Visualization for Analyzing Ubiquitous Learning Logs

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Abstract: This paper describes a system that can be used to visualize some ubiquitous learning logs to grasp and discover several learning flow and timing. Visualization of the system is based on vast amount of learning data in ubiquitous learning environment. Ubiquitous Learning Log (ULL) is defined as a digital record of what learners have learned in the daily life using ubiquitous technologies. It allows learners to log their learning experiences with photos, audios, videos, location, RFID tag and sensor data, and to share and to reuse ULL with others. This paper will reveal about the relationship between the ubiquitous learning logs and learners by using network graph. Also, this paper will explicate the system through which learners can grasp their learning time, histories, knowledge and location.

Keywords: ubiquitous learning, network graph, time-map, information visualization

1. Introduction

Recently, researchers in the educational engineering area have been studying focusing on ubiquitous themes. For example, CSUL (Computer Supported Ubiquitous Learning) or context aware ubiquitous learning (u-Learning) have been constructed using computing technologies such as mobile devices, QR-code, RFID tag and wireless sensor networks (Hwang et al., 2008; Ogata & Yano, 2004). These learnings take place in a variety of learning space such as classroom, home and museum. Also, the cutting-edge technologies can provide the right information using the contextual data like location, surrounding objects and temperature.

Therefore, many researchers have been focusing on effective learning with ubiquitous technologies. We have developed ubiquitous learning system called SCROLL (System for Capturing and Reminding of Learning Log) (Ogata et al., 2011). The system will support international students to learn their target languages. Traditionally, international students take memos when they have learned something in their daily lives. However, if the notes have not been taken in detail, they can neither actively recall what they have learned, nor the location where they learned them. Therefore, we have proposed SCROLL which enables learners to recall their past learning experiences by saving them to the system with location, photo, or video as digital records.

Also, these learning dataset include spatiotemporal data. Spatiotemporal data usually contain the states of an object, an event or a position in space over a period of time. These datasets might be collected at different locations, various time points in different formats. It poses many challenges in representing, processing, analysis and mining of dataset due to complex structure of spatiotemporal objects and the relationships among them in both spatial and temporal dimensions (K.Venkateswara Rao et al., 2011, 2012).

Similarly, it poses many issues about relationship between the learners and the ubiquitous learning logs due to complex structure of the ubiquitous learning logs in SCROLL. In addition, it is important for learners to recognize what and how they have learned by analyzing and visualizing the past ULLs, so that they can improve what and how to learn in future (Ogata et al., 2011). To tackle these issues, it is necessary to reveal relationships between the learners and the ubiquitous learning logs.

Therefore, this paper proposes a method to visualize relationships between the learners and the ubiquitous learning logs using Time-map and network graph. The objective of this study will reveal how the learners learned language in their daily lives. Therefore, this paper will visualize learning data collected from SCROLL, and as next step will analyze them.

2. Related Works

2.1 Learning Analytics and Knowledge

In recent years, Learning Analytics and Knowledge (LAK) has been drawing an attention from researchers of such fields as educational engineering, information science and network science. To date, Course Management System (CMS) and Learning Management System (LMS) enabled us to record learners' access logs onto server. The Learning Analytics (LA) aims for practical use based on learning mechanisms revealed by visualizing, mining and analyzing vast amount of learning data (Ferguson 2012). This paper focuses on the Social Learning Analytics (SLA), a subset of the LAK (Buckingham 2012). The SLA puts forward presenting appropriate information to learners at the appropriate timing through the Dashboard in real time. As a new challenge, this paper aims to reveal about relationships between learners and learning logs on spatiotemporal fields.

Therefore, this paper is expected to contribute to educational improvement and strategies below.

- This study facilitates the analysis of learners by visualizing all data on spatiotemporal.
- This study enables future prediction about learners and learning environment from visualized learning logs.

2.2 Time-map

Time-map is a library of javascript, which collaborated with Google map and SIMILE (Semantic Interoperability of Metadata and Information in unLike Environments) TimeLine (SIMILE project). SIMILE focuses on developing robust, open source tools that empower users to access, manage, visualize and reuse digital assets. The time-map function means that the user can scroll the timeline and then the Google map will display the learning logs recorded during learners' selected period. It is designed to help learners to reflect what they have learned. For example, if a learner clicks his learning logs on timeline, Google map will display their positions as shown in Figure 1. After visualizing log information, Time-map will facilitate learners to reflect on their logs with spatio and temporal information. They are able to grasp their learning context and time zone. Also, it is a possibility that the geographic information is a clue of recalling what they have learned.
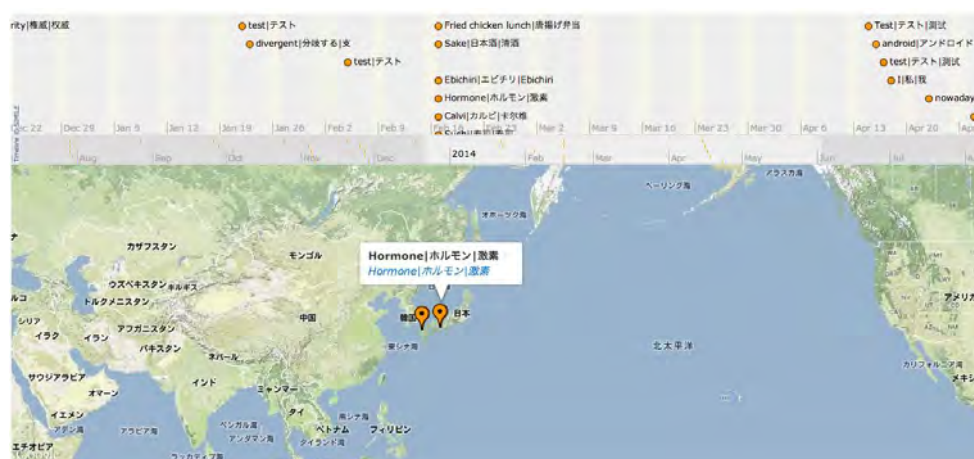

Figure 1. Time-map

3. Design of the system

3.1 SCROLL

With the evolution of the mobile device, people prefer to record learning contents using mobile devices instead of taking memos on paper. Most of the language learners have their own learning notes. In this paper, learning log is defined as a recorded form of knowledge or learning experiences acquired in our daily lives.

One of the objectives of SCROLL is to support international students in Japan to learn Japanese language from what they have learned in formal and informal setting. It adopts an approach of sharing user created contents among users and is constructed based on a LORE (Log-Organize-Recall-Evaluate) model which is shown in Figure 2 (Ogata et al., 2011).
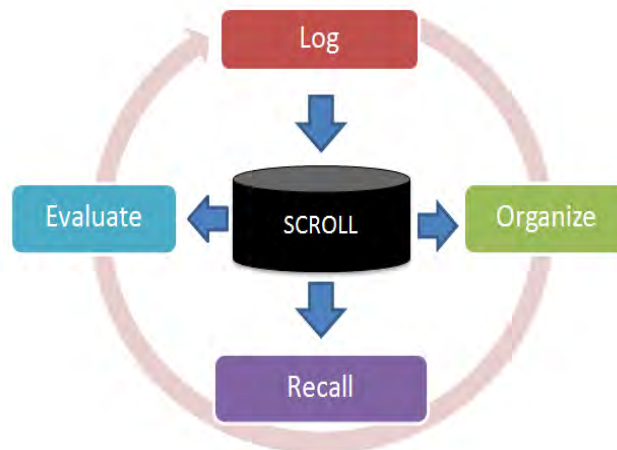

Figure 2. LORE model in SCROLL

SCROLL is a client-server application, which runs on different platforms including Android mobile phones, PC and general mobile phones shown in Figure 3. The server side runs on Ubuntu 12.04.2 and it is programing using Java, Spring MVC and Mybatis. The developed software for Google phone is a native java application based on Android SDK (Li et al., 2012).
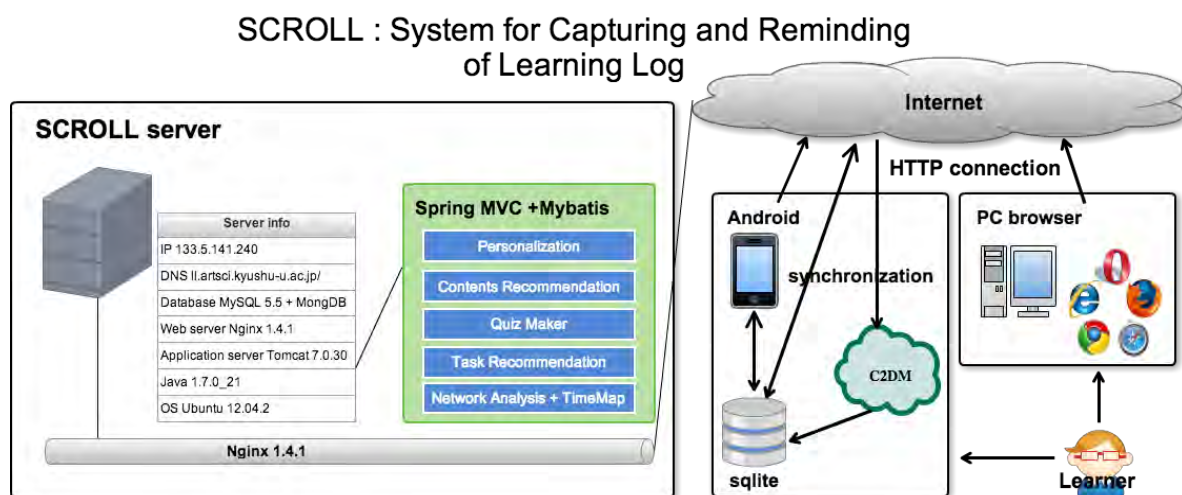

Figure 3. The architecture of SCROLL

3.2 Collecting a ubiquitous learning log on SCROLL

The learners can record some learning language such as English, Japanese and Chinese with a photo using android device and SCROLL as shown in Figure 4. Figure 5 shows a learning log on android device.

The learning log includes meta-data such as author, language, created time, location (latitude and longitude) and tag. The learners will record or review a learning log using these functions on android device. Such iterative learning is supported by our quiz function on SCROLL. There are three types of quizzes generated automatically by the system, which are yes/no quiz, text multiple-choice quiz and

image multiple-choice quiz. Figure 6 shows an image multiple-choice quiz interface generated automatically based on the meta-data of ULLs.

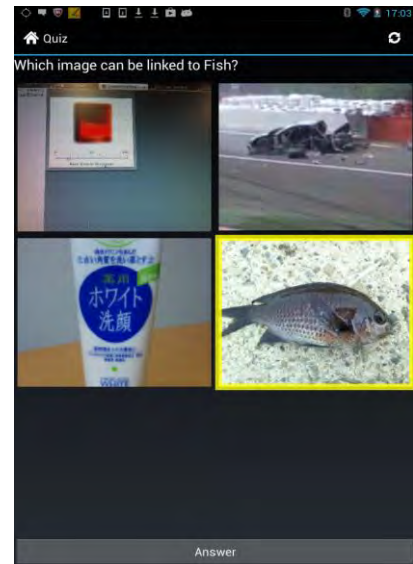Figure 4. Learning note

Figure 5. A learning log

Figure 6. Quiz

3.3 Structure based on network graph in SCROLL

To reveal several relationships between the learners and knowledge or knowledge and location, we have uniquely defined them as three-layers structures as shown in Figure 7.
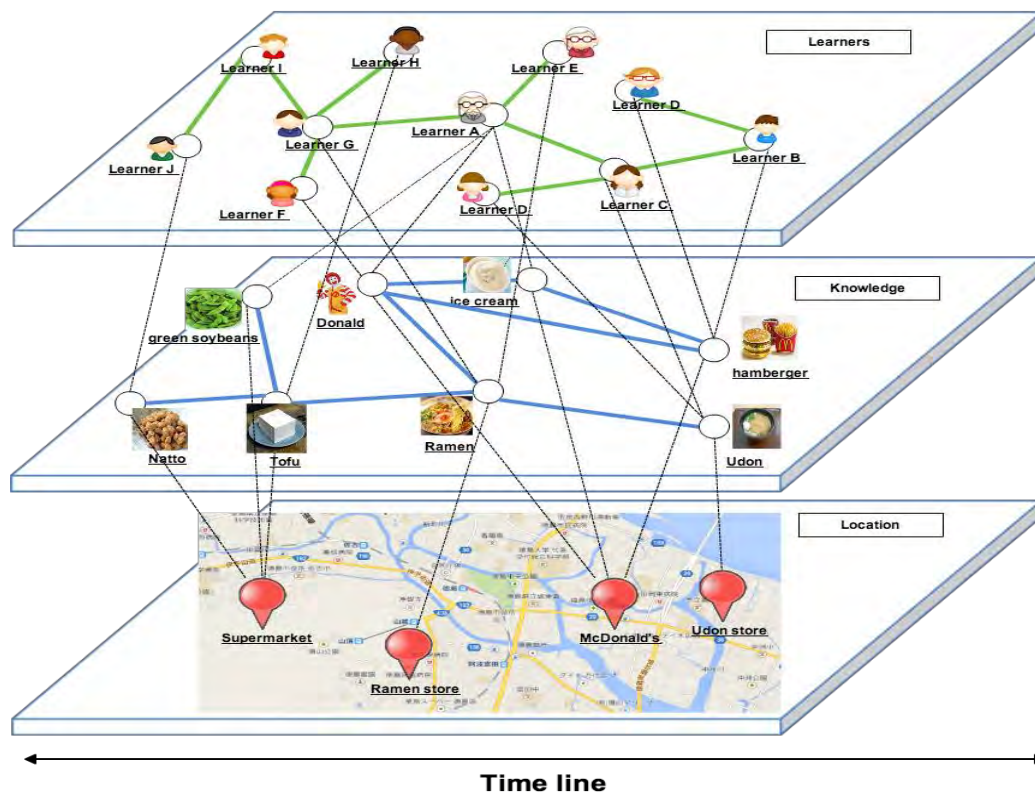

Figure 7. Three-layer structure in SCROLL

The upper layer contains each author in order to confirm position of own or other learners.

The intermediate layer contains the knowledge that learners learned. Also, some fields of learning tasks can be included in this layer. For example, some task-based learning in ubiquitous learning environment can be carried out using knowledge and event (Mouri et al., 2013; Sharon 2013). The

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scalability of the layers can be enhanced and the field of visualization can be widened by linking one's own learning logs to the knowledge learned by doing tasks.

The lowest layer contains data such as location and time. In order to realize spatiotemporal visualization of our learning logs, nodes on the intermediate layer are linked to the nodes on the lowest layer.

Analysis by categorizing three-layers has following advantages:

- Places with a large number of links to the related knowledge are the places where they can learn a lot of knowledge. For example, if a certain supermarket or convenience are related with a lot of knowledge such as natto, green soy beans, tofu, miso soup, and cup noodle, by analyzing relationships between the knowledge and the location the System can provide learners with a valuable learning information.
- Knowledge which is related to many places is the knowledge which we can learn in various places. For example, if a learner experience tea ceremony of a traditional Japanese culture at the university in Japan, a set of tea ceremony related knowledge (eg. tea, seize: to sit in the correct manner on a Japanese tatami mat) can be learned in other various places. The tea can be learned by purchasing at the supermarket and the seiza can be learned at the martial art gym.

4. Implementation

This section describes ways of the implementation of the system for visualizing the three-layer structure using network graph and Time-map.

4.1 System for visualizing network graph in SCROLL

4.1.1 How to create node or connect edge on three-layers

Firstly, system for visualizing network graph will create authors' node on the upper layer. To date, the number of learners in SCROLL is approximately three thousand people.

Secondly, the system will create knowledge node on the intermediate layer. Then, the system will connect authors' node related to knowledge node that learners have learned. For example, if learner A learned a learning log like "natto (a traditional Japanese food made from fermented soybeans)", "tofu (bean curd)" and "sushi", the system will connect "learner A" of node on the upper layer to "natto", "tofu" and "sushi" on the intermediate layer.

Thirdly, the system will create location node on the lowest layer. Then, the system connect knowledge node on the intermediate layer to node of the location on the lowest layer. For example, if the learner A have learned knowledge of "natto" at the supermarket in Japan, the system will connect "natto "on the intermediate layer to the latitude and longitude of "supermarket" on the lowest layer.

4.1.2 Color of visualized nodes

The learners might get confused when they recognize past learning logs because there might be too many of visualized nodes. Therefore, it is definitely necessary to establish some criteria for distinction of each node. To effectively distinguish kind of each node, we defined as Table 1 below using node color.

Table 1: Color to distinguish the kinds of nodes

Node	Layer	Node color
Learner's own name	Upper layer	Pink
Names of other learners	Upper layer	Blue
Knowledge of learners	Intermediate layer	Yellow
Location of learners	Lowest layer	Red

- Pink color node shows the learner's own name on the upper layer. If connecting the pink node to yellow node on the intermediate layer, edge color will be decided as pink so that they can be easily recognized as the learner's own logs.
- Blue color nodes show the names of other learners on the upper layer. If connecting the blue node to yellow color node on the intermediate layer, edge color is decided blue color.
- Yellow nodes represent both the learner own knowledge and the knowledge of other learners. For example, the learner can recognize his own knowledge because edge between the learner own name on the upper layer and the knowledge on the intermediate layer is pink color. In addition, the learner might discover knowledge of other learners related to own knowledge.
- Red color node shows the location of learners on the lowest layer. The node includes latitude, longitude and created time.

4.2 Combining network graph and Time-map

The interface of the network graph on web browser is shown as Figure 8. The learners can recognize relationships between own/others author and knowledge by using the network graph interface. The learners' node (red or blue node) on the network graph is connected to many knowledge (yellow node) in accordance with node color. The network layout consists of using Yifan Hu multilevel layout (Y.F Hu, 2001, 2005).
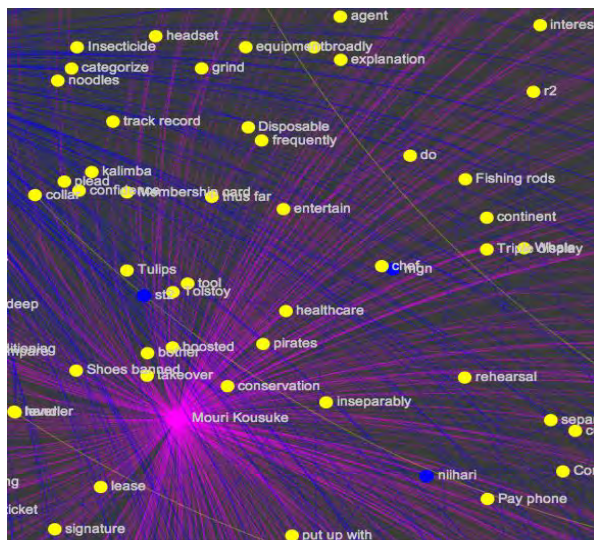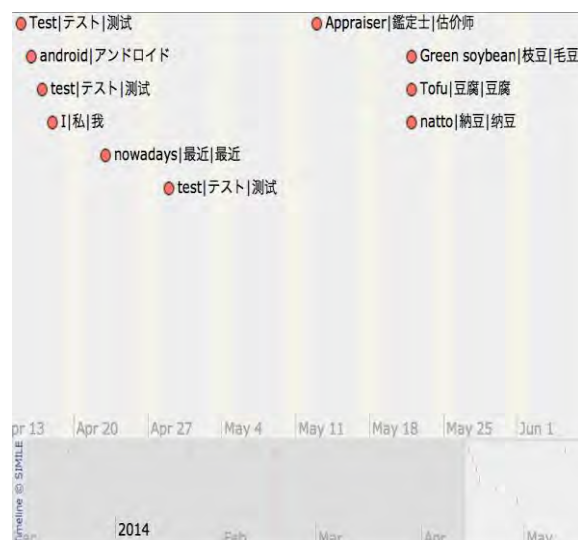

Figure 8. Network graph on web browser

Figure 9. Time line on web browser

Figure 10. Time-Map on web browser

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It is a very fast algorithm with a good quality on large graphs. It combines a force-directed model with a multilevel algorithm to reduce the complexity. The repulsive forces on one node from a cluster of distant nodes are approximated by a Barnes-Hut calculation (Barnes and P. Hut., 1986), which treats them as one super-node.

The interface of Time-map on web browser is shown as Figure 9, 10. Figure 9 shows the sample of learners' timeline. It represents the shift of learning history in accordance with lapse of time. The learners might forget the learning logs when and where they have learned before. Therefore, the system can remind the learners of them by combining timeline with map as shown in Figure 10.

We have developed the system for visualizing who is learning what, and when, where and how by combining these interfaces. The learners will find it useful with the following respective reasons.

- The learners can be aware of relationship between their own knowledge and other knowledge. The new knowledge can be found easily by viewing the network graphs.
- The system will remind them of their learning logs recorded during the specified period of time by showing them on the timeline (default: two month before and after the setting time). Besides, the system will lead them to be aware of knowledge recorded right before or after the knowledge of their interest which was recorded by other learners. Therefore, it will give them a clue on what to learn next. For example, if learner A learned a natto at the supermarket, there is a possibility that learner B had already learned it. When the learner B learned a natto, he/she might have learned other natto related words such as tofu and green soybeans. Natto related words which learner B had learned would be recommendable learning contents for learner A. That way learners can learn their target language more effectively using visualized information.

5. Evaluation

5.1 Method

Eight international students studying at the university of Tokushima and Kyushu participated in the evaluation experiment. Participated students were from China aged between 21 and 34. Their length of stay is from 1 month to 5 years. The participant information is shown in Table 2.

Before the evaluation stared, we explained about how to use the system for visualizing learning logs to them. They've never used SCROLL. Therefore, they used SCROLL for one day before using system for visualizing learning logs. They at least recorded five learning logs one day, and then they recorded learning logs using our proposed system for one week. After the evaluation, the participated students were asked to fill in a five-points-scale questionnaire, and they have evaluated the performance, usefulness and learning effectiveness on this system.

Table 2: Detail of students

	Age	Gender	Length of stay
Student A	24	Male	2 years
Student B	26	Male	2 years
Student C	21	Male	2 years
Student D	34	Male	5 years
Student E	23	Male	1 months
Student F	23	Male	1 months
Student G	23	Female	1 years
Student H	25	Female	7 months

5.2 Result and discussion

The questionnaire results are presented in Table 3.

Q1-Q5 are the questions to ask its usability and usefulness of our network graph. Q6-Q9 are the questions to ask the importance and performance of the system combining the Time-map and the network graph.

From the results of Q1 and Q2, it reveals that the learners were able to efficiently grasp their own or others' knowledge using the network graph for visualizing learning log.

Q3 result indicates that the learners were able to grasp similar knowledge between their own knowledge and other knowledge. Q4 result indicates that they were able to grasp knowledge using different color. When they found other learners or knowledge, the most of students recognized them from nodes' color. Therefore, it was effective to distinguish other learners and learning log by color. Q5 result indicates that network graph of the system was useful.

Q6 and Q7 results indicate that the learners were able to discover other interesting learners or knowledge that they didn't know. When the learners discovered new knowledge or other learners, what they had discovered is shown in table 4. Table 4 shows the multiple-choice questionnaire. Most of them discovered the knowledge from the process number 2. This is because the learners were able to discover the knowledge in this system thanks to visualizing all learning logs.

Q8 resulted in the lowest average score in questionnaire. This seems to be because that effectiveness comes not only from grasping their own learning trend. Therefore, the system needs to recommend appropriate learning trend from other learners' learning trend in future. For example, if learner A learned the "natto" in the supermarket, and learner B already might have learned the "natto" at different or same location. After learner B learned "natto", he/she might have learned continuously some related words such as green-soybeans and tofu. Similarly, after the learner C learned the "natto", he/she might have learned some related word such as rice and soy sauce. Therefore, it is useful in future that the learners can be aware of next learning trend by other learners' trend being recommended.

Q9 result indicates that the learners were able to recall the knowledge using the system combining the network graph and Time-map.

Table 5 lists the open-ended comments of the participants about the problem they found using the system and their suggestions for the improvement of the system.

It was suggested that improving UI (User Interface) design and function would be helpful to recognize their knowledge. Taking these issues into account, our future works will be described in the next section.

Table 3: Result of the five-point-scale questionnaire

Question	Mean	SD
1. Were you able to grasp your own knowledge using network graph?	4.50	0.50
2. Was this system useful to find new knowledge?	4.62	0.48
3. Were you able to recognize relationship between yourselves and other learners?	4.12	0.59
4. Were you able to grasp whole knowledge and your own knowledge by the node color?	4.25	0.66
5. Was network graph of the system useful?	3.87	0.92
6. Were you able to discover knowledge of interest on Time-map and other learners' knowledge?	4.62	0.48
7. Were you able to distinguish one learner from another and to discover interesting learner?	3.37	1.40
8. Was it important to grasp your own learning trend on Time-map?	2.87	1.45
9. Were you able to recall the knowledge when and where you have learned by using system for visualizing learning log with Time-map?	4.5	0.70
10. Please rate on a five point scale how much it helped you to grow your Japanese/English vocabulary.	4.37	0.48
11. Please rate on a five point scale how much it helped you to improve your Japanese (English) ability.	4.37	0.48

Table 4: The process of discovery of knowledge and other learners

Process	Total (8/8)
1. The learners randomly chose one from all of nodes.	3/8
2. The learners discovered interesting knowledge by chance.	6/8
3. The learners discovered it because their own knowledge and other learners' knowledge were same knowledge.	3/8
4. The learners discovered some knowledge from other learners (blue node).	2/8
5. Other (Free description)	0/8

Table 5: User comments

Users' suggestions (Open-end questionnaire)
1. It is very easy to use. I was able to find new knowledge.
2. I think that you should improve the UI design on network graph. It was the complex screen.
3. There were too many learners on interface, so it would be confusing. I think that you need to improve it.
4. The interface is difficult to understand.

6. Conclusion and Future work

This paper described the system for visualizing relationships between the learners and the learning logs. International students can add their knowledge as the learning log in SCROLL, and then SCROLL can provide learning contents to recall what they learned based on their learning contexts. By using the system that we proposed, the international students can discover the knowledge related to others learners and the interesting knowledge. The initial evaluation was conducted after implementing the function to visualize the learning logs and the learners. Five-point-scale questionnaire conducted after the evaluation shows that the system supported the international students by visualizing the learning logs. As mentioned in section 5.2 results and discussion, it needs improvement of its UI design and functions. Therefore, we will improve the system by excepting useless knowledge using filtering function.

In the future, we will develop a new function so that the system can analyze various situations focusing learning analytics such as network analysis (Freeman 1978; Shane 2014), decision tree (Bitner 2000) and association rule (Florian 2005). In addition, we will consider quantitative measures and user self-reported data when evaluating the function.

Acknowledgements

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