Investigating Memory Recall by Visualization of Photo Network

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Abstract
We are developing an app that presents photographs in such a way as to increase the user's motivation for activity by activating memory recall and awareness. In this paper, as a initial investigation for this project, we report a photo-network visualization system and a initial experiment conducted to assess its validity. The system groups related pictures in terms of the objects and scenes in the images. The system allows user to view the photographs interactively by selecting nodes in the network. In an experiment, participants reported that viewing the photographs on the system actually improved their memory recall. Furthermore, we uncovered evidence that certain photographs better promoted memory recall than others. We also analyzed the tendencies of the participants when selecting nodes, and whether the photographs elicited feelings of fondness or interest.

Author Keywords
Photo Network; Visual Attribute Recognition; Visualization; Memory Recall; Activity Motivation

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction

Knowledge logging refers to a method for keeping track of what user have read, learned, and understood. We believe that the technology used for knowledge logging can be distinguished from ordinal life logging in terms of attaching semantics to data. What kind of thing supplies semantics to data? In this study, we address this question in the context of a semantic network developed for artificial intelligence. It is pointed out that human memory has a networked structure in the brain [1]. According to the theory of semantic networks, individual data have attributes, and the structure of human knowledge can be expressed by connecting these data together, based on these attributes.

In this study, we prototype a knowledge-logging method that constructs a semantic network from data. The data that we treated are photographs of the events that users of the system participated in. The photographs can be considered basic life log media. Several studies have researched the effect of using photographs to promote memory recall [2]. In our study, this life log data were annotated using an automatic visual attribute recognition technique, and using its output, a network for the photographs (a "photo network") was constructed. Furthermore, we designed a system, with which users can browse the photographs on the constructed network.

We also discuss how the visualization of such a photo network affects the memory of users. We conducted experiment to determine what users recall when browsing the photo network and what kind of discovery they do. To do so, we analyzed the log and the verbal protocol data.

In the next section, we present the visualization system for the photo network. Subsequently, we describe the experiment we conducted to evaluate the system. Finally we discuss the implications of the results of the experiment.

Photo Network Construction

Photographic Data

The system developed in this study uses photographs taken during an overnight trip, in which several university students participated. At this event, 399 photographs were collected from the participants. As a user of this system to mention later, we assume the participant of this event.

Recognizing Visual Attributes in Photographs

The collected photographs varied considerably. Some photos focused on a single person, whereas other photographs contained a group of people. The objects in photos also differed. Some included a scenic landscape, and others captured images of food, animals, etc. We surmised that it might be possible to understand the relationship between photographs by recognizing these attributes and classifying the photographs based on these attributes. In this study, we visualized a photo network to represent the semantics of the events, and to understand the relationship between the photographs based on attribute recognition process. We used the ReKognition API [3] developed by Orbeus Inc. ReKognition is an image-recognition engine based on deep-learning technology that can be used to recognize attributes in photographs.

Network Construction

Using a network-visualization platform called Gephi [4], we added coordinate information to nodes, and constructed a layout to visualize the results from the attribute recognition process. We used Force Atlas as the layout algorithm [5]. Force Atlas is a dynamic repetition

based algorithm for determining the coordinates of a node by calculating the gravity acting on connected nodes and the repulsion between all nodes.

Thus, the attributes of the photographs were recognized and the photo network was constructed. The nodes correspond to photographs or tags. A tag represents an attribute given as a result of the attribute recognition process. Tag nodes were placed next to photograph nodes, and vice versa. The tag nodes connect photos that have the same attributes.

Figure 1 shows the constructed network. In the figure, similar photographs appear in close proximity to one another.

Photo-presentation System
With the network constructed with the recognized attributes of the photographs, we developed an interactive photo-browsing system using D3.js (D3:Data Driven Document) [6], a JavaScript library for operating documents based on data for development.

The user of the proposed system is able to browse photographs by choosing a node on the network. When a node is selected, its outline is emphasized, and the selected node is highlighted in red. Likewise, nodes that are next to red nodes are highlighted green, and, nodes next to green nodes are highlighted blue; the remaining nodes are pale-colored. In addition, the label for the selected node is displayed on the network. Because tags with users' names are of particular importance to users, these tags are always emphasized, and labeled such.

Figure 2 shows an example of a screen-shot after a user clicks a node that represents a photograph. The window on the left lists the attributes of the photo, and the window on the right displays adjacent photos that share these attributes.

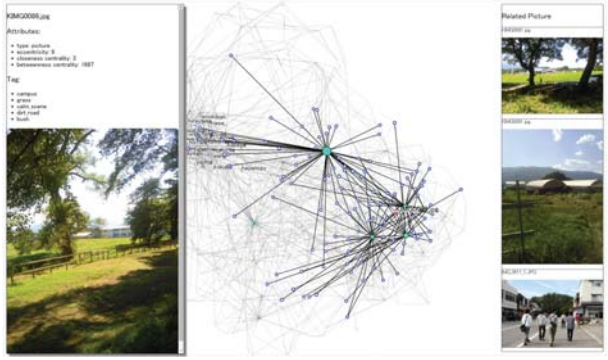

Figure 2: Screen-Shot of Photo-presentation System.

Experiment

Purposes
In our experiment, the same participants who attended the event used the photo-presentation system. The experiment was designed to evaluate the following.

1. To determine the validity of the tags issued by ReKognition and the validity of the network structure.
2. To evaluate the influence of the system on the users' cognition. In particular, we examined its effect on memory recall and motivation for future activities.
3. To determine how the system might be improved to better promote memory recall and motivation.

Participants
Six graduate-/-under-graduate students (between 22 and 23 years old) participated in the experiment. All of these

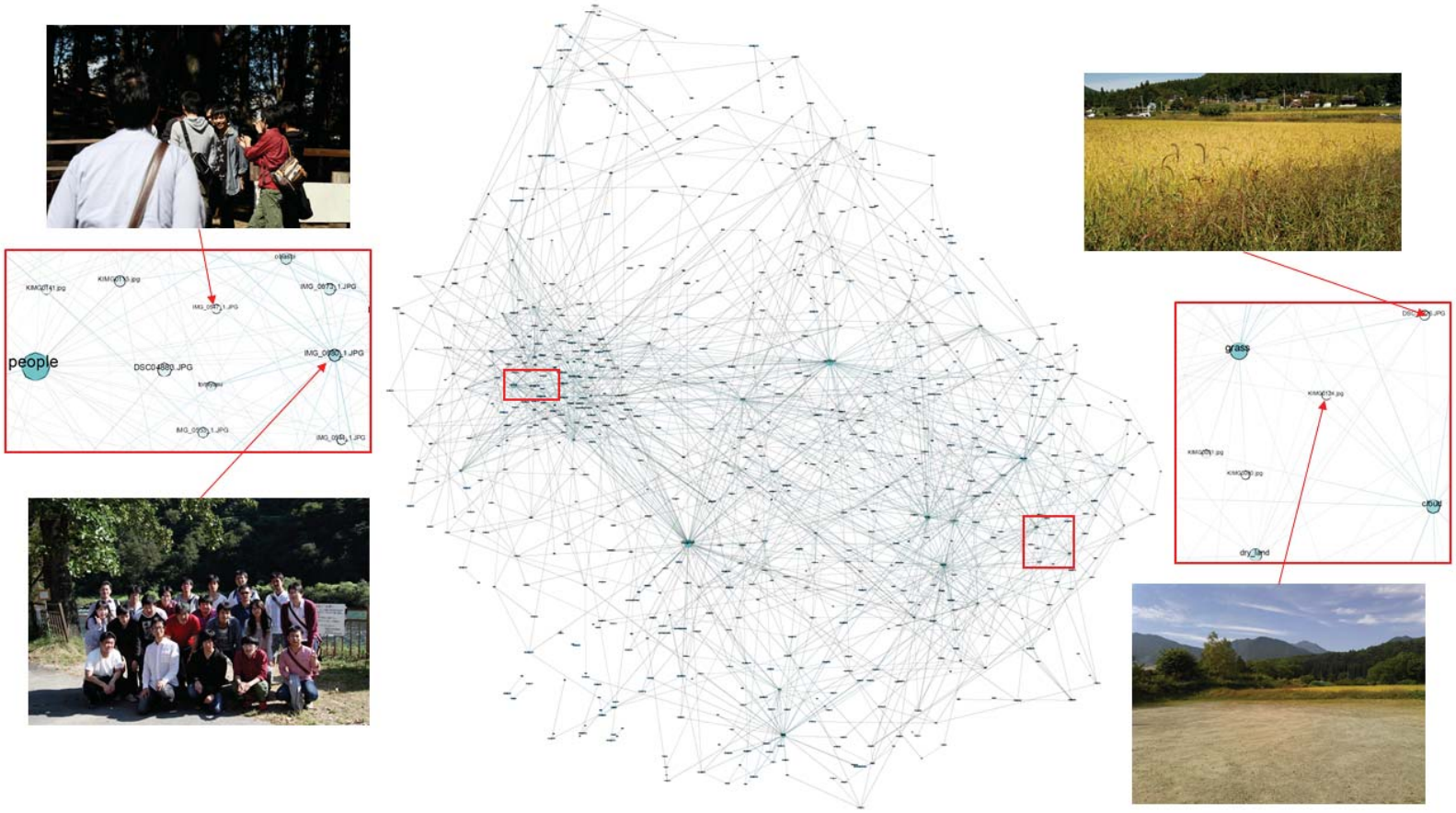

Figure 1: Constructed Photo Network.

students took part in the event during which the photographs used for the network were captured.

Procedure
First, the experimenter provided a summary and explained the purpose of the experiment to the participants. The experimenter also provided simple instructions for operating the system. The participants were asked to verbalize their thoughts during the experiment (using the so-called "think-aloud method"). To familiarize the participants with the think-aloud method, they verbalized their thoughts while attempting a simple Sudoku puzzle, before engaging in the main task.

The participants were asked to fill out a questionnaire prior to using the system. The participants then used the system for 30 minutes. Finally, they responded to another questionnaire after having used the system.

The latter questionnaire contained the following two items, whereas, the former questionnaire contained only the first.

1. Free description summarizing the event and the user's impression of it.
2. Five-point scale evaluations regarding the validity of the tags and the effect the system has on the user's memory.

Results

Questionnaire Results
Regarding the descriptive summary of the event provided by the participants, we compared the two questionnaires (before and after using the system) in terms of the number of written items in the summary (see **Figure 3**).

All of the participants increased the number of summary after using the system.

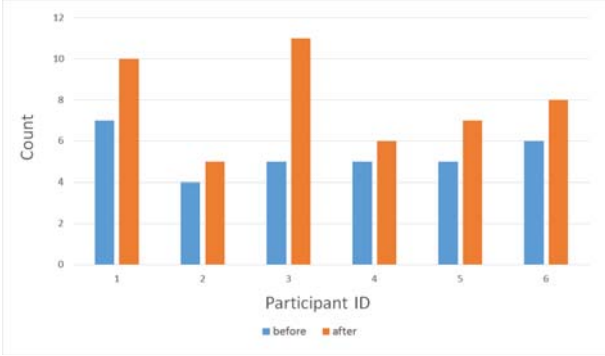

Figure 3: Change in the Number of Items in the Summary before and after the Experiment.

Table 1 summarizes the evaluation scores obtained from the five-point scale evaluations. We obtained high evaluation scores for three items: "the usefulness of the system in terms of one's memory recall of the event" (Q3 in **Table 1**); "the usefulness of the system for increasing one's awareness of the event" (Q4 in **Table 1**); and "the increase in motivation as a result of using the system" (Q5 in **Table 1**). In addition, when asked whether they felt similarity between the photographs located in near positions (Q7 in **Table 1**), we obtained a high score, whereas the validity of attached tags (Q6 in **Table 1**) resulted in a lower score.

Interest in Related Pictures
We classified how the users clicked on nodes to analyze their behavior.

- 1-step : Clicking on a node next to the currently selected node

Table 1: Result of 5 Points Scale Evaluations.

	Participant ID						
	1	**2**	**3**	**4**	**5**	**6**	**Average**
1.Usability	2	4	3	4	3	3	3.2
2.Layout	4	5	4	4	4	4	4.2
3.Memory Recall	5	5	4	5	5	4	4.7
4.Awareness	4	4	4	5	5	5	4.5
5.Increase in Motivation	4	4	4	5	5	5	4.5
6.Validity of the Tags	2	2	3	3	2	2	2.3
7.Clusters of Related Pictures	5	5	4	5	3	3	4.2
8.Interest in Related Pictures	4	5	4	4	4	4	4.2

- 2-step : Clicking on a node next to the 1-step nodes
- Jump : Clicking on a node at least three steps away from the currently selected node
- Same : Clicking on the same node as the currently selected node
- Free : Clicking on a node other than the above

In addition, we analyzed the verbal-protocol data obtained during the experiment and classified the verbalized thought into the following categories.

- Description
  Utterances describing the photographs or the displayed information
- Evaluation
  Utterances evaluating the tag or somethings related to the objects in the photo
- Emotion
  Utterances expressing emotion upon seeing the photograph
- Recall
  Utterances expressing the occurrence of memory recall
- Motivation for future activity
  Utterances expressing an increase in motivation for future activity

We thus classified the utterances for each click made in the experiment. When an utterance applied to multiple categories, we classified it in each category. For example, the following utterance was classified as both a "Description" and a "Motivation". "This is a photograph of menu taken during dinner. I want to eat there again."

For all combinations of the classes of clicking and verbal utterances, we calculated the correlation coefficients between the number of clicks and the utterances ($n = 6$, where n denotes the number of participants), as shown in **Table 2**. We found a strong positive correlation, 0.875 ($p < .05$), between the number of "Description" utterances and "1-step" clicks. By contrast, there was a strong negative correlation, -0.844 ($p < .05$), between the number of "Description" utterances and "2-step"

Table 2: Correlation between the Number of Utterances and the Number of Clicks.

	Description	Evaluation	Emotion	Recall	Motivation
1-step	0.875*	-0.323	-0.291	0.231	-0.584
2-step	-0.844*	0.098	0.485	-0.062	0.631
Jump	-0.474	0.520	-0.406	-0.535	0.563
Same	-0.489	0.320	0.396	0.136	-0.416
Free	0.012	0.645	-0.533	-0.692	-0.077

clicks. Although it was not significant, the correlation for the number of utterances classified as "Motivation" resulted in the opposite pattern to that of the utterances classified as "Description", As such, utterances of "Motivation" had a positive correlation with the number of "2-step" clicks and a negative correlation with the number of "1-step" clicks. The number of utterances of "Recall" had a higher negative correlation with the number of "Jump" and "Free" clicks.

Discussion

Validity of the Recognized Visual Attributes and the Constructed Network

The participants in the experiment did not consider the tags from the attribute recognition process particularly valid. Nevertheless, most participants felt that many similar photographs gathered at local regions on the network. Therefore, even if the tags generated with ReKognition were ostensibly spurious, they were nonetheless successful in combining associated photographs in the network.

Effect from Visualizing the Network on the Increase in Motivation and Memory Recall

The descriptive summaries increased after the participants used system, and all of the participants scored the items for memory recall and motivation higher than four points on the five-point scale. Furthermore, from the utterances recorded during the experiments, the effect of the system on memory recall and motivation was confirmed. Therefore, the proposed system has the potential to bolster memory recall and motivation.

Recommendations for Future Design

Given the correlation between the utterances classified as "Description" and "1-step" clicks (see **Table 2**), we submit that the interpretation of the image or tag is promoted when the user clicks on a adjacent node. The correlations between "2-step" or "Jump" clicks and utterances classified as "Motivation" (see **Table 2**) also suggest that motivation is promoted by searching for a node at least three steps away from the currently selected node. Thus, we conclude that closely related photographs should be displayed when attempting to increase the user's interpretation of a photograph and for promoting memory recall. We also conclude that unrelated photographs should be displayed when attempting to increase the user's motivation.

Summary

In this study, we constructed a photo network generated from an automated attribute recognition process, and we

designed a system for visualizing this network. Furthermore, we carried out an experiment to evaluate the proposed system. We believe that the proposed network is a form of knowledge logging, because it represents the semantics of life log media, namely photographs. The experiment we conducted reveals the potential for augmenting human mind with knowledge logging technology.

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