A Rapid Prototyping Method for Discovering User-Driven Opportunities for Personal Informatics

A Case Study in a Domestic Environment

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Abstract—**We propose a rapid prototyping method for discovering user-driven application opportunities for personal informatics. The key idea here is that our discovery is realized by empowering users themselves to figure out and express the meaningful information they want to capture and interpret through the prototypes we provide, in an economical and effective way. From the user study, we could extract the key patterns of information usages for family members: (1) recalling life patterns; (2) self-examination; (3) mutual concern; (4) regulation, which are important insights to be considered in developing new applications for personal informatics.**

Keywords-prototyping; user-driven; discovery; personal informatics

I. INTRODUCTION

As the development of ICT (Information and communication technologies) has been increasing and will continue to increase the quantity and the range of information available, it is important to figure out how such information can be utilized in a valuable way that can meet the values and needs of people. Although ubiquitous computing is gradually becoming a reality, our understanding has been more about what is possible in terms of technology than what is valuable and needed in our daily life context [1]. This would be even truer in the case for personal informatics [2]. Sterling introduced a new concept of an artifact, “spime” [3], which archives every data generated anytime anywhere by us and around us. However, it is not clear at all what exactly spime will become as a product and how people will utilize it.

Most of the approaches used in existing research in this domain have focused on the ‘evaluation and testing’ of a particular concept or generating ideas based on the result of the ‘observation’. Testing-driven approaches have mostly focused on the validation of the concepts with working prototypes in the controlled environment. When the concepts are found to be invalid, there is not much learning from the failure in spite of the high cost for developing the prototypes. Even when they were proven to be valid through such processes, it is hard to see other possibilities beyond the boundaries of those particular prototypes. The observation-based approaches have pervaded our investigations to date, but we cannot be sure whether the observed and tested prototypes would work well in a real life environment equipped with ubiquitous computing technologies.

In this paper, we propose a user research method adopting a new rapid prototyping approach to effectively ‘discover’ human-centered opportunities for personal informatics applications in the domestic environment. This approach focuses on two steps: first, how we can effortlessly capture the personal information that is meaningful to users themselves, and second, how to provide effective feedback that can support users in reflecting their lives on their values. We are particularly interested in developing personal life care systems to promote family values as an example domain for exploring the opportunities for personal informatics and its design strategies.

In this paper, we explain in detail how we developed the prototypes and what we discovered through the prototyping approach implemented in the users' daily life environment.

II. PROTOTYPING METHOD

According to Lim et al. [4], prototypes can be understood in relation to its specific purpose of use, which can be categorized into (1) evaluation and testing; (2) the understanding of user experience, needs, and values; (3) idea generation; and (4) communication among designers. Whereas most of the current research focuses on the evaluation and testing, our new rapid prototyping method has its purpose particularly on the understanding of user experience, needs, and values. The core of our idea lies in realizing that we can discover opportunities for a human-centered application of a personal informatics system in a credible way without implementing a fully-working and high-cost ubiquitous computing environment.

Our idea of enabling such discovery follows two principles: 1) users themselves (not designers, researchers, or developers) actively determine what information should be captured and monitored, and 2) users themselves actively manipulate, integrate, and reflect on the information that was provided to them [5]. What we pursue here is that the process of discovery happens through users' experience of utilizing the information itself. This idea sets the role of a user as the subject of discovery apart from the researchers’ interventions.

With this intention, we devised our prototyping kit in two major parts. To address the first principle, we devised a portable sensor kit to capture information through a DIY (Do-It-Yourself) approach. To address the second principle, we designed the feedback outputs to be displayed real-time on a display where users can easily recognize the information captured, as well as printed on cards to provide a way for them to rearrange and to reinterpret the information for their own reflection as they would with journaling

The design of the sensor kits is a crucial factor because our method relies heavily on users actively handling the kits themselves. The physical package should be flexible to be used in many different situations in order not to disrupt the users' decision. Similarly, the sensor kits should not appeal a certain purpose of use or a certain situation to be used in, because the purpose of use itself is to be determined by the users. This clearly separates our method from the 'technology probe' [6].

The credibility of our method takes root in the engagement of the users into the discovery in their real life environment. As we assume that people are capable of using information for their own benefits with practice, their decisions, activities, and reflections for capturing and utilizing the information in their daily life context can be regarded as the result of their intelligent and independent judgment, and a natural process for the information to figure out and fit into its proper opportunities. Thus, our method can also be distinguished from the 'cultural probe' [7], which regards the users as the source of inspiration, not the direct subject of discovering the opportunities.

III. PROTOTYPE DEVELOPMENT

Before the specification of the prototype system, we conducted a preliminary user study with two families to figure out what they truly value to achieve their happiness, and they care mostly health, safety, convenience, self-development, emotional well-being, communication, and family bonding [8]. Based on the information needs in particular situations in the domestic environment that they reported, we also figured out what kinds of sensors can provide the information that people need for achieving those values. For this prototyping, we chose four sensors (light sensor, flex sensor, noise level detector, and RFID reader) which are expected to be most effective to capture helpful data in the daily life context.

The prototype developed in this study (Figure 1) consists of eight sensor kits, one main computer which a master node that wirelessly processes the captured data from the sensor kits, history database storing such data constructed by the main computer, and a display providing visualized pattern feedback of the data to users, and cards that are printed out recording the feedback information.

A. Sensor Kits

We used four kinds of sensors, namely, light sensor (photo cell) for detecting the brightness of the environment, flex sensor for the bend caused by physical contacts, sound sensor, and RFID reader. We wanted to enable the users to capture not only the data of the environment in rather passive ways, but also the data of people themselves in active ways, that is to say, capturing the human activities or emotional status with their own decision and effort. This information could be gathered through more complex and intelligent system including the sensors for detecting physiological condition directly from human bodies and the cameras for sophisticated image processing techniques. Instead of those, RFID reader was regarded suitable for the 'active' data logging, with the advantage of cheap price and the potential to see more diverse ways of utilizing the information and the human interaction around there.

Each sensor kit includes a sensor, a microprocessor (Arduino), a Xbee module, and batteries (six 1.2V AA in series). Eight sensor kits were provided to the users (2 light sensors, 2 flex sensors, 1 sound sensor, and 3 RFID readers with a tag set each). Flex sensors were embedded into cushions with 20~30cm length.

Figure 1. Components of the prototypes: a) flex sensors, b) light sensors, c) RFID reader without the encloser, d) card type RFID tags, e) coin type RFID tags. (Counter-clockwise from the top right)

Three sets of RFID tags, two card type sets and a coin type set, were designed to capture user-driven information that is directly meaningful for themselves. A card type set was for the customized use and consisted of four card tags with different colors on one side. On the other side, a piece of blank paper was attached to allow the users to write a memo for recognizing what it means to log that card. The purpose of coin type set was fixed to capture various emotional statuses of the family members. Printed facial expressions were attached to five tags (each stands for being pleased, touched, surprised, sad, and angry).

Flexibility of installation was an important issue. To enable users to capture the data in a variety of situations that they want to, each sensor kit is packaged in an enclosure and a transparent PVC bag with a strap, so that it can stand alone, and can also be tied to human bodies or other objects in the environment. We also devised it in a way that batteries can easily be replaced by users themselves whenever it is necessary.

B. Feedback

A feedback program provides a real-time monitoring panel and a history viewer corresponding to each sensor. Also, users can print the screenshots on cards to rearrange and reinterpret the information for their own reflection. Following statements are the requirements of this feedback program: 1) The program should be easy to use and control without much technical knowledge. 2) A real-time monitoring panel and a history viewer should graphically represent the characteristics of each sensor data intuitively.

To satisfy the first requirement, the feedback program was implemented on a touch-screen laptop. Users can control all actions by touch. In a normal mode, this program displays real-time data of all sensors in parallel. If a sensor failure occurs for some reason (for example, a battery failure), an alert message is displayed. This will encourage users to check the sensor. Users can get into the history viewer mode by tapping on each sensor section. The history viewer displays the 12-hour history data in one page. A user can navigate the time window by tapping [PREV] and [NEXT] button, or flicking left and right. Also, a screenshot can be printed out by tapping the [PRINT] button. The program goes back to the normal real-time monitoring mode by tapping any place on screen other than those buttons. For the second requirement, we carefully designed the feedback graphics for each sensor to reflect its characteristics.

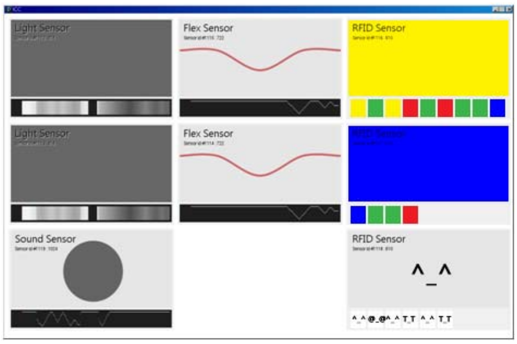

Figure 2. Sensor representations in the real-time feedback

The real-time feedbacks are shown in Figure 2. The data from the light sensors are represented with dark and bright colors to reflect the amount of light. The flex sensor data are represented with the curved string that shows how much flex sensor was bent. The sound sensor represents the level of loudness by the size of a circle. Two RFID sensors directly show the color of each card. Another RFID sensor that we used as an emotion sensor shows the emotion type with text and emoticons. Each feedback panel also shows the brief history of the logged data.

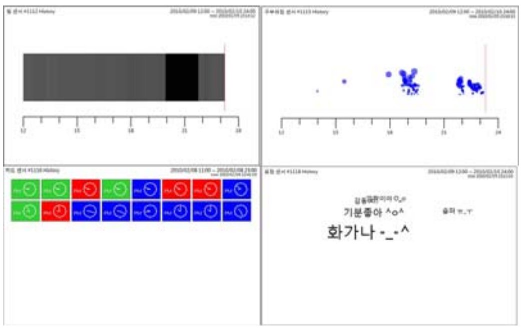

Figure 3. Sensor representations in the history viewer

The feedback designs of the history viewer mode are shown in Figure 3. From left to right, top to down, they are light, flex, sound, RFID, emotion sensor feedbacks. The light sensor representation is not very different from the real-time representation. Flex sensor and sound sensor feedbacks filters out data to show only significant changes. In the first row, all horizontal axes are timelines. For the RFID sensor feedback, it displays the sequence of values with the tagged time represented with an analog clock. Emotion sensor feedback is represented with a tag cloud.

IV. USER STUDY

The prototype is deployed to a family with 6 members: two children (both are female elementary school students), their parents in 30s, and grandparents in 60s. While the parents are working during the daytime, the children spend time with their grandparents. We expected that such diversity of the family members across three generations could help us to get interesting results with a wide range of issues. The family used the prototypes for two days.

Figure 4. The touch-screen laptop and the photo printer installed in the living room of the users' house

A. *Procedure and Settings*

On the first day, the researchers visited their house to install the touch screen and the photo printer (Figure 4). Detailed and clear explanation was also essential to make them understand the purpose of this study as well as the function of each sensor. To be successful in the implementation, the users were encouraged to be active and creative in using the prototypes. They should not be trapped in the conventional ideas of using things. They also need to be free from the mood of "being tested" or "being pressured to find the right answer". They were instructed to decide the purpose of use by themselves, and print out the cards twice a day for each sensor.

After the two days, the researchers visited again for debriefing. Following questions were asked about each sensor : 1) Place : Where were the sensor used?, 2) User : Who used it?, 3) Purpose : What was the purpose of use?, 4) Reflection value : What kind of changes came up on your thoughts or behaviors?.

B. *Results*

This section is the summary of what we have discovered through the users. Following statements are the brief description of their experiences of each sensor kit and its feedback, in terms of where and who used it for what purpose.

The light sensors were fixed in the living room, kitchen, and bedroom, or worn on the body. Mother and father were the main users and they did not define the purpose of its usage before they use it. They experimentally put them in many different places and saw what can be captured. What was interesting from these sensors was that the users discovered the value of the information captured from the sensors after they reviewed the feedback even though they from the first place did not know what these sensors could be good for. Different from the light sensors, the flex sensors had clear intention of usage beforehand. They were used as a wrist cushion when they use a keyboard or write with a pen, and also used as a neck pillow. Father and the children used them, sometimes just for fun. The sound sensor was fixed in front of the TV, in the living room. All family members used it to detect the noise of children when they shout or run inside the house. What was interesting about this sensor was that the family members tend to be quieter than usually only with the existence of this sensor. The card type RFID tags (for customization) were used for well-regulated life of kids (watching TV, eating snacks) and health care for the grandfather (drug or urination check). The coin type RFID tags (for expressing emotion) were used by all family members to get to know the emotional status of family members collectively.

Through this research, we could extract the key patterns of information usages for family members, which must be carefully considered in developing new applications for personal informatics and lifecare information systems for domestic environments and activities.

1) Recalling Life Patterns

Parents recalled their life patterns from the feedback. The parents and children used flex sensors (embedded in the cushion) for their physical comfort when they studied or worked, and easily recognized the time spent on those activities. In case of the light sensor, even though they did not pre-define the purpose of use and just installed it in the living room, they pull out the value of its information when recalling the specific activities that they did like sleeping in the early evening and eating at night time, referring to the brightness change recorded.

2) Self-Examination

As we mentioned with the sound sensor, sometimes the captured data or the existence of the sensor itself provided chances to reflect on their behaviors. The sound sensor installed in front of TV in the living room happened to effectively detect whether the TV was turned on or not. The father said that he tended to watch TV less being aware of the sensor; watching TV too much was shameful thing for them to do. The mother said it would be better if the feedback shows a threshold for the noise that we should not reach concerning the neighbors.

3) Mutual Concern

The feedback of emotion tags (RFID coin type) promoted the family members to be concerned about what happened to other family members. The parents said that they could start conversation with their children by asking them what happened or what made them to log that emotion.

4) Regulation

The card type RFID tags were customized to check whether their rules are kept properly. One set was used for well-regulated life of children and the other set was for health care of the grandfather. The users logged the data by themselves but they said they did not feel uncomfortable about recording. The mother told that the RFID helped them not only to keep the rule by themselves but also to persuade each other to keep the rule as it provided solid records of what they did.

V. CONCLUSION

We propose this method for discovering user-driven application opportunities for personal informatics in the domestic environment. The key idea here is that our discovery is realized by empowering users themselves to figure out and express the meaningful information they want to capture and interpret through the prototypes we provide, in an economical and effective way. The key patterns of information usages extracted from the user study, recalling life patterns, self-examination, mutual concern, and regulation, are valuable insights to be considered in developing new applications for personal informatics. We see the value of this approach not only in terms of efficiency and effectiveness, but also in the point that this line of idea is also supported by what is expected for future where users themselves will define their own artifacts to use with the pervasively archived information.

ACKNOWLEDGMENT

We would like to thank Jaesik Yun, Jihun Lee and Jungu Sim for their valuable efforts to this research. This research is funded by ICC (IT Convergence Campus at KAIST) and KMCC (KAIST-Microsoft Research Collaboration Center). It is also supported by WCU (World Class University) program through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (R33-2008-000-10033-0).

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