an Intelligent Sensing Interface Invisibly

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Abstract. *Based on the importance of human behavior analysis in HCI research, this paper discusses the property of interaction in sending/receiving direction with diverse cases. A unit of contextual bricks was created as research model continuing to discover the possible solution on the problem that how to merge the novel media and technology into our living space invisibly with the exhibition of appropriate information. The prototype of contextual bricks preserved the characteristic of stability with cellular hexagonal structure, and each unit was designed with communicable construction. The people could get the contextual information from other spaces as seeing through the walls. In the future study, the contextual bricks have good applied possibility and developments in each kind of areas.*
Keywords: *Context-aware; Ambient Intelligence; Context information interface; Interaction design; Communication design.*

Introduction

The technology, nowadays, makes our life more convenient and more comfortable through providing every kind of information around the world. The information could be visualized to create a representation decorated in our living space (Skog, 2004). It also might be formed through words delivering by personal mobile device. Because of more and more kinds of information we needed in our life, the notion of context with user-centre design framework was proposed based on psychology theory to address the relationship between the context of user,

application, and usability (Bradley and Dunlop, 2004). This framework developed a summary model of context in which human-actions emerge to explore the social, cultural, and interactive significance (Bradley and Dunlop, 2005). Applied these concepts to assist the research on the field of Human-Computer Interaction (HCI), context-aware application is not only to give the different types of information to suit the users, environment, or human behavior but also to automatically provide auxiliary information fit for scenarios by predicting user behaviors in advance. Through correct detection about the contextual activities and events in particular human-behaviors

or specific places, researchers could provide the exactly needed information to users. For example, a kitchen interface with embedded sensors offered the accurate contextual content, such as showing object's characteristic, processing status, tasks, and position, to make physical spaces more intelligent (Lee et al., 2006). This successful application proved the necessity of context information for humankind. Display on the environmental surface was also useful in interacting intuitively. Besides, For better usability, interaction, and intuition, perceptual surfaces (Rekimoto and Matsushita, 1997) and tangible interface (Sharlin et al., 2004) expanded the spatiality of applications. For more spatial usage, contextual information applied to be a communication signals among people (Prante et al., 2004).

In this paper, we attempted to develop the concept that combined invisible interface in the field of ambient intelligence with context-aware application into the physical space. Although there have been lots of related researches recent decade, it was still lack of an integrated interface to discuss the interaction factors on context-aware and concern about how to merge the novel media and technology into our living space invisibly with the exhibition of appropriate information. Therefore, the objective of this paper is to propose a suit of research prototype

that was applied for fully discuss the context-aware construction and application in practice. An innovative interface for fitting in with user experiences was created based on the design principles analyzing from passed cases, in addition; its framework was designed for combining all of the interactive phenomena were possible to happen. Finally, the prototype of contextual bricks is tested on the physical environment to collect interaction data in order to the advanced research in discussing the possible applications of contextual bricks in each kind of areas. Through the simplification design into several specific components in the future, the completed suit of bricks will tend to use effectively and easily.

Design Principles

Contextual brick was set to provide the surrounding information on its display surface and specially devised to focus researches on the field of context-aware application design. Therefore, we firstly analyzed the effectiveness of interaction via case study to extract some standard rules as design principles in concept developing stage. Context, construction and interaction were three important determinants in designing the form and function of a device. Their mutual relationship is to complement each other.
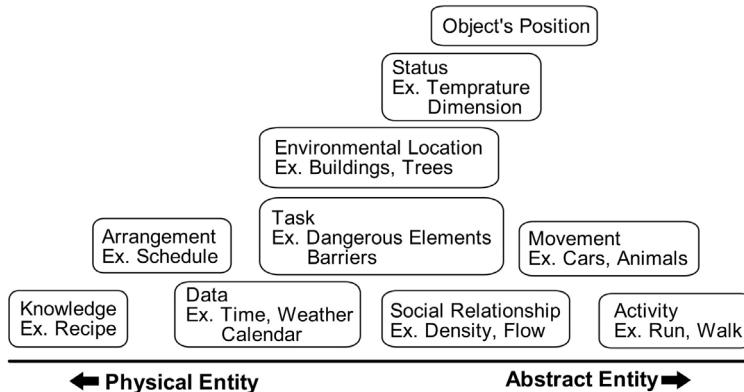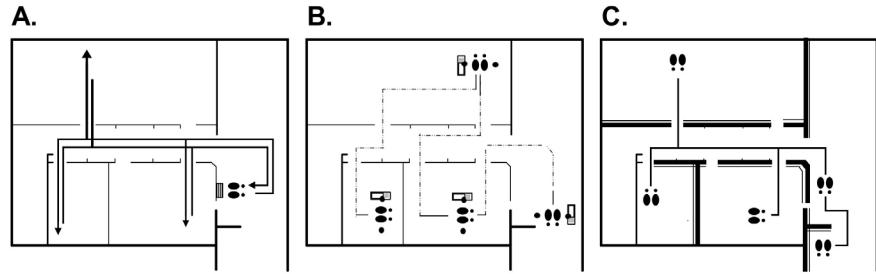
Figure 2
User Experience of three
kinds of interface.

Context was inner content and construction was outer appearance. In consequence, interaction was produced following by their combination.

Context-physical and abstract entity

Context source came from physical, social, task and temporal information (Bradley and Dunlop, 2004). Information was represented by the physical forms of words and pictures or abstract forms of sound, touch, and patterns. There were some different effects among the forms that express a piece of information. These display types might restrain the amount of content in single piece of information or affect the human comprehension of messages in reasoning and interpretation. Therefore, some kinds of context information were suit for describing with physical entity but somewhat was opposite.

Therefore, a brief summary from references about present information expression was described with Figure 1. We could infer that the property of information approaching physical entity expression was static and complicate. On the contrary, the group approaching abstract entity expression was dynamic and single because the literation of these contexts was too difficult for people to grasp thoroughly. Compared with literal description or elaborate pictures, it is more appropriate to use simplified patterns to avoid burdening with noise handling. It is similar to metaphoric language and the advantage was its simplicity.

Construction-invisible interface composing

The content of contextual information decides interfaces functions. In order to display the diversity of information, it is important to consider making users interact intuitively and conveniently. There are more and more devices and machines involved in our living space. This paper discussed the user experience of three kinds of interface as Figure 2.

- Plan A had installed the immobile display interface. The user behavior inside was repeated and inconvenient to acquire immediate information. In addition, the interaction came up passively when user wanted to become aware of something.

- The user at plan B carried a portable device to send command or receive latest information on the go. Although the information is readily available, this device was heavy baggage for the user in mental and behavioral. It is easy to lose or mislay somewhere in the house.

- In the plan C, the space was disposed invisible interface for ambient intelligence. The user could grasp information from the nearest interface. The invisible installation enhanced usability of devices without changing current user mode of living. Among all of the three, this is the best and applicable way in the field of context-aware to build interaction and communication between humans.
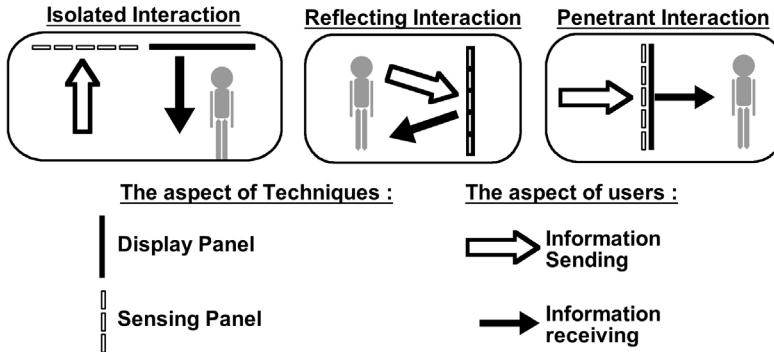
Interaction-sending/receiving direction

As the result of above analysis, we attempt breaking the definition of physical objects in our living space, such as a wall, as intermediary media to rediscover its significance for the user who lived inside or walked outside. Therefore, we summarized present and pass ambient display cases and review their sending/receiving direction to find an innovative way fit for context-aware interaction.

- In Isolated Interaction, sensing panel and display panel were configured separately in two disparate places, such as the augmenting kitchen appliances (Lee et al., 2006). Also probably, one of the reactions was electrical wave or digital signals (Skog, 2004). It was often applied when the sending information was distinct from receiving information. Sometimes the information sender and receiver were the same but sometimes different.

- The feature of Reflecting Interaction was that both actions interchanged at the same spot. For example, the wooden mirror shared the same behavior and interaction for user (Rozin, 2003). In addition, Hello.Wall was settled in office buildings to store information from people who passed by and support user to grasp information from this wall-sized ambient display (Prante et al., 2004).

- Penetrant Interaction was designed in this paper for the contextual bricks. Because the consideration of context-aware application, we created a novel interaction direction fitting for the characteristic that information sender and information receiver must be different and could not see to each other.

Interactive Techniques

A suite of the contextual bricks was hexagonal sensing/display elements that included various sensors and multiple output interfaces. Each hexagonal brick also had sensor/emitters along the edge where they could be stacked up to communicate with one another. In order to improve the efficiency in context-aware application, the bricks preserved the attribute of stability with honey-comb structure, and each unit was designed for specific construction. It also could
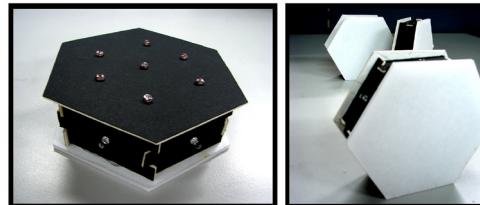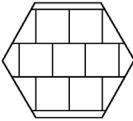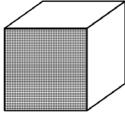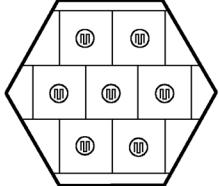
Table 1
Structure of sensing brick.

Inner Structure	Type of Sensor	Detect Range	Samples
	Photoresister	0 - 15 cm	
	Pyroelectric Sensor	5 - 250 cm	
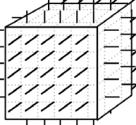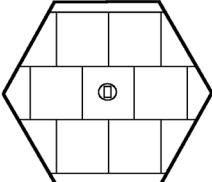
use to be embedded into some kinds of objects to merge into our living space invisibly.

The multi-sensing system and the contextual display were configured in bricks' two surfaces separately. Each unit contained a kind of sensing circuit, a sort of realizable output system, and an individual power supply. All of its interactions were the effect of permutation and combination of contextual bricks.

Context-sensing

The contextual bricks were sensible of spatial context by dealing with electric signals from several sensors. Light and infrared radiations were two kinds of its input factors. This bricks got the contextual information from shading the sensors. The contextual bricks could detect two kinds of human behaviors. One is movement; it let users be able to control their surrounding conditions, such as trafficability or crowded information on the street outside a building, and easy to percept variation of activity situation inside. Other is existence; the contextual bricks also trailed the spatial situation, such as human or object's position.

The inner structure of contextual bricks divided into seven spaces for the deployment of sensing and display elements. We used two types of sensors for different detect models. One is photoresistor; there were seven sensors in a bricks as the skin of a room because of its short detect range. Although it could not aware the movement of the center of a room from sides, the detecting expression from it was subtler. Another is Pyroelectric sensor; because its detect range was farther and wider, there was a sensor in the middle of brick. In addition, its effect perceived like piercing through a room but the represented shape was sketchy and vaguer.

Position-indicating or notifying

The display surface of the contextual brick could deploy with three kinds of interface and each interacted with distinct sensation. SMT LED was set for light pattern representation; Piezo buzzer was set for sound notification; and case fan was set for contacting the users with wind. If someone or something stays on the sensing surface of the contextual bricks, these interfaces will show the context immediately to indicate their position, movement, or activities.

Type of Output Interface		
Light - SMT LED	Sound - Piezo Buzzer	Touch (by wind) - Case Fan

Information-linking

The contextual bricks had a specific application on its structure design. Users were able to freely arrange these bricks follow their purpose or compose for their favorite function. The construction rules describe in the figure 7. There are some LED and photoresistors on the lateral sides of the hexagonal prism. The letters are assigned as marks in the figure 7. The A, B, and C sides set with the LED elements, in addition to the D, E, and F sides set with the photoresistors. Therefore, this interface has ability to deliver the contextual information through adequate arrangement. If some units get a signal from sensors, other units can receive the same meaning of signal by the sensing elements on the lateral sides. In another word, if the LED on the A, B and C sides lights, the photoresistor on the opposite side will detect the light to run the circuit. It creates an information-linking system to complete this contextual interface.

Applying scenarios

The application of contextual bricks was not only to display assistant personal information but also be able to collect the public and social information in the house.

This research prototype might be applied for four scenarios. For lighting, the single unit of the contextual bricks put as button to light the LED array with appropriate arrangement. Moreover, it is an interface for communicating with people who are in the different spaces. In addition, it displays the surrounding context with invisible installation. For home care, the function of the position-indicating conform the security about baby or elder in the house without watching. In other words, it made an interactive communicated interface merged in the physical space to acquire the surrounding information, such as object's position, child's movement, and someone's call, needed in daily life.
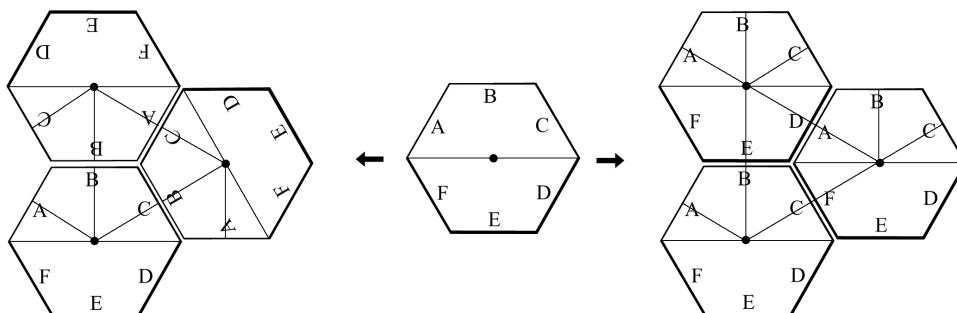
Conclusion

This integrated contextual interface induced a new living style and behavior. It reconsiders the definition of the Information application. The additional function should attach on the existent objects to create an invisible interface being convenient for user. And different interaction direction design would transform a device into diverse results. Although the contextual brick still had a lot of limitation in constructional practice, the multiple sensing/display interfaces were useful in context research. The further possibility of these bricks is really extensive under our research. Recently we are endeavoring to experiment on its applications in various ways and discover more appropriate and more natural methods in the context expression. In the future works, we will continue to explore the correlation among living objects, hiding information, and varying lifestyle.

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