Real World Objects as Media for Augmenting Human Memory

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ABSTRACT

This paper describes wearable interfaces for augmenting human memory, i.e., providing users with functions for archiving, transporting, exchanging, and retrieving their experiences by employing real world objects as memory storage, in everyday life. A user conceptually encloses his/her experiences gathered through his/her sense organs into real world objects by simply touching the objects. He/she can also disclose and experience for himself/herself the augmented memories stored in an object by the same operation. This paper presents the following two wearable modules/interfaces for augmenting human memory: the "*Ubiquitous Memories*" and the "*I'm Here!*" The *Ubiquitous Memories* provides users with the functions for associating augmented memories with real world objects. The "*I'm Here!*" retrieves the last recorded augmented memory which contains the target object indicated by the user by automatically and continuously detecting objects held by the user. We believe that the above modules can be integrated into a memory albuming system.

Keywords

Augmented Memory, Wearable Computing, Real World Objects, and Memory Albuming and Sharing

INTRODUCTION

Our research goal is to develop methods and their computational components for augmenting human memory in everyday life. Augmented memory technology has been investigated extensively in recent years in the field of wearable computing [8,10,11]. Such technology makes it easy for a user to refer to multimedia data which include his/her viewpoint video for recalling his/her experiences, e.g., for remembering the person who stands in front of him/her [1,2]. In these systems, the user wears both a head-mounted camera for continuously recording his/her viewpoint images and a head-mounted display (HMD) for viewing information given by the system.

We have proposed a framework for augmented memory albuming systems, named *SARA* [3,7], where 1) a user's viewpoint images are always observed, 2) the images along with the data observed by other worn-sensors are analyzed to detect current context, 3) the images are stored with the context as his/her augmented memories, 4) the memories are additionally annotated/indexed by him/her for later retrieval, and 5) he/she can recall his/her experiences by viewing the memory retrieved by consulting the indexes. We consider the memory albuming to be one of killer applications for wearable computing in everyday life [6].

It is important for memory albuming systems to equip functions for managing memories, i.e., archiving transporting, and retrieving augmented memories. The *Ubiquitous Memories* proposed in this paper provides users with such functions by associating augmented memories with real world objects. He/she is allowed to rearrange his/her memories for later retrieval. He/she can also hold and convey the memories with the associated objects.

Although most of existing augmented memory researches considers managing a user's personal memories, we believe that sharing memories among users is one of essential functions. A user would augment his/her problem-solving ability by referring to others' experiences if they are properly associated with the given problem. The *Ubiquitous Memories* helps its users exchange their experiences. A user is allowed to view all the memories associated with the indicated object if the owner of each memory has approved of other users viewing it. The user can reuse human experience by remembering his/her own memories or by viewing other users' augmented memories rearranged in a real world object.

A memory retrieval function provides a user with the ability for retrieving proper augmented memory from a huge memory archive which continuously increases in recording his/her everyday activity. The "*I'm Here!*" proposed in this paper is an object-based memory retrieval module that identifies the object held by the user. The "*I'm Here!*" shows the user the last recorded video which contains the target object indicated by him/her. Viewing the video, he/she can remember where it is. Prototypes of the two proposed modules/interfaces are independently implemented. They realize natural operations for managing augmented memories by employing ubiquitously spread real world objects as memory archives.

UBIQUITOUS MEMORIES

Conceptual Design

We propose a conceptual design for ideally and naturally bridging the space between augmented memory and human memory by regarding each real world object as an augmented memory archive. Conventionally, a person often perceives and understands a new event that occurred in the real world referring to his/her experiences and knowledge, and then stores the memory of the event into his/her brain. He/she then obtains knowledge to cope with the event by analogically associating the event with his/her experiences. Real world objects, which are related to the event in some sense, could be strong triggers for him/her to remember the event. Suppose that a user had a birthday party with her husband. Many objects in the party space can be memorial ones, e.g., the birthday present, the gift box, the musical box on the table, and the pendulum clock in the room. A real world object also could be the medium for archiving memories which are in some sense similar to each other.

To seamlessly integrate between human experience and augmented memory, we consider that providing users with natural actions for storing/retrieving augmented memories is important. A "human hand" plays an important roll for integrating the augmented memory into objects. Human body is used as media for both perceiving the current context (event) as a memory and propagating the memory to an object, i.e., the memory travels in all over his/her body like electricity and the memory runs out of one of his/her hands in our design. We propose a conceptual design to ideally and naturally correspond augmented memory to human memory. Terms of conceptual actions in Figure 1 are defined as follows:

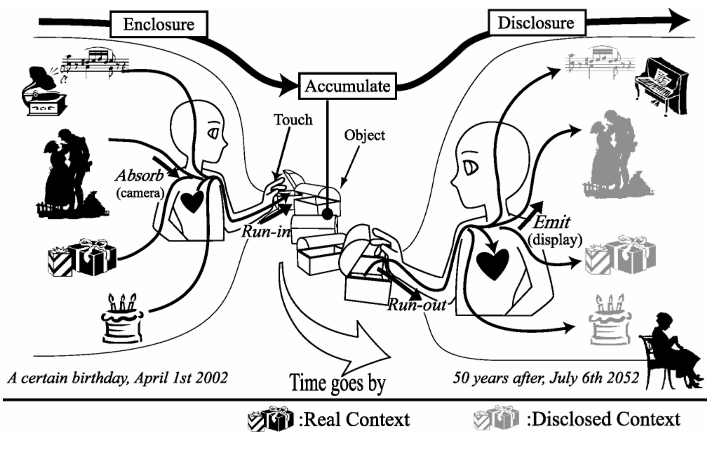


Figure 1: Concept of the Ubiquitous Memories

Enclosure action is shown by two steps of behavior. 1) A person implicitly/explicitly gathers current context through his/her own body. 2) He/she then arranges contexts as ubiquitous augmented memory with a real world object using a touching operation. The latter step is functionally similar to an operation that records video data to a conventional storage media like a video tape. The two steps mentioned above are more exactly defined as the following actions:

Absorb: A person's body acquires contexts from an environment, his/her own body, and his/her mind, as moisture penetrates into his/her skin. Such operation is called "Absorb" and is realized by employing real world sensing devices, e.g., a camera, a microphone, and a thermometer.

Run in: When a person touches a real world object, an augmented memory flows out from his/her hand and runs into the object. A "Run in" functionally associates an augmented memory with an object. In order to actualize this action, the system must recognize a contact between his/her hand and the object, and identify the object.

Accumulation denotes a situation where augmented memories are enclosed in an object. The situation functionally means that the augmented memories are stored in computational storages somewhere on the Internet with links to the object.

Disclosure action is a reproduction method where a person recalls the context enclosed in an object. The "Disclosure" has a similar meaning of replaying media data. This action is composed of the following "Run-out" and "Emit" actions.

Run-out: In contrast to "Run in," augmented memory runs out from an object and travels into a person's body. Computationally, the "Run out" 1) identifies the storage where the augmented memories linked with the object are stored, and 2) retrieves them from the Internet to his/her wearable PC.

Emit: The user restores the context by experiencing some of the retrieved augmented memory in his/her body, and mind. The system should be employed devices, e.g., on a HMD, and a headset, that can play back an augmented memory.

By enclosing an augmented memory in an object, memory-finding behavior directly corresponds to object-searching behavior where the object is associated with the memory in some sense. This correspondence makes a wearer get more intuitive power to find the augmented memory using the principle of human memory encoding [14]. Suppose that a person won first prize in the 100-meter dash at an athletic festival and got a plaque. He/she can easily recall the event when he/she just looks at the plaque because he/she associated the event with the plaque in his/her mind. By providing the wearer with the way to computationally

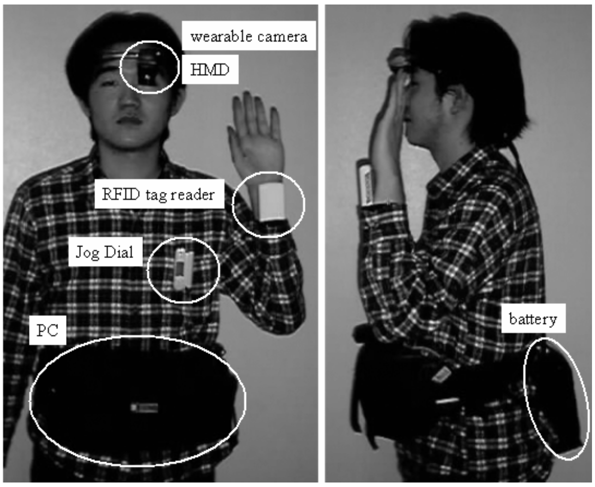


Figure 2: Worn Equipments of the *Ubiquitous Memories*

associate an event with an object, he/she can easily recall the event by finding out the object.

The operation "touching" is employed not only for realizing metaphors that a human hand implies ("Run-in" and "Run-out"), but also for naturally controlling an augmented memory system. *CyberCode* [12,13] proposed a method to detect visual tags in a scene captured by a camera to identify virtually controllable real world objects. Although it is difficult for both the user and computational devices to explicitly select the target object among detected objects in using visual tags, the proposed touching operation makes the selection easier.

Hardware

Figure 2 shows the worn equipments of the prototype of the *Ubiquitous Memories*. The wearer basically wears a HMD to view video memories, and a wearable camera to capture video memory of the wearer's viewpoint. The wearer also wears a Radio Frequency Identification (RFID) tag reader/writer to his/her wrist. The wearer attaches RFID operation tags to control the system to the opposite side of wrist that is set the RFID tag reader/writer. The wearer uses a VAIO jog remote controller for additionally control the system. The wearer carries a PC on his/her waist. The RFID device can immediately read the RFID tag data when the device comes close to the tag. The entire system connects to the World Wide Web via a wireless LAN.

We currently assume that an RFID tag is attached to/implanted in each real world object. We have employed a short-range type RFID system for 1) identifying each real world object, and 2) controlling the stage of the system. The range of the RFID strongly depends on an RFID tag size. Basically, when the wearer touches an object, i.e., the RFID tag reader on his/her wrist comes close to the RFID tag attached to/implanted in the object, the system identifies the object by reading the tag information.

(a) Touching an object (b) Replaying the disclosed memory

Figure 3: HMD view of the operation DISCLOSURE

The information written in an RFID tag contains two types of data. One is to identify a certain object attaching an RFID tag. We have employed a Serial Number (SRN), which is unique to each RFID tag, as an object ID. Another is data 1) to indicate the URL of the server where augmented memories associated with the corresponding object should be stored, and 2) to send a command to the system when the wearer touches one of operation tags.

System Operation Modes

The *Ubiquitous Memories* system has six operation modes: ENCLOSURE, DISCLOSURE, DELETE, MOVE, COPY, and NONE. Note that the system in the NONE mode reacts to wearer's actions only when one of operation tags is touched. Two basic operation tags and three additional operation tags are prepared to change the current mode. The wearer can select one of the following types:

ENCLOSURE: By touching the "enclosure" tag and an object sequentially, the wearer encloses the current augmented memory into the object. In the mode, "Absorb" function and "Run in" function are sequentially operated.

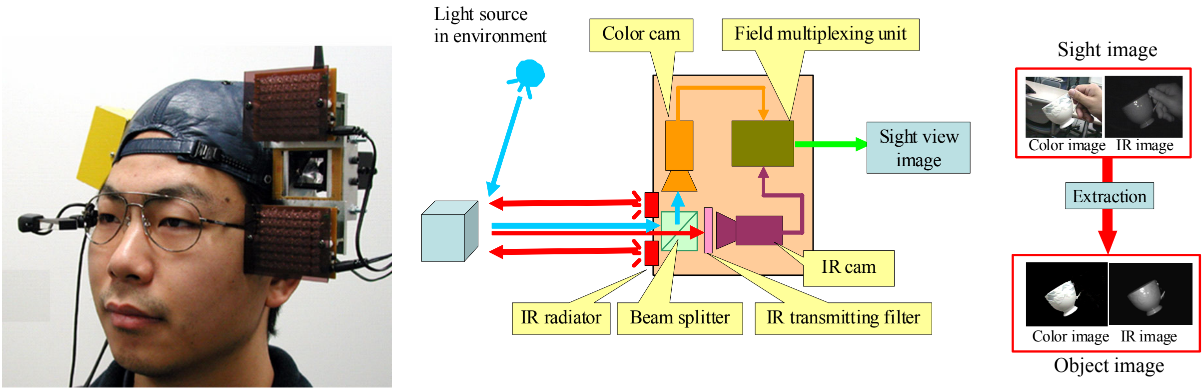
DISCLOSURE: The wearer can disclose an augmented memory from the object he/she touches, i.e., he/she can experience for himself/herself the memory. In the mode, "Run out" function and "Emit" function are sequentially operated. Figure 3 shows screenshots of the system.

The wearer can treat a video memory in the real world like paper documents or data in a PC using the following types of operation tag:

DELETE: The wearer can delete a video memory enclosed in a certain object in "DELETE" mode. This mode is used when he/she accidentally enclosed a wrong video memory, or when he/she thinks that a certain video memory is not needed anymore.

MOVE: This mode is useful when the wearer wants to move a memory from a certain object to another object. For example, the wearer encloses a video memory to a notebook in advance when he/she is in a business trip. He/she rearranges memories to each appropriate object after he/she comes back to his/her office.

COPY: In this mode the wearer can copy a video memory to other objects. An event often has contextual relations with plural real world objects. This mode enables him/her to disperse a video memory to appropriate objects.



(a) Head-mounted devices (b) Block diagram of the ObjectCam (c) Extracting an object image

Figure 4: Overview and configuration of the ObjectCam

Sharing Memories with other wearers

By accessing a real world object, in general, a wearer of the *Ubiquitous Memories* can view all the augmented memories associated with the object if the owner of each memory has approved of others viewing it. A wearer is forced to set the publication level to an augmented memory to limit users who can refer to the memory when he/she encloses it in an object. Additionally the wearer is allowed to set the reference level that indicates the type of candidate memories to be disclosed. We have defined the following attributes:

Publication Level: One of the following three types of publication level is set when the wearer encloses a video memory to an object:
Private: Only the owner of the memory can disclose it.
Group: Members of the specified group can disclose it.
Public: All users are allowed to disclose it.

Reference Level: This level is selected when a wearer discloses a memory from an object. The following three types of reference level can be set:
Personal: He/she can disclose his/her own memories.
Group: He/she can disclose memories of his/her group.
Public: He/she can disclose all the memories if the owner of each memory approved of other users viewing it.

In the disclosure process a wearer can easily find the desired video memory if the number of memory candidates that ware enclosed in the touched object using the jog controller. As the number of enclosed memories increases, however, it becomes more difficult for the wearer to find the memory to be disclosed among the candidates even if he/she limits them by selecting one of the reference levels. By employing the jog dial device, the system provides the wearer with the means to view a snapshot of each memory in the HMD and to select the desired memory by turning around the dial and pushing down the controller.

Discussions

We conducted an experiment to evaluate the effect of employing real world objects as media for augmenting human memory [4]. In this experiment we select three memorization strategies for comparative evaluations and 20 test subjects were included. The system showed the following two considerable results which imply that the system is more useful than conventional externalized memory-aid strategies:

1. People tend to use the system similar to conventional externalized memory-aid strategies such as a memorandum, and a photo album.
2. The result shows "Enclosure" and "Disclosure" operations, which enable wearers to directly record/refer to a video memory into/from an object, have an enough effectiveness to make ubiquitous memories in the real world.

The RFID devices are not essential to implement the concept of the *Ubiquitous Memories*, e.g., an object recognition technology as described in the next section can be applied to identify the object the user is touching. RFID devices are currently suitable for discriminating between real world objects and implementing the *Ubiquitous Memories* because an RFID tag does not require batteries.

I'M HERE!

Hardware and System Design

The "*I'm Here!*" retrieves the augmented memory recorded when the wearer lastly held the object that is indicated by him/her [15]. Viewing the video that was observed by his/her head-mounted camera, he/she can remember where and when he/she placed it. Ultimately we expect that the system will act as if the object itself tells the user "*I'm Here!*" The "*I'm Here!*" continuously identifies the observed object held by the user as one of the registered objects.

We have developed an "ObjectCam," which is a head-mounted combined camera device, to extract an object image from a user's viewpoint image (Figure 4(a)). A video frame consists of a color image field and an infra-red (IR) image field (Figure 4(b)). An IR image displays the reflected IR luminance caused by the IR light source on the device. The system obtains the object image by eliminating background regions from the viewpoint image with the luminance of the IR image, and hand regions by using skin color (Figure 4(c)).

We employ an Integrated Probabilistic Histogram value (IPH) to represent the feature of an image of the object held and manipulated by the user [5]. In object registration, the system records a video of the object. The system divides the images of the object into several image groups which are made from the extracted object images, based on the appearances of the object. The system constructs the feature value from the representative image of each group. We have proved that the proposed method is useful for the user to find objects by experiments [16].

Discussions

The "*I'm Here!*" provides a wearer with the means for retrieving the augmented memories associated with real world objects held by him/her along with the means for identifying each hand-held object. In everyday life, a human sequentially handles plural objects to perform a task. For instance, when he/she wants to have a cup of coffee, he/she prepares his/her cup, boils water in a kettle, and stirs the coffee with a spoon. We are also planning to extend the system to recognize the task the user performs from the sequence of symbols, i.e., accesses to identified objects. Such function would realize that the system suggests to the user what objects should be used [10] and where they are placed.

CONCLUDING REMARKS

This paper introduced methods for managing augmented memories employing real world objects. Each object is considered as a medium for archiving augmented memories and also as a front-end interface for a wearer to access augmented memories. The *Ubiquitous Memories* provides its users with the functions for both transporting and exchanging memories along with the functions for retrieving memories by touching a real world object. This paper also introduced another object-based memory retrieval function "*I'm Here!*" that recognizes the object held by the wearer. We believe that employing real world objects is one of key issues for augmenting human memory. Prototypes of these modules are independently implemented. We are currently integrating them into an augmented memory albuming system.

We are planning to continue implementing and integrating modules for *Memory Retrieval, Exchange, Transportation*, and *Editing*. *Memory Editing* will be particularly important because the augmented memory albuming system should provide the user with a method to make annotations in augmented memories. Bridging the space between real world and symbolized world is also essential to improve the memory albuming functions.

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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