Towards a Wearable Cognitive Prosthesis to Support "What" and "Who" Type Memory Activities

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ABSTRACT

In this paper, we introduce a wearable cognitive prosthesis[1] we have implemented previously [6, 5, 9, 12, 7, 8]. The technology for recording and sharing experiences such as those used in augmented memory has been extensively studied in recent years [1]. The aim of these studies is to enable users to receive the following benefits; 1) less time wasted in everyday life, 2) a recycling of experiences, and 3) a facilitation of human-to-human interactions. Previously designed systems, including ours were designed for people with ordinary cognitive processing abilities. These systems are not suitable for people with dementia because the memory process of people with dementia is different from the memory process of a person with ordinary cognitive processing. In this paper, we discuss the design of a system for people with dementia. Our existing systems must be partially or totally redesigned in order to realize a cognitive prosthesis that can perform for the sufferers of dementia.

1. INTRODUCTION

Wearable computing technology has been investigated extensively in recent years resulting in smaller and smaller computers with larger and larger storage capacities. An advantage of a wearable system is that a user can get various services "anytime" and "anywhere". This advantage is good for memory aid because human memory activities take place anytime and anywhere. Interesting research in recording a user's experiences has been discussed in such examples as life-log [3]. J. Gemmell et al. have attempted trying to digitize their lives as much as possible in the *MyLifeBits* project [4]. The main point of view of the life-log project is the method of recording and analyzing experiences.

In addition to people with ordinary cognitive processing, people with dementia and people with amnesia are also studied as target users in memory aid research [2]. Unfortunately, however, sufferers of dementia or amnesia have not been studied in term of computer-aided memory prostheses as much as ordinary, unremarkable users. At least two reasons exist for this: One is the difficulty of design and evaluation. Generally, almost all system developers, researchers, and their colleagues are cognitively ordinary people. Therefore, designing a system useful for the sufferer[2] is difficult. Moreover an evaluation of the designed system is even more difficult than designing the system itself because few opportunities for experiments using test subjects with dementia or amnesia under the controlled conditions. Another reason for less design and evaluation for sufferers of dementia is the gap in market size. The population of people with ordinary cognitive processing is larger than the population of people with dementia or amnesia. Market size obviously determines what research will be done and what will not.

Facilitating "ordinary people" with "people with dementia/amnesia" interaction is necessary to both group living together because both must interact in many situations together daily. One of possibility of making this interaction smoother and more comfortable is a universal design of a cognitive prosthesis from ordinary people through people with dementia or amnesia. The universal design would expand market size. In order to achieve universal cognitive prostheses, researchers and developers must employ an ordinary person and a person with dementia or amnesia as users to design services and interfaces.

In this paper, we first introduce designs of wearable cognitive prostheses for people with ordinary cognitive processing and then discuss these designs and how they may be used for sufferers of dementia or amnesia. We have designed and implemented four types of systems. The systems are respectively called *Residual Memory* [6], *Ubiquitous Memories* [5], *I'm Here!* [9, 12], and *Nice2CU* [7, 8]. We discuss especially the *I'm Here!* system and the *Nice2CU* system. The *I'm Here!* system supports an object finding task (a 'what-type' memory activity). The *Nice2CU* system enables a user to remember a person's name, birthday, hobby, etc. The system supports a recollection of an event that is triggered by a person who is in front of the user (a 'who-type' memory activity). Both memory activities are important for not

[1]We usually call our memory aid system "augmented memory". In this study, we term this kind of system "cognitive prostheses".

[2]Note that we term simply a person with dementia or amnesia "a sufferer" in this paper.

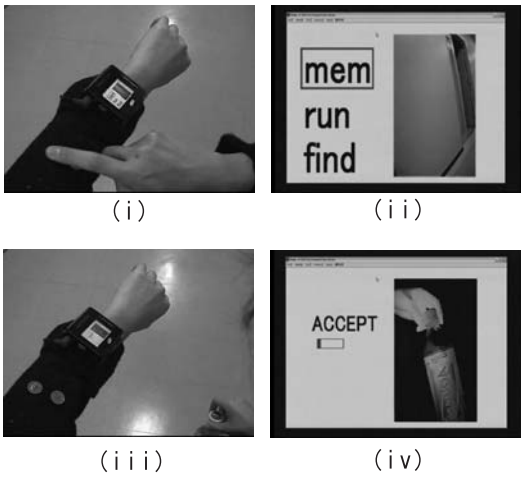

Figure 1: Registration mode of the *I'm Here!*.

only ordinary people but also for people with dementia or amnesia.

2. OVERVIEW OF OUR SYSTEMS

2.1 I'm Here!

This system retrieves the last recorded video of a user's viewpoint including a handled object from a video database. The *I'm Here!* system is composed of a wearable camera [11], which is specially provided for detecting an object handled by the user, a sleeve-on display, and a sleeve-on switch. The *I'm Here!* system includes three operation modes as follows:

Registration: A user first selects this mode (Figure 1 (i) and (ii)) (STEP-I). The user then picks up an object that the user wants to register (STEP-II). The user moves and rotates the object in front of the wearable camera (Figure 1 (iii)) (STEP-III). The system starts capturing appearance data of the object as images (Figure 1 (iv)) (STEP-IV). The system then extracts features for recognizing the registered object (STEP-V). Finally, the system records both the feature data and a thumbnail including the object (STEP-VI).

Observation: The system has been recording a video while a registered object has been in the view of the wearable camera (STEP-I). The system then updates the database just after the object disappears from the captured image (STEP-II).

Retrieval: The user selects this mode (STEP-I). The user checks thumbnails (Figure 2 (i) and (ii)) (STEP-II). The user selects one thumbnail including the object that the user wants to find (STEP-III). The system replays the last recorded video including the handled object (STEP-IV). Finally, the user finds the object (Figure 2 (iii)) (STEP-V).

2.2 Nice2CU

This system retrieves the last recorded video of a user's viewpoint including the person who is in front of the user. The *Nice2CU* system is composed of a wearable camera for detecting the person in front of the user, and a wrist-on RFID

Figure 2: Retrieval mode of the *I'm Here!*.

Figure 3: Observation and retrieval mode of the *Nice2CU*

(Radio Frequency ID) tag reader. The *Nice2CU* system includes the following two operation modes:

Registration: A person comes to meet a user. The person gives the user a business card attached to an RFID tag (STEP-I). The user reads the information recorded in the RFID tag by using the wrist-on RFID tag reader (STEP-II). The system registers the person's information data (name, birthday, hobby, and etc.) and feature data that are for recognizing the person using the wearable camera (STEP-III).

Observation and Retrieval: The user meets the person again. The system recognizes the person (STEP-I). The system has been recording a video while the registered person has been in the view of the wearable camera (STEP-II). The system then updates the database just after the person disappears from the captured image (STEP-III). The system displays the person's information data, and replays the video recorded when

the user last met the person (Figure 3) (STEP-IV).

3. DISCUSSION OF SYSTEM DESIGNS

3.1 Distinguishing an Operator from a User

A system design model distinguishing an operator from a user is important in achieving a wearable cognitive prosthesis for sufferers. Both the *I'm Here!* system and the *Nice2CU* system have registration, observation, and retrieval mode. It is especially hard for the sufferer to understand how he or she can operate the system in the registration mode and the retrieval mode. A caregiver including the family must control the system as an "operator" in these two modes. The subject person in this case is the sufferer who records his or her own experiences. The sufferer then implicitly requires service as a user.

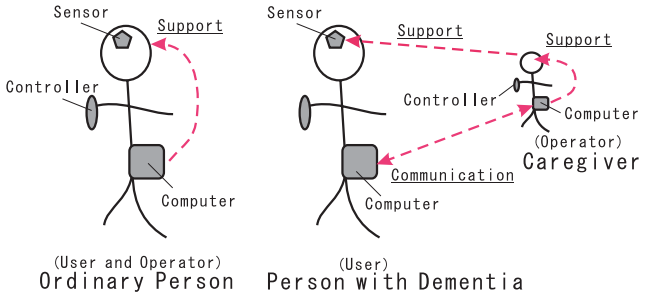

Figure 4: A system design model distinguishing an operator from a user

Figure 4 illustrates the system design model which distinguishes an operator from a user. An person with ordinary cognitive processing behaves as a user in conjunction with an operator. The system supports the user directly. On the other hand, a sufferer is only a user. The sufferer's system establishes communication with a caregiver's system. The caregiver's system supports the caregiver to be able to care for the sufferer by using the information from the sufferer's system. A system developer can design both systems with a system configuration. Performing rules for input and output depending on the user is important if the core design is universalized.

3.2 Arranging Articles for Everyday Use

In terms of a wearable system, methods exist for recognition of objects: 1) an appearance-based object recognition method and 2) a tag-based object recognition method. In the case of appearance-based object recognition, a wearable system extracts an object image from an image captured by using a wearable camera. On the other hand, a wearable system can employ a visual tag or an RFID tag to detect an object. In this paper, we select an RFID tag system for recognizing an object.

A person with ordinary cognitive processing arranges physical objects by him or her self. Objects can be classified by the frequency type of their use. High-use objects are articles for everyday use. Low-use objects represent objects stored in a warehouse, cupboard, etc. for a long time. The total number of registered objects should be over 100 even though a user limits objects to those he or she wants to find quickly. In the case of a sufferer, the sufferer would find it difficult to complete an object finding task. A person doing the object finding task instead of the sufferer would be a caregiver including the family. The number and variation of objects that must be managed are fewer than in the case of people with ordinary cognitive processing. Objects, which should manage carefully, are valuables for the sufferer. These objects are sometimes "troubled objects" between the sufferer and the caregiver. The priority registration of troubled objects would lift the burden of finding objects that the sufferer wants from the caregiver. We assume that the number of troubled objects for everyday life is 10 at most.

In the case of the appearance-based object recognition method, a user uses the system to capture many appearances of an object so that there are many appearances when the object posture is changed. Also, the user must associate the name and property of the object with the features calculated from the set of the appearances of the object. In comparison with the appearance-based method, the tag-based object recognition method allows the user to register only the name and property of the object with an RFID tag. Most objects would be represented by attached or implanted RFID tags, respectively only if a tag-based ubiquitous society was widely extended from what it is today. Also, the tag would include the name and property of the object with the tag in advance. However, a user with the appearance-based object recognition method never omits an operation for an association of the name and property of the object and the feature computed from the set of the appearances of the object.

The tag-based object recognition method is more suited to performing as a cognitive prosthesis for sufferers than the appearance-based object recognition method. In the case of the tag-based method, there are some objects to which RFID tags cannot be attached. Nonetheless, RFID tags can be attached to all the sufferer's objects if a caregiver attentively selects objects to buy for the sufferer.

3.3 Controlling Inter-Personal Communication

A sufferer might feel a higher calmness of mind by interacting with ordinary people. The person with ordinary processing emphasizes exchanging correct information to keep communication channels open with other people. The sufferer, in contrast, finds it difficult to establish communication with an another person, such as an acquaintance. In order to establish a connection, both the sufferer and the acquaintance must be aggressive. Facilitation of a communication channel and keeping it open is an important issue in allowing the person with ordinary processing to perform action for the connection.

The *Nice2CU* system we have designed for ordinary people activates thier communication channels by allowing the exchange of information between communicators. Four types of information about a person are essential to this system:

A PROFILE includes current information about the person (e.g. person's face, name, sex, birthday, blood type, birthplace, current address and affiliation.)

An EXPERIENCE contains an event memorized by a certain person, and includes the context of what hap-

pens in an event that was experienced together by a recipient and a target person.

A MESSAGE includes a temporary memorandum similar to a "post-it" for delivering a message to the target person. For instance, the recipient suddenly remembers that he or she wants to repay money to the target person when the recipient accidentally runs into this target person.

HUMAN RELATIONS consists of the above elements: PROFILES, EXPERIENCES, and MESSAGE. For example, the target person was the recipient's former boss when he was in college.

The system selects and displays appropriate information for facilitating communication by calculating the latest relationship among the user, the target person, and other people. The ordinary person can interact with others by considering displayed information correctly. On the other hand, the sufferer finds it difficult to establish communication with others by using only the displayed information. Knowing how to get information from a sufferer is necessary for keeping communication channels open with the sufferer. To get such information, the system must give appropriate information to activate communication to "a sufferer", "an acquaintance", and "a caregiver" respectively. If a sufferer as a user meets a person he or she has met before, the sufferer cannot establish communication with the person because the sufferer will find it difficult to recognize who the person is. The system must give the latest past-information in all information that the sufferer can remember, e.g. events in the childhood. For instance, a system, which can recognize when they have met, similar to the *Nice2CU* system, displays photos or videos recorded in the childhood. Also, the system must let the acquaintance understand that the past-information is useful in making conversation with the sufferer. The recorded video of when the sufferer met the acquaintance is also available for the caregiver. The caregiver can talk about the event with the acquaintance of the sufferer. Additionally, recorded video would be more useful once the caregiver edits the video and annotate semantic data on the video [10].

4. CONCLUSIONS

In this paper, we have introduced wearable cognitive prostheses that we have implemented in the past. Especially, we explain the *I'm Here!* system for supporting an object-finding task and the *Nice2CU* system for remembering an acquaintance's information. We also discussed the designs of these systems in regard to people with disease associated with dementia or amnesia so as to improve or redesign these systems for people with dementia or amnesia. We have proposed a system design model distinguishing an operator from a user. It is important for developers to achieve a cognitive prostheses for both people with ordinary cognitive faculties and people with dementia or amnesia.

5. ACKNOWLEDGMENTS

This research is supported by Core Research for Evolutional Science and Technology (CREST) Program "Advanced Media Technology for Everyday Living" of Japan Science and Technology Agency (JST).

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