

Visualizing Ubiquitous Learning Logs Using Collocational Networks

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Abstract: This paper describes a system that can be used to visualize some ubiquitous learning logs using collocational networks to discover several learning patterns. 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 and collocational networks. 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, collocational networks

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, network graph and collocational networks. The objective of this study will reveal what and how the learners learned language in their daily lives. Therefore, this paper is aimed to recommend appropriate learning patterns and trends for the learners, using collocational networks.

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.

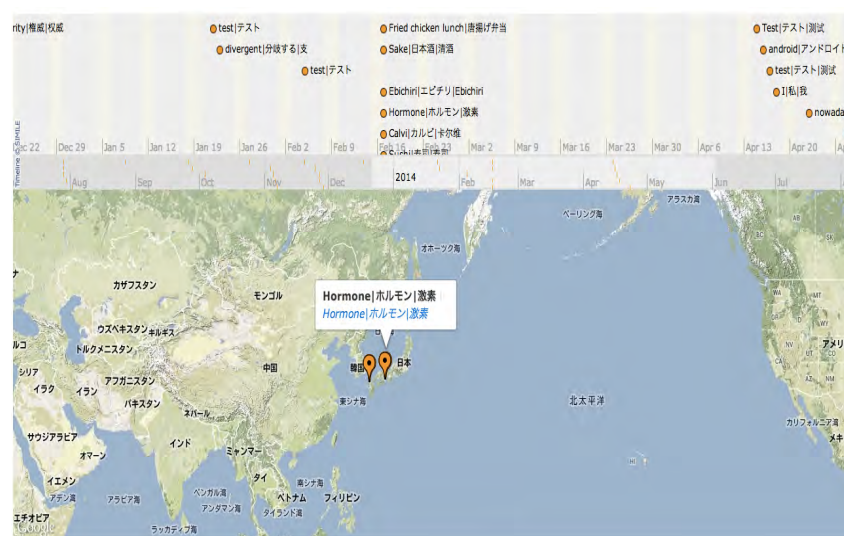


Figure 1: Time-map

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).

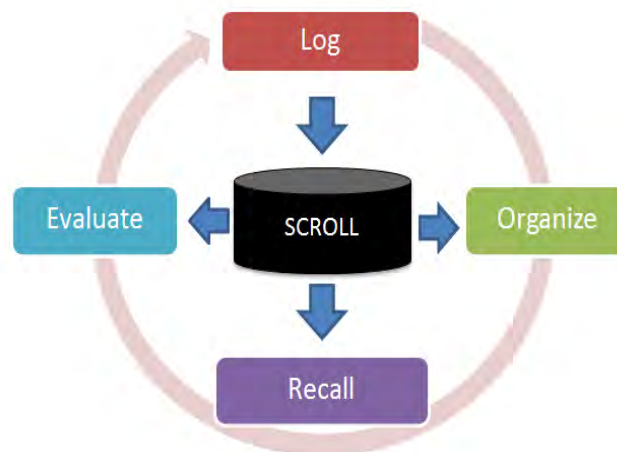


Figure 2: LORE model in SCROLL

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 programming 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).

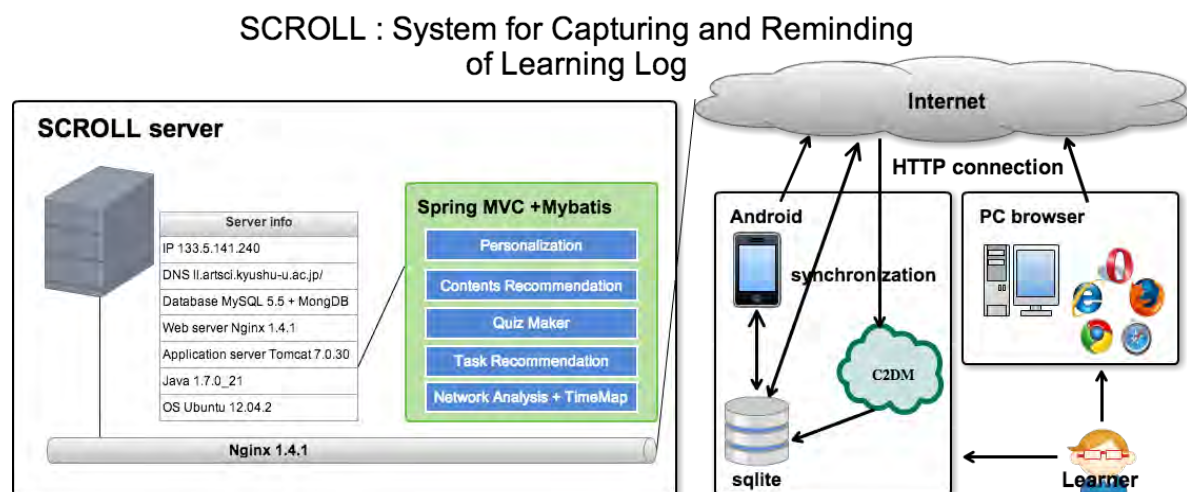


Figure 3: The architecture of SCROLL

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

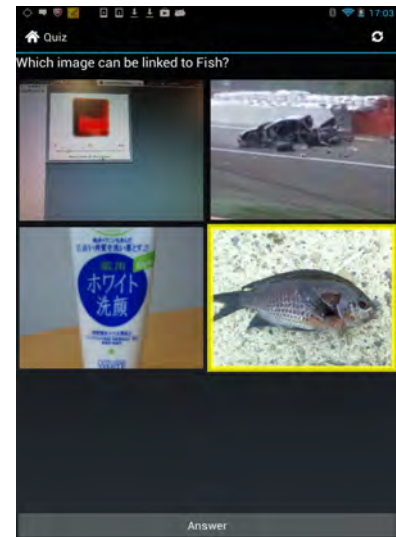


Figure 6: Quiz

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.

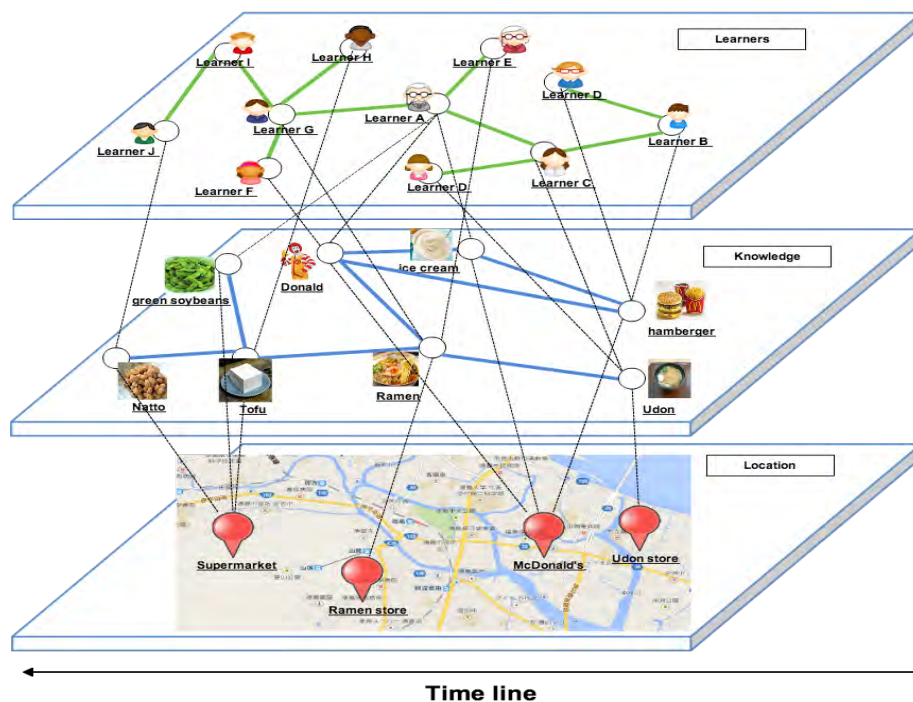


Figure 7: Three-layer structure in SCROLL

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 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, seiza: 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.

3.4 Collocational networks in SCROLL

Collocational networks are two-dimensional networks which contain interlinked collocation, i.e. word which occur together in a text. The concept of collocational networks originates in an article by Williams (Williams 1998). In his study, Williams uses the network as a corpus linguistic tool in order to create specialized dictionaries. Also, Magnusson describes an important to visualize most central concept in the text. There are some collocational networks on the SCROLL. For example, if a learner A learned natto (a traditional Japanese food made from fermented soybeans) at the supermarket, he/she might learn other food at the same time. Therefore, the collocational network can show relationships between the knowledge and time. Similarly, it can show collocational relationships between knowledge and place and place and time.

In this paper, we propose a method using collocational networks in order to predict their learning patterns and trends in the future and to expand their field of view. Using recorded collocational data on SCROLL, this study have constructed the collocational networks.

Firstly, the collocational relationships between knowledge on the intermediate layer will link in time-series order what they have learned. For example, if the learner A learned a tofu in the next learning after studying a natto, the natto and tofu on the intermediate layer will be connected. Also, if the learner B learned a green soy beans after studying a natto, the natto and the green soy beans on the intermediate layer will be connected in the same way. By linking their knowledge and knowledge in the next learning, SCROLL can be predicted knowledge that they might be able to learn in the next learning.

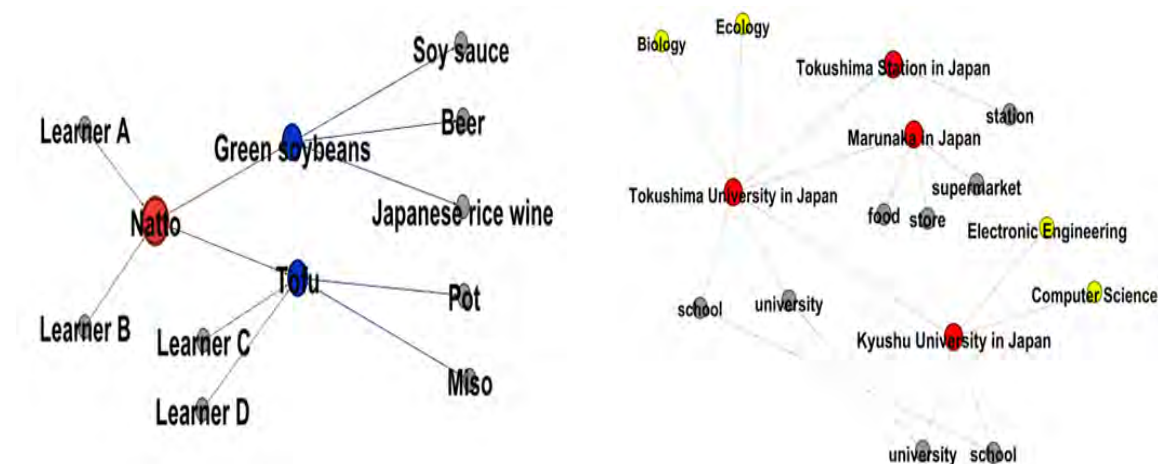


Figure 8: Relationships between knowledge, place and time on collocational networks

However, their notable knowledge is a possibility which is connected many edges. For example, after the learner A and B learned the natto, there are two learning path as described above. That is, there are two paths of "they learn the tofu after learning the natto" and "they learn the green soy beans after learning the natto" as shown in figure 8 (left network image). Figure 8 is one of an example of some learning patterns, and there are many learning patterns in actually in the ubiquitous learning environment.

Secondly, in this paper, we attempt to categorize the names, such as hospital, university and restaurant of nearest place where they have learned, using Google place api from the latitude and longitude of past ubiquitous learning logs. Also, some buildings acquired from its place include a lot of attributes. Hence, it is necessary to construct collocational network including the place and the attributes.

For example, if a learner A learned the word such as "electronic engineering" and "computer science" at the kyushu university in japan after studying some word such as "ecology" and "biology" at the tokushima university in japan, it is created edge to connect "tokushima university" to "kyushu university" on the lowest layer. On the other hand, a learner B learned another word at the tokushima station near the university after studying some words such as "ecology" and "biology" at the tokushima university in japan, it is created edge to connect "tokushima university" to "tokushima station" on the lowest layer. In addition, prediction of the next learning place is determined by the number of the attributes of the place. For example, the collocational network shown in Figure 8 (right network image) is connected from the tokushima university to tokushima station, marunaka (Supermarkets' name in japan) and kyushu university. The attributes of the tokushima university include "university" and "school". Similarly, the tokushima station includes "station", and the marunaka includes "supermarket", "shop" and "food", and the kyushu university includes "university" and "school". By comparing to attributes of three types, it is evident that the attributes of the tokushima university and kyu-shu university are same.

Therefore, there are a possibility that two learning place are high relationship. However, there is a possibility that the distances between two places are a far. That is, it is necessary to calculate the distances between current position of the learner and target learning place. Also, as described above, to expand a field of their view regarding the place is effectiveness in order to understand learning situation and context.

4. Implementation

This section describes ways of the implementation of the system for visualizing the three-layer structure using network graph using collocational networks 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", "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
Representative learners	Upper layer	Green
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.
- Green color node shows the names of famous or representative learner on the upper layer. If connecting the yellow node to the green node on the intermediate layer, edge color will be decided as green 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 network graph for visualizing relationships between the learners and ubiquitous learning logs is shown in Figure 9. The learners can recognize relationships between own/others author and knowledge by using the network graph interface. Figure 9 shows an example of interface on collocational network based on knowledge. The network layout consists of using two basic layouts and an original layout.

The first layout consists of using Yifan Hu multilevel layout (Y.F Hu, 2001, 2005). 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 second layout consists of using the random network. It is simple algorithm generating them randomly on the graph after filtering some nodes, and then the system will connect relationships related between node and node.

The third layout consists of using original layout we have developed. As shown in Figure 9, the layout regards x axis as time axis. In this figure 9 case, the knowledge that they might be studying in the next learning after studying the natto will be generated to right side in constant interval (Next knowledge are tofu, coffee, router and kimchi).

Recommendation objects in Figure 9 are shown rankings in the learning trends in order to expand a field of their view from visualized ubiquitous learning logs on the network graph. By arranging the in-degree centrality in the high order from the ubiquitous learning logs that they might study in the next learning, the learners are able to recognize famous or representative learners and important knowledge.

Time-map function in Figure 9 consists of the timeline and Google map. 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. 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 in the next learning.

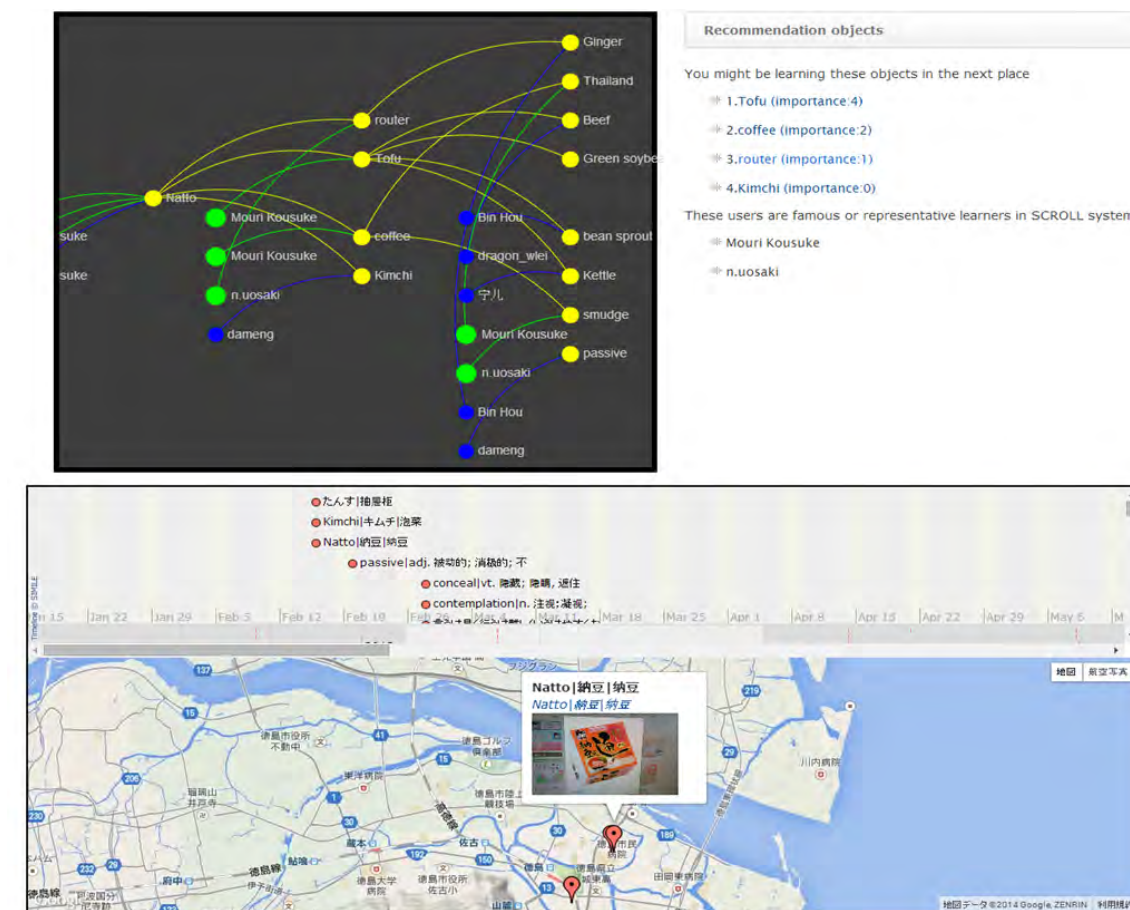


Figure 9: Interface of this system

5. Conclusion and Future work

This paper described the system for visualizing relationships between the learners and the learning logs, using collocational networks. 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.

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).

Acknowledgements

Part of this research work was supported by PRESTO from Japan Science and Technology Agency, and the Grant-in-Aid for Scientific Research No.26350319 from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan.

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