Spatial Electronic Mnemonics: A Virtual Memory Interface

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Abstract. This paper proposes a novel idea of the Spatial Electronic Mnemonics (SROM) that augments human memory by using electronically annotated and/or converted materials based on places, objects and people in the real world. The SROM provides effective recall cues for information to be memorized with visual materials such as digital images captured and modified for easy association. A basic function as well as structure of SROM and some plans to construct the SROM is presented. The initial implementation and a preliminary registration experiment of spatial virtual memory peg are demonstrated.

Keywords: Memory augmentation, Pegs, Images, Locations, Wearable computer.

1 Introduction

The amount of information that we come across is continuously growing by remarkable advance in information technology. However, we do not necessarily have sufficient method to effectively utilize the vast information in our daily activities. One of the powerful solutions would be information retrieval or mining by a computer, however semantic manipulation in the search for information has not successfully realized only to depend on a keyword. An effective information use in a truly creative task can not be achieved only by machine retrieval, but be performed virtually only by the human brain. A creative work to produce novel idea is only done through manipulating information in mind. So, more information available instantly will produce more ideas. Not all vast information perceived by the user are memorized and utilized naturally, however it will probably be possible to assist mental process of memorization of the user by wearable/ubiquitous computers. These new computing machines attached to the user or distributed in the environment provide a good base for a novel mnemonic technique for the effective use of large amount of information discarded so far due to overflow.

It is well known that mental images provide strong promoter in memorization [1]. One of the oldest methods to augment human memory is the method of loci that made use of visual image effectively. The history of mnemonics [2] supports this cognitive

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phenomenon. In general, however, the mnemonics itself is not necessarily easy to memorize. The user of mnemonics has to master the technique, which limited the number of users of large capacity mnemonics.

In this paper, a novel idea of electronic augmentation of human memory, the Spatial Electronic Mnemonics (SROM) is presented. The SROM is an augmented cognition interface that expands memory capability so that the user can effectively exploit the vast information obtained by him/her.

The SROM introduces edited and annotated photo/video images of a real space to form an external Virtual Memory Space (eVMS) where the user entirely subjectively places items to remember. Although the SROM inherits powerful characteristics of classic mnemonic devices, such as the method of loci, the peg system, etc., clearly new components to enhance the functions as well as specifically ease of learning or unconscious/enjoyable mastering are provided by the SROM.

2 Spatial Electronic Mnemonics

2.1 External Virtual Memory Space (eVMS)

The SROM provides the user with devices to effectively construct and make use of cognitive memory space based on electronic augmentation of real space and objects.

The cognitive memory space that refers to the real space is termed the External Virtual Memory Space (eVMS) in the present research. The eVMS resides in the user's mind. The addressing indices to the eVMS include places, objects, people and their electronic augmentations. The indices are generically called Virtual Memory Pegs (vMPegs).

The eVMS construction is performed with the following working hypothesis.

1. Basic principle: the item to memorize is associated to a vMPeg, and localized in the eVMS to effectively augment the recall probability of the item.
2. Create association: the item to memorize is associated with a vMPeg appropriately presented at the time the item occurred so that the item is located in the eVMS to increase recall probability effectively.
3. Recall promotion: implicit cued (spontaneous) recall is scheduled by making the eVMS dependent on a context so that the item is recalled when it is needed.
4. Deletion control: deletion of an item from the eVMS is promoted by interference or self decay based on increased manipulability of the eVMS.

2.2 Virtual Memory Peg (vMPeg)

A vMPeg is a tag to the location in the eVMS. Basic characteristics of the vMPeg are the same as usual memory pegs.

1. Framework for recall: a vMPeg provides a framework of memory addressing immediately recalled when needed. It is visual and concrete. The order of vMPegs is defined as an ordered set. Otherwise, an exhaustive scan in the set of vMPegs is possible for an unordered set.

2. High associability: a vMPeg is associable to other events and objects. It is visual, concrete, and easy to make a story.
3. Fast and easy to build: a vMPeg is created with effective assistance of wearable/ubiquitous computers faster and easier than conventional method (performed without computers) with high retention, large number of items, fast and accurate recall.

A vMPeg has three material types and three attributes for each type. The types are a *location* type, an *object* type and a *human character* type. The location type is based on places and their landmark where we can go or imagine standing before. The object type is created from any objects in the world. The human character type is based on any persons the user knows.

Three attributes are *familiar*, *real*, and *virtual*. A familiar type vMPeg is a real and familiar place, object, person easy to access for the user. A familiar vMPeg is episodically firm for the individual. A real type vMPeg is a real place, object, person not accessible or hard to access for the user. It includes famous places, persons, art works, or expensive products. A virtual type vMPeg is a place, object and avatar created by virtual reality system.

vMPegs are created from places, objects and people in the forms of annotated/animated photos and videos and other electronic devices/materials, augmented by IC tags, smartphones, and wearable/ubiquitous computers. A vMPeg is a fundamental element of the SROM and eVMS.

2.3 eVMS Operations of the SROM

The SROM system includes three basic functions to manipulate the eVMS through vMPegs.

1. Registration of vMPeg: to establish a vMPeg so that it works as a framework for addressing the eVMS by electronically augmenting places, objects and people. Fast acquisition, long term retention, and a large number of items are expected merits of vMPegs. The visual images provide efficient coding for memory in the operation.
2. Association of vMPeg: to fast establish relations to other events and objects of vMPegs with high retention. Optimized association for high recall ratio is explored during the extended process of association.
3. Recall Manipulation: to adaptively adjust vMPeg to control characteristics of functions of voluntary recall and deletion of memory.

3 Registration of Location-Type vMPegs

3.1 A Method to Register Location-Type vMPegs

As one method of vMPeg registration, we propose a building process for location-type vMPeg. The method involves three features: graphic digits, photograph of location, and graphics arrangement in the photograph by the user. The vMPeg is a series of places that the user selected to use as peg locations. A picture of a place or an object of interest at the place is captured by a camera. When taking a picture, the user observes a live video image of the place as well as an overlapped graphics that indicates a digit number shown in Fig. 1. The graphic digit is associated with the (background) scene of a place with the user's arbitrary arrangement inside a video frame. The sequence of places captured is traceable in a physically continuous path that helps the user recall each place in the sequence. The associated graphic digit strengthens the hookup between the places in addition to direct mapping of a digit to the place. The method was evaluated by a memorization experiment below.

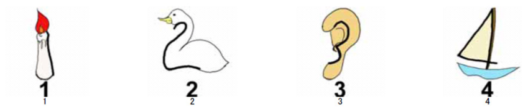
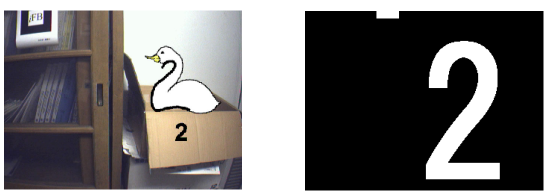


Fig. 1. Graphic digits

3.2 Presentation Condition

The subjects memorized a series of locations in two conditions: SROM condition and no-SROM condition.

SROM condition
The image presented in the SROM condition is shown in Fig. 2(a). A graphics indicating the ordinal number of the place, in this case a swan for the second, is overlaid on the background image of the location. The subject arranged the swan in a cardboard box by positioning his body and rotating his head to orient the camera on the cap to the appropriate direction. The subject observes the image by a single-eye head-mounted display. The graphic digit moved and related to the place makes an impressive visual image for the observer with an episode of his intention to create the image. It is expected that these will produce effective recall cues for the location sequence.



(a) (b)

Fig. 2. Presented images in (a)SROM condition, (b)no-SROM condition

no-SROM condition
In a usual condition to memorize many places, the images of the place are only recalled sequentially with its ordinal number in the mind. So, only the Arabic ordinal number assigned to each place is presented in the no-SROM condition. The displayed image is shown in Fig. 2(b).

In the both condition, the images in Fig. 2 are presented for ten seconds after the picture is taken. A rectangle progress indicator for the ten-second observation moved right at the top the display.

3.3 Experimental Setup

As shown in Fig. 3, a cap mounted small camera captures the user's view, and a single-eye head-mounted display (SV-6, MicroOptical Corp.) presents the overlaid video image or an Arabic digits image. In the experimental area, fifty AR markers (AR toolkit [3]) are put on a wall or objects. The display control is triggered when the camera detected one of the markers. A notebook PC in a backpack controls both sensing and displaying during the experiment. Subjects' responses are recorded as they performed pointing on a map displayed on the monitor screen of a desktop PC in addition to recording of their voices for think aloud protocol.

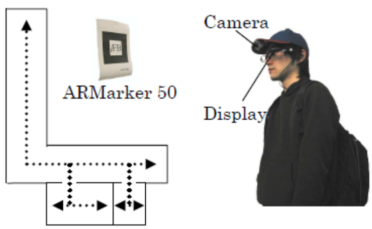


Fig. 3. Experimental workspace and wearable setup

3.4 Procedure

Within an about forty-meter path that had fifty AR markers, the subject selects twenty-five markers arbitrarily and memorize the place and its ordinal number starting from one end of the hallway. The system detects the user's selection of a marker (place) when the marker is within the field of view for two seconds and the system notifies the user it by a short sound. After five-second wait, the system captures the scene of the place and then displays a designated image for ten seconds. For SROM condition, the subject performs framing of a camera so that the graphic digit and the scene can be related to facilitate memorization. The subjects learned the graphic digits from 1 to 25 before the experiment.

The duration from the beginning to the end of last (twenty-fifth) presentation is about ten minutes. The subject was asked to recall all the places and point them on the map after two minutes rest with eyes closed. After reported the places at random order following the indication on the screen, the subject answered the places serially from the start. The answer was also video taped for protocol analysis. Each subject performed two conditions with separation of an hour rest. The start point and the goal point were exchanged between the two conditions to avoid learning effect. The recall procedures were performed three times: immediately after the experiment, two days later, and four months later. The subjects are six graduate and under graduate students with normal visual acuity and memory twenty-three years old on the average.

4 Results and Discussion

The average percentage correctly recalled and the average response time are shown in Figs. 4 and 5 (where error bar indicates standard error). Correct recall in the case of SROM two minutes after was 94.7 %, 89.3 % and 92.0 % for serial recall, random recall and the average, respectively. No-SROM condition exhibited statistically significantly lower correct recall ratio against the SROM condition. Significant difference was observed in the result obtained two days after the session. This indicates that SROM provided appropriate encoding for recall based on its three features of graphic digits, a photo of selected location, and the arrangement of a graphic digit in a background scene. The response time was longer in the SROM condition, which would be ascribed to transformation between the ordinal number to its graphic figure. The verbal report the subject showed during the response session supports this cause. It is expected that this extra time is reduced when the user is accustomed to the graphic figures. As compared to serial recall, random order recall seems more difficult for subjects. Although not statistically significant the correct recall was lower when recalled in a random order. The average response time was longer in the random recall than in the serial recall. The serial recall had a cue of places and it was performed after the random recall, which may account for the difference.

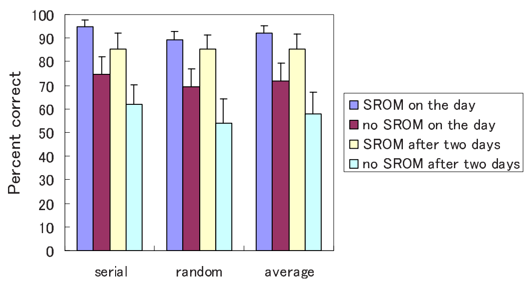


Fig. 4. Percentage correctly recalled

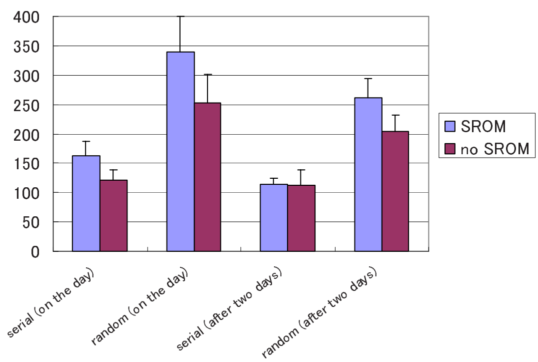


Fig. 5. Response time (in second)

Figure 6 shows the retention after a long period. SROM indicated a very high recall ratio of 62 % after four months while no-SROM was 15 % recall. It is considered that SROM could constructed effective cognitive organization for recall in view of short interval distances and less salient features of locations designated to include in the series to remember.

The result of subjective evaluation performed after the session is shown in Fig. 7. The question was "Was it easy to memorize places?" The scores differed remarkably between SROM and no-SROM conditions, 4.1 and 1.9, respectively. The subjects felt it much easier to memorize with SROM than no-SROM. They left such comments that memorability was increased even for the places with no distinctive features by creating characteristics on the fly relating graphic figures to the place, and that more increase in memorability is expected if more familiar places are used as a basis for vMPegs.

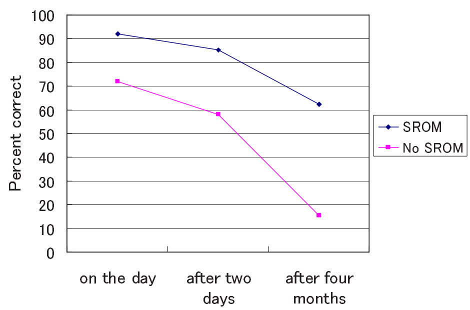


Fig. 6. Retention after a long period

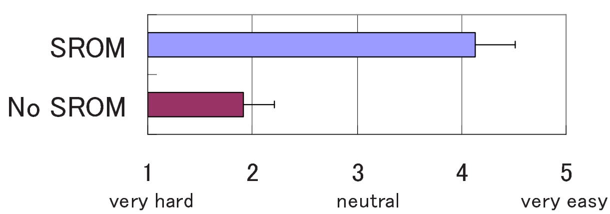


Fig. 7. Subjective evaluation for ease of memorization

5 Conclusions

A basic idea of spatial electronic mnemonics is proposed in which traditional techniques of mnemonics is augmented by electronic devices. In terms of a registration phase of SROM system, a location–type vMPeg is partially implemented and evaluated. A new technique to arrange graphic figures to relate them to a background image of location was evaluated experimentally. The result suggested this technique the user takes a photo of a place as overlapped with graphic figures significantly assisted memorization of locations as a basis of spatial mnemonics. Specifically a definite effectiveness was expected in subjective cognitive load of the user during memorization process.

References

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