Image Mnemonics for Cognitive Mapping of the Museum Exhibits

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Abstract. This paper discusses a new approach to assist human learning at the museum based on spatial and graphic information on mobile devices. A technique for memorizing a number of unstructured items is called mnemonics. Although its effects were remarkable, acquiring the skill to take advantage of the mnemonics is generally difficult. The present study provides a new technique of photo montage to fully exploit the effectiveness the mnemonics by facilitating the enrollment process. The proposed method utilizes images for a memory peg that are processed with mobile devices on the fly. After the basic structure is presented, the location type virtual memory peg (vmPeg) system is discussed. The evaluation of the system on the number of memory pegs revealed its coverage up to 50. The applicability of the method to museum exhibits specifically for children was also evaluated. The results of both experiments exhibited remarkable retention that suggested positive potential of this new mobile enhanced mnemonics.

Keywords: Cognitive space · Photomontage · Learning in a museum · Mobile device

1 Introduction

Museums have long been a medium for information transfer in the form of passive acquisition of knowledge. The advent of very small mobile computers such as high performance smartphones and handheld tablet PCs is rapidly changing the learning in museums. Spatial natures brought by the portability introduced interactive information support for the visitors. Learning is more effectively achieved when the visitor is engaged with exhibits in the museum than simply looks at exhibits and reads captions of them. A memory aid is one of effective uses of mobile computers since it is with the user at the moment of information acquisition. In the conventional memorization techniques that extend human memory capacity, it is known that spatial property including location and visual image is very effective for memory retention [1].

The present study investigates the characteristics of the memorization aid, the spatial electronic mnemonics (SROM) system [2], that expands user's cognitive memory space and its applicability to the museum learning. The method takes advantage of the property of human cognitive process on the real space and visual image using mobile devices to fit the process. It solves the problem of conventional memorization techniques, and

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expands the memory capacity by changing concrete external space into cognitive memory space.

2 Mobile Learning Assistance

The spatial electronic mnemonics [2] could effectively utilize both the sensation of location of a real space and its image to create a virtual cognitive external memory space based on a mobile device. The system enhances the human memory performance by conforming to its nature of the image memory superiority and the episodic memory high retention. Visual image composition is used in the system to establish the virtual memory pegs (vmPeg) that assists encoding and organization of memory items [3]. The organization of items is formatted by both the number-shape images (graphic numerals) and the photographs of places that had a serial order. The encoding and organization are intensified also by doing the arrangement of a graphic numeral on the image of a place by the user where the particular combination makes a good link between the two. It is important that the arrangement operation is performed by the user her/himself in the real space overlaying the graphic numeral on the real scene to make a virtual image space with a specific meaning as shown in Fig. 1. The essential source of effects of the vmPeg is both the series of the photomontages and the user behavior to establish them.

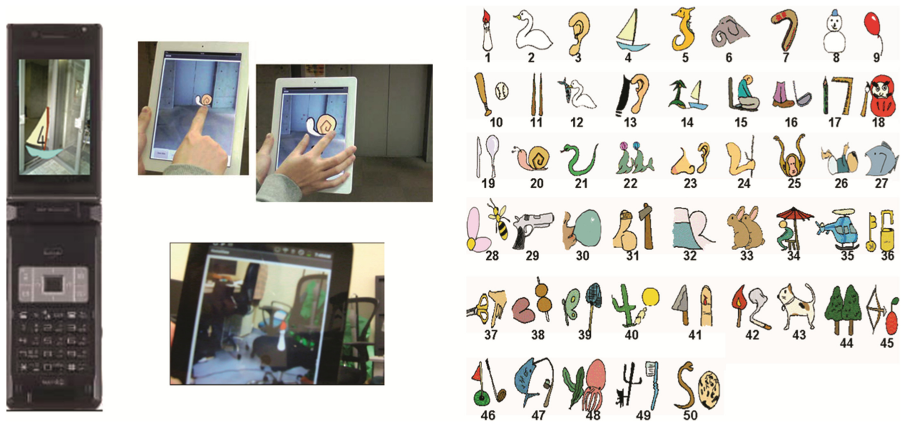


Fig. 1. SROM system running on a camera phone (left), iPad and Android terminals (center). Graphic numerals up to 50 to annotate photos (right).

The augmentation of human memory of this system has its basis on the method of loci, the peg and the link mnemonics. These traditional mnemonics have long been known [4], however they have not been in popular use because they depended heavily on the user's self-reliant effort. The SROM system as a new mobile mnemonics assists to set up a very large amount of virtual memory space extremely easily by using a smart (camera) phone and a mobile/tablet computer shown in Fig. 1.

The SROM system provides the user with cognitive mnemonic devices to effectively construct and make use of a memory space that we refer to as the external virtual memory space (eVMS). The eVMS resides in the user's mind as a cognitive map. The addressing indices to the eVMS include graphically augmented places, objects and people that are generically called as virtual memory pegs (vmPegs). The vmPeg is a cognitive tag to the location in the eVMS. Basic characteristics of the vmPeg are the same as usual memory peg such that it gives a framework of recall of many items and it is associative. However, the functions of the vmPeg are more augmented by an electronic support than the usual memory pegs.

The vmPeg has three basic features. First, it provides a framework of recall that holds many items in a randomly accessible form. It is visual and concrete for ease of encoding. Second, it is highly associative to other items or objects to memorize. Visual representation or annotation is introduced for associativity. Third, it is fast and easy to build. The vmPeg is created with an effective assistance of mobile computers to enable faster and easier acquisition, a higher retention ratio, a larger number of items, quicker and more accurate recall than conventional methods.

A vmPeg has three source material types on which it is built, and further three attributes for each of three types. The types are the location type, the object type and the human character type. The location type (shown in Fig. 2) is based on places and their landmarks where we can go in front of them or imagine standing before the scene. The object type is created from any objects in the world. The human character type is based on any person figures. The three attributes of each type define differences in the sources: familiar, real, and virtual ones. A familiar type vmPeg is based on places, objects, and people that are a real and familiar easy to recall for the user. A real type vmPeg is made of real places, objects, and people on the earth that may not be accessible or easy 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 in a virtual environment.

Fig. 2. Location type virtual memory pegs (vmPegs) composed of a photograph of a place and the annotation of a graphic numeral.

The SROM system includes three basic operations to manipulate the eVMS through the vmPegs.

1. Registration of vmPegs: to build vmPegs so that they work as a framework for addressing the eVMS.

2. Association of vmPegs: with targets to memorize. The vmPeg establishes relation to other items and objects with high later retention.
3. Assisting recall: by adaptive adjustment of a vmPeg to control characteristics of functions of voluntary recall and deletion of item in the eVMS.

3 Spatial Mnemonic Performance in the Location Type VmPegs

3.1 Objective of Evaluation

Although the vmPeg is essentially a cognitive item, its apparent, prior form is a composite picture (photomontage) that the user made by combining a number figure with the background scene at the place. By using smartphone, the composition is easily performed. This combination process including adjustment input is crucial for memorization. In addition, the number of usable vmPegs determines the practical utility when the user memorizes items for the task demand. We conducted an evaluation experiment that focused on the relations between the size (length) of the vmPegs and the recall ratio of them since the number of items of interest in a museum may tend to be large.

By comparing the recall ratios in the cases that the number of locations was set to 25 and 50, we examined the dependency of the SROM's memorization performance on the vmPeg length. The control condition was the memorization without the SROM support. The recall ratio was recorded with three time delays of immediately after the memorization, two days later, and a week later.

3.2 Procedure

The participant took pictures at the places arbitrarily selected in the university campus by a camera phone after the participant started to walk from the designated start point to the end point. The distance between the two points was about 100 m. The number of places to take pictures was 25 and 50. The subject learned the graphic numerals for a short time before the experiment.

In the SROM condition, the participant made a photomontage by placing a graphic numeral displayed on the screen of the camera phone with live background scene. Figure 3-left shows an example vmPeg that a participant composed in which the second graphic numeral of 'swan' was riding on a bicycle. After taking (composing) a shot of a place, the recorded picture was displayed on the phone screen for five seconds in the both cases where the graphic numeral was on the screen or not (control condition). The participant was asked to remember the picture (the vmPeg or a simple scene) during the five seconds. Twenty-five locations were memorized by vmPegs shown in Fig. 3-right in the case of SROM condition. After each shot, the participant was asked to do a mental calculation task—subtraction from a three-digit number on the screen by 3 repeatedly—to prevent the rehearsal of the image of the place until s/he reached to the next place.

Fig. 3. A vmPeg composed of a bicycle and a swan as the second place (left). The series of 25 vmPegs created by a participant with a camera phone (right).

Two minutes after the participant finished all the shots and compositions, the participant answered the places orally according to the indication of Arabic number shown on a computer screen. The answer voice was recorded by a sound recorder. Correct answer feedback was not provided to the participant. Both the random order recall and the serial recall were performed in this order. Every participant performed both (SROM and without SROM) conditions with a separation of an hour. In order to investigate the long term retention of the vmPegs, the participant was asked to recall the places two days later and one week later without notice. Again, no answer feedback was given.

The six students from the university and graduate school volunteered to perform the experiment. All of them reported their normal visual acuity and memory performance. The participants and places for the experiments were different between the two sets of 25 and 50 locations.

3.3 Results and Discussion

Figure 3-right shows twenty-five photomontages (vmPegs) created by one of the participants. The graphic numerals looks to be placed at an appropriate position to make a meaning for later easy recall. The recall ratios for 25 and 50 locations are shown in Fig. 4a and b, respectively. Three delay-times (0, 2, and 7-day delay) are in different colors. The participant answered both in a random order and then in a serial order according to the designated Arabic number on the PC screen.

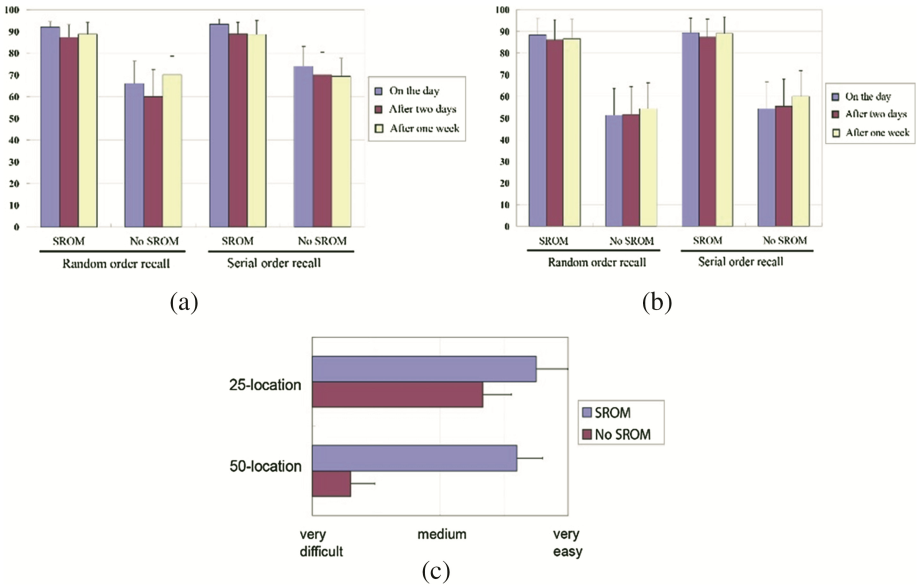


Fig. 4. Recall ratio of (a) 25 locations, and (b) 50 locations. (c) Subjective evaluation of ease of memorization. (Color figure online)

The result of the SROM condition for 25 locations (Fig. 4a) was markedly higher than the no SROM condition. With the SROM the participants correctly answered around 90 % of 25 locations. The decrease of the ratio after seven days was very small, which indicates that the retainment of memory was highly stable. On the other hand, the ratio without the SROM was 60-70 % correct answer in both random and serial order recalls.

This advantage of SROM condition was also observed in the 50-location experiment. The difference between SROM and no-SROM conditions rather increased as compared to the 25-location condition, while the SROM condition retained 90 % level correct answer ratio. The ratio of no-SROM condition was only 50 % level. Note that the high correct answer ratio of SROM was almost constant despite the increase in number of items to remember. The order of recall report—random or serial—had no effect on the recall ratio.

The result of subjective evaluation on the ease of memorization by a questionnaire is summarized in Fig. 4c. The participants reported a higher score for the SROM conditions than no SROMs. A marked difference was observed in the 50-location recall. The difference in ease of recall between conditions of SROM and no SROM was smaller in the 25-location condition. The advantage of the SROM seems to increase along with the amount of locations. On the other hand, the effort level that was induced to memorize locations was lower in the SROM than no SROM. However, a few subjects reported that they had a difficulty in relating a graphic numeral to the background scene in the case where two graphics looked to have little relation.

4 Application to Museum Exhibit Learning

To investigate practical applicability of the SROM, the authors conducted an evaluation experiment at the Science Museum in Tokyo. The museum exhibit is one of appropriate targets of the SROM system. Many objects in the museum may be easily forgotten even after a long-duration tour. The SROM system was used to remember the exhibit objects in the room that featured the science of gas. The participants were sixteen children of an age of elementary school (9 to 12 years old, the mean age was 10.5) who visited the museum during the winter holidays. We solicited children around the exhibition room of gas on the third floor (Fig. 5 center).

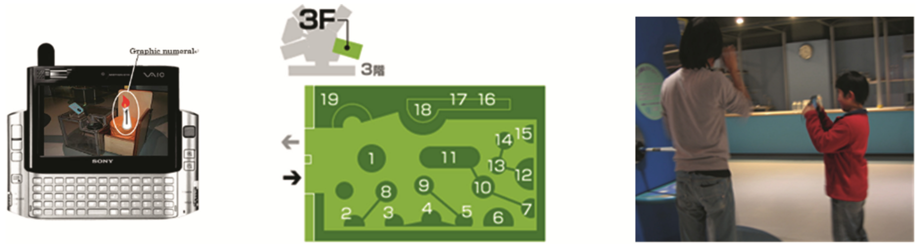


Fig. 5. SROM installed handy mobile PC (left. Vaio-U, Sony Corp.). Exhibition room featuring 'gas science' on the third floor (center). The image composition by a child with the experimenter (right).

A light-weight mobile PC (Sony, 500 g) with a touch sensitive screen was used for an easy operation. Moreover, the graphic numeral was made movable in the display by the finger. We asked the participant to walk with the PC and take a picture of exhibits using the method of SROM and without the SROM for comparison. The number of locations to remember was reduced to ten taking the age into consideration. Thus, we used only five graphic numerals so that the participant learned the numerals with only a glance. Also, testing the memory retention of participants after the memorization experiment was performed in the form of recognition in stead of recall.

4.1 Evaluation Procedure

The participant went through the exhibit room of the gas science shown in Fig. 5 after he/she received an instruction from the experimenter. The experimenter guided the participant. The participant took pictures of ten exhibits in total with the graphic numeral overlaid for odd-numbered places and without it at the even-numbered places. The experimenter asked the participant to take a picture by framing and touching the screen to position an overlaid graphic around the exhibit. After the shot, the picture was displayed for 5 s for memorization. Then a'next' button appears on the display; the participant pushed it when he/she moved to the next exhibit to shoot. At even-numbered places the display showed Arabic number of the place outside the video frame of the mobile PC. After the all shoots in front of the exhibits, we showed printed graphic numerals to the participants while they were answering to the questionnaire. The recognition test asked which of photographs was that he/she shot and where it was in the sequence from 1 to 10. We printed twenty pictures which included on the sheet ten additional pictures (distractors) the experimenter took beforehand. The participant wrote the number under the pictures.

4.2 Results

Figures 6 and 7 show the photographs the participant took and composed (left). The graphic numerals were appropriately placed to be memorized easily. These images indicate that the system was very easy to use even for a child.

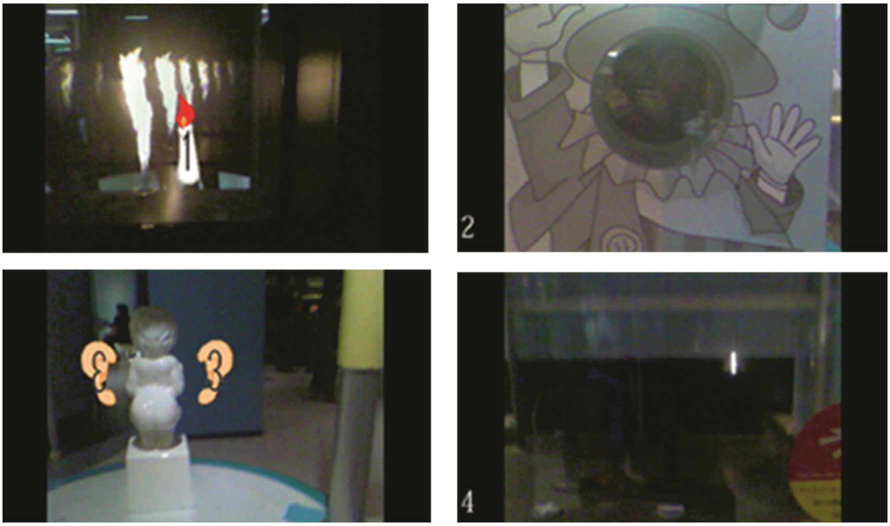


Fig. 6. Composed images (left) and shot (no composition) images (right) by a participant

The recognition ratio is shown in Fig. 8a. The score of the SROM condition was significantly higher than no SROM which suggested the SROM was effective in memorization also for school-age children. Figure 8b indicates the time for taking a picture of one exhibit. It took 14 s for the SROM, and sec without the SROM. The difference was statistically significant. It is considered that the five seconds were spent for composition of the photograph. This short-time easy operation to adjust the graphic numeral on the exhibit scene seemed very effective to increase attention to the exhibit object and to create a strong vmPeg for the later recall. The higher recognition ratio suggests that memorization and recall ratio would also be increased for the exhibit objects if so performed since the vmPeg seemed to have been successfully built. The utility of the vmPeg applied to the museum exhibit is more based on the graphic numeral than location cue since the visitor is usually not familiar with the layout of the exhibits. The recall clue provided by the vmPeg seemed much dependent on the composition task of the photomontage.

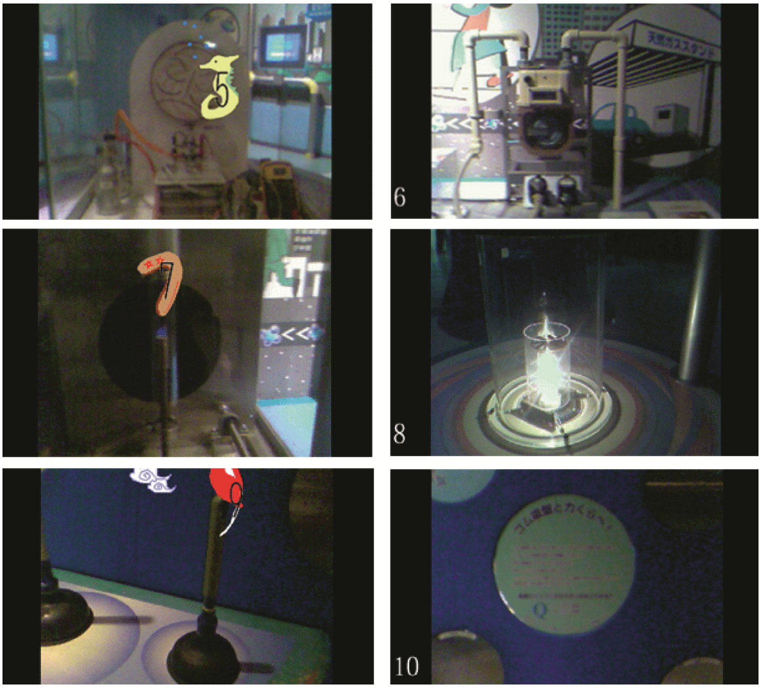
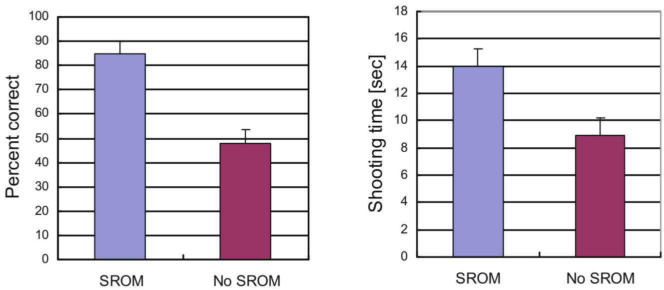


Fig. 7. Composed images (left) and shot (no composition) images (right) by a participant, continued.



(a) **(b)**

Fig. 8. (a) Recognition ratio for the exhibits. (b) Time for shooting one exhibit. (Error bars show SEM). (Color figure online)

5 Conclusion

We presented the basic concept of a spatial electronic mnemonics (SROM) that is based on a photomontage performed by a mobile device at the location in a very short time duration. According to the results of the evaluation experiment, the effectiveness of the method was maintained even when the number of vmPegs (locations) was doubled from

25 to 50. The application of the system to the museum exhibit suggested its effectiveness even for the elementary school children. The exhibit items could be mapped to the cognitive space, which might form the base of learning in the museum.

The future work includes the assistance of the composition task in addition to the support for the next stages of the association aid and the recall aid.

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