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Ubiquitous Learning Project Using Life-logging Technology in Japan

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ABSTRACT

A Ubiquitous Learning Log (ULL) is defined as a digital record of what a learner has learned in daily life using ubiquitous computing technologies. In this paper, a project which developed a system called SCROLL (System for Capturing and Reusing Of Learning Log) is presented. The aim of developing SCROLL is to help learners record, organize, recall and evaluate ULLs. Using SCROLL, learners can not only receive personalized quizzes and answers to the questions, but also navigate and be aware of their past ULLs supported by augmented reality views. In particular, this paper introduces an approach that helps learners record their learning experiences in daily life from life-log photos with the help of SenseCam. To evaluate the effectiveness of this system, a case study of an undergraduate English course is presented to show how it can be used to facilitate seamless learning.

Keywords

Mobile learning, Ubiquitous learning, Learning log, Life logging

Introduction

CSUL (Computer Supported Ubiquitous Learning) or context-aware ubiquitous learning (u-Learning) is defined as a technology-enhanced learning environment supported by ubiquitous computing technologies such as mobile devices, RFID tags, and wireless sensor networks (Ogata & Yano, 2004; Wu, Hwang, & Chai, 2013). It is characterized by its augmented learning environment which presents information on personal mobile devices through the Internet based on the detection of physical objects in surrounding environment using sensing technologies (Hwang, Tsai, Chu, Kinshuk, & Chen, 2012).

The fundamental issues of CSUL are:

1. How to record and share learning experiences that happen anytime and in any place.
2. How to retrieve and reuse them for future learning.

To tackle these issues, LORAMS (Linking of RFID and Movie System) (Ogata, Matsuka, El-Bishouty, & Yano, 2009) was proposed. There are two types of learners in this system. One type consists of providers who record their experiences on video. The other type are learners who, when encountering some problems in their learning, may find the videos uploaded by the first groups of learners useful. The system automatically links between physical objects and the corresponding objects in a video and allows sharing among users. By scanning RFID tags, LORAMS shows users the video segments that include the scanned objects. Although this system is useful in certain environments, it is not currently easy to apply in practice. Therefore, we have begun a more practical research project called "ubiquitous learning log" (ULL) in Japan in order to store intentionally what learners have learned as ubiquitous learning log objects (ULLOs) and consequently reuse them. The project was conducted from October 2009 to March 2013 with the financial support by PRESTO of the Japan Science and Technology Agency (JST).

We define a ubiquitous learning log (ULL) as a digital record of what a learner has learned in daily life using ubiquitous technologies, and propose a model called LORE to show the learning processes from the perspective of the learner's activity (Ogata et al., 2012). In this paper, we propose a system called SCROLL (System for Capturing and Reusing Of Learning Log) that helps learners log their learning experiences with photos, audios, videos, locations, QR-codes, RFID tags and sensor data, and share their ULLOs with others. Also, a learner can receive personalized quizzes and answers to their questions. This system is implemented both on the web and on the Android smartphone platform. With the help of built-in GPS and cameras in smartphones, learners can navigate and be aware of past ULLOs via the augmented reality view.

Originally, the term "learning log" was used for personalized learning resources for children. The logs were usually visually written notes of learning journals, which could become an integral part of the teaching and learning program and which had a major impact on their drive to develop more independent learners. Research findings indicated that journals were likely to increase meta-cognition and reflective thinking skills through students becoming more aware of their own thought processes (Hung et al., 2014; Hwang, Wu, Zhuang, & Huang, 2013; Stockwell, 2007; Susan & White, 1994; Wood Daudelin, 1996). Our approach focuses on how to enrich learning logs and promote retention and meta-cognition by using mobile, ubiquitous and context-aware technologies.

Life-logs

Life-logs are a notion that can be traced back at least 60 years (Bush, 1945). The idea is to capture everything that ever happens to us, to record every event we experience and to save every bit of information we ever touch. For example, SenseCam (Hodges et al., 2006) is a sensor-augmented wearable still camera which is proposed to capture a log of the wearer's day by recording a series of images and capturing a log of sensor data. This is a great tool for recording life logs, as it is a small digital camera that is combined with a number of sensors to help capture a series of images of the wearer's whole daily life at the proper time, and can be worn around the neck (Figure 1). Originally this device was designed as a memory aid.

Figure 1. SenseCam

MyLifeBits (Gemmell, Bell, & Lueder, 2006) stores scanned material (e.g., articles, books) as well as digital data (e.g., emails, web pages, phone calls, and digital photos taken by SenseCam). The Ubiquitous Memory system (Kawamura, Fukuhara, Takeda, Kono, & Kidode, 2007) is a life-log system using a video and RFID tags. Another application, Evernote (www.evernote.com), is a tool to save ideas using mobile devices such as Android and iPhone. The common idea of these projects is to use life-log data as a memory aid. SCROLL, however, aims to utilize life-log data for the learning process.

SCROLL

Design

In this paper, a ubiquitous learning log (ULL) is defined as a record of what a learner has learned in daily life using ubiquitous technologies. ULL is considered as a set of ULLOs (Ubiquitous Learning Log Objects). The learning can also be considered as the extraction of meaningful knowledge from past ULLs that serves as a guide for future behavior (Wood Daudelin, 1996). Figure 2 shows the learning processes from the perspective of the learner's activity model called LORE (Log-Organize-Recall-Evaluate). These four steps are explained as follows:

1. Log what the learner has learned: When learners face problems in daily life, they may learn some knowledge by themselves, or ask others for help. The system records what is learned during this process as a ULLO. We designed two modes to record learning contents – active and passive. Here is a typical scenario of the active mode – when a foreign student in Japan walks into a supermarket, there are many foods that he/she does not know how to say in Japanese. The student can take a photo of this food by Smartphone and ask someone how to say it in Japanese, then log the learning content as a ULLO including the photo, the name of the food in both Japanese and the learner's mother language, location, time, etc. However, in the passive mode, a device such as a life-log camera can take photos of food and record the contextual information such as location and time automatically and wait for the learner to review the recorded contents before logging them as ULLOs.

2. Organize ULL: When a learner tries to add a ULLO, the system compares it with other ULLOs, categorizes it and shows similar ULLOs if they exist. There are many ways of categorizing ULLOs. For example, a foreign student

in Japan learned a new word "tofu" in a supermarket and logged this process as a ULLO. This ULLO can be categorized as "Japanese," "Food," "Supermarket," etc. As such, it is difficult for the system to categorize it. Therefore, in the designed system, users can add their ULLOs into multiple categories and add several tags to each one. After that, they can review the learned contents by category/tag. Similar objects can be found by matching titles, content of photos, locations and categories, and then the knowledge structure can be regulated and organized.

3. Recall ULL: Learners may forget what they have previously learned. Rehearsal and practice in the same or another context in idle moments can help to recall past ULLOs and to shift them from short-term to long-term memory. Therefore, the system provides some quizzes and reminds the learners of their past ULLOs.

4. Evaluate: It is important to recognize what and how learners have learned by analyzing their past ULLs, so that they can improve what and how to learn in the future. Therefore, the system refines and adapts the organization of the ULLOs based on the learners' evaluation and reflection.

All of the above learning processes are supported by SCROLL.

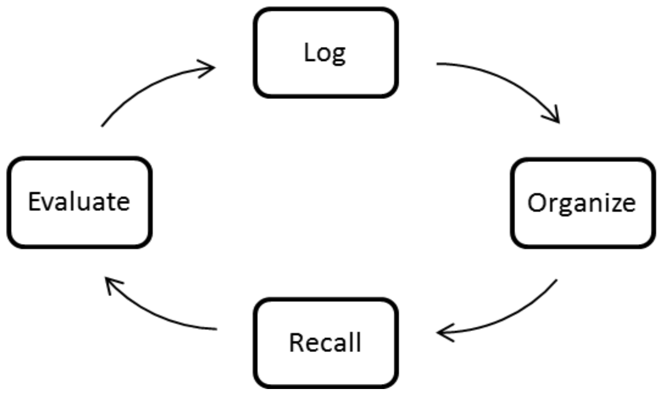


Figure 2. The LORE model

We designed SCROLL to implement several types of learning, including self-directed and personalized learning, reflective learning, collaborative learning, situated learning, experiential learning, and seamless learning.

Self-directed and personalized learning

The first kind of learning is self-directed and personalized learning. We designed SCROLL based on the following two objectives that enable self-direction and personalization:

- The system can be aware of a learner's current context. Currently, the context includes location and time. For the location information, the system can detect whether learners are near the place where they uploaded a learning log and whether there are location-based learning logs recorded by other learners nearby. If either requirement is met and if the availability of the device is high, the system will present a quiz based on the knowledge gained in that location or notify the user of the surrounding learning logs added by others.

- The system can record the context data when learners use the system as their context history and then detect their learning habits by analyzing their context history. If the system detects learning habits, and the circumstance meets these habits, it will issue a recommendation message to encourage the user to review what he/she has learned.

Reflective learning

An important goal of the SCROLL system is to help learners recall what they have learned after they have archived their learning logs. When a learner captures a learning log, in addition to its location-based property mentioned above, a number of things are designed as retrieval cues for the learner. For instance, according to the picture superiority effect (Defeyter, Russo, & McPartlin, 2009; Shepard, 1967), learning logs with pictures are much more likely to be remembered than those without. In addition, according to the basic research on human learning and memory, practicing retrieval of information (by testing the information) has powerful effects on learning and long-term retention. Moreover, compared with repeated reading, repeated testing enhances learning even more.

For the above two reasons, taking advantage of photos, locations and so on, the quiz function is proposed. Three types of quizzes can be generated automatically by the system: yes/no, text multiple-choice and image multiple-choice.

Usually, learners can examine themselves by taking quizzes (Hwang, Tsai, & Yang, 2008), but two more ways that are instigated by the system are provided. One is that when a learner moves to the place where he/she captured the knowledge, the system can present quizzes about the learned knowledge. The other is that if learners have learning habits, the system will prompt them to review what they have learned using quizzes. These two methods are discussed in detail later in the paper.

Collaborative learning

We designed SCROLL to also encompass collaborative learning. Since learning logs are logs registered arbitrarily by each learner, collaborative learning in SCROLL adopts an asynchronous model. Any learner in this system is able to share ULLOs, and the system will show their shared ULLOs to others. Besides, they can also ask others questions about their shared ULLOs. In reflective learning, shared ULLOs can also be used to generate quizzes in order to help learners learn more objects.

Situated learning and experiential learning

According to Lave & Wenger (1991), situated learning is learning that takes place in the same context in which it is applied. Itin (1999) defined experiential learning as “learning from experience.” We introduce a concept called "task" in SCROLL to implement situated learning and experiential learning. Learning in the same context enhances the learning effect, and past experiences help learners learn effectively. Tasks refer to the activities through which they can acquire knowledge. Tasks are conducted in the circumstances where learning can happen such as in a school, hospital, post office and so on. For instance, if the system recommends the Japanese word “トマト(tomato)” to a learner in a supermarket, learners can talk with the staff in the supermarket using the word “トマト (tomato),” such as asking its price, location, related recipes and so on. It has been proved that by talking with a native Japanese speaker using the recommended word, learners can master the word well (Jonassen & Grabowski, 1993). The activity of asking about the information is a kind of “task.” Learners who save learning logs are responsible for providing what kind of knowledge can be gained by carrying out the task, and one learning log can be used in several tasks. Moreover, the system provides some predefined tasks in different contexts in order to reduce the learners’ burden when they save their learning logs. In addition, the tasks can be created by the learner and designated by the administrator of the system.

The system assigns an appropriate task for a learner according to the difficulty level of the task and the learner’s ability. For example, asking the price of the product is easy for learners, while asking about vegetable recipes is quite difficult for most learners. When learners receive the recommended learning log and the task, they are also asked to provide feedback for the system. For example, they are asked to take photos of the target object if the learning task is to find where the object is. Moreover, if the learning task is to learn about the place of the object, they need to collect and fill in the environmental information on the system. Only by providing feedback can the users prove that they have really gained the knowledge. Moreover, if the learners meet new problems when carrying out the tasks, they can record them in photos, videos, audios or texts and upload them to the system in order to ask for help. Such accumulated data is also meaningful for other learners.

Seamless learning

Recent progress in mobile and wireless technologies offers us a new learning environment, namely "seamless learning" (Wong & Looi, 2011). It allows learners to learn anytime, anywhere, and provides them with multiple ways of learning throughout the day. By seamless learning, we mean learning which occurs with seamless transitions between in-class and out-of-class learning (Hung et al., 2013). The American College Personnel Association (1994) has indicated the importance of linking students' in-class and out-of-class experiences via providing seamless learning environments to achieve academic success.

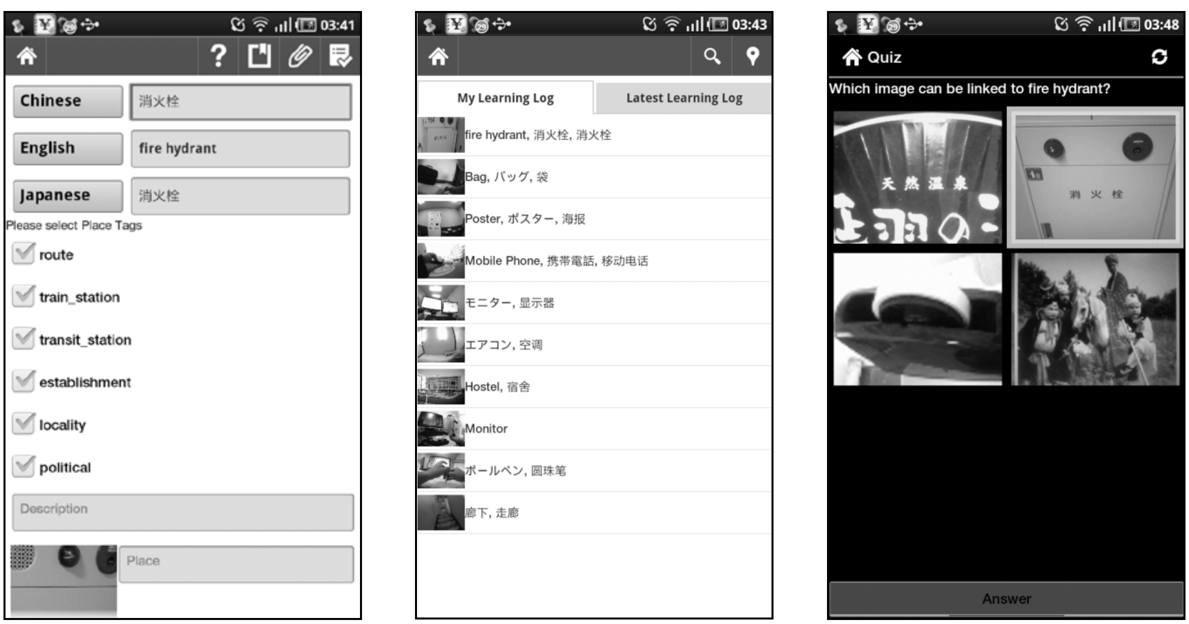
Based upon the above ideas, we designed the following Seamless Mobile-Assisted Language Learning Support System (hereafter called the SMALL System) (Uosaki et al., 2012) as a sub-project. The main objective of SMALL is to link learners' out-of-class learning to their in-class learning. Once a learner uploads a newly learned word to SCROLL, our main system, SMALL, runs a search through the previously updated textbook data. If the new word is found in the textbook data, it jumps to the textbook page where this word is used. Another example is that when a user reads an uploaded textbook and clicks a word, then it jumps to the SCROLL system page to show how other learners have learned this word in different contexts in their out-of-class learning. In this way, users' out-of-class and in-class learning can be intertwined. We learn words from contexts. In order to master words, it is important to come across them used in various situations.

System interface

We implemented SCROLL both on web and smartphone platforms. It consists of the following components:

ULL recorder

This component facilitates the way learners upload their ULLOs to the server whenever and wherever they learn. As shown in Figure 3 (1), in order to add a ULLO, a learner can take a photo, ask questions about it and attach different kinds of meta-data to it, such as its meanings in different languages.



(1) Add ULLO (2) ULLO List (3) Quiz

Figure 3. SCROLL interface on an Android mobile phone

ULLO list (left) and Quiz (right)

Figure 4. SCROLL Web interface

ULL finder

If a learner registers a new ULLO, the system checks whether the same object has already been stored by comparing the name fields of each object using a thesaurus dictionary. Also, a learner can search ULLOs by name, location, text tag and time. Using this function, learners can understand what, where and when they learned before. Figure 3(2) and Figure 4 (left) show the list of the learner's ULLO, which helps him/her to recall all of the past ULLs. Besides, it allows the learner to be aware of others' learning objects and to re-log them if deemed useful. This means that a learner can make a copy of another learner's learning object into his/her own log. Therefore, learners can obtain a considerable amount of knowledge from others even though they have not experienced that knowledge themselves. By sharing ULLOs with other learners and relogging the other learners' ULLOs, the acquisition of knowledge is enhanced.

ULL reminder

As shown in Figure 3(3) and Figure 4(right), the system generates simple multiple-choice quizzes based on the meta-data of the stored ULLOs. For example, the idea of "quiz with image" is to ask a learner to choose an image that describes the word given by the system. The system immediately checks whether the answer is correct or not. These quizzes are generated according to the user's profile, location, time and the results of past quizzes and helps learners to recall what they have learned (Li et al., in press). The quiz function is designed not only to help learners to reinforce what they have learned, but also to recommend what other learners have learned and to remind them of what they learned in the past according to their current location and their preferred time. In order to achieve these targets, they can take quizzes whenever they want. In addition, they can send their location information to the server continuously. Therefore, the server side can automatically assign quizzes for them based on their location and time information. It notifies them by showing an alert message and vibrating the mobile phone. Whenever they move around an area where they have encountered some objects, the system will send them quizzes regarding those objects. Furthermore, they can set a time schedule to receive the reminder quizzes.

ULL navigator

The ULL navigator provides mobile augmented reality that allows the learner to navigate through the ULLOs. Like Wikitude ("Wikitude," n.d.) and Sekai-Camera ("Sekai Camera Web," n.d.), it provides a learner with a live direct view of the physical real-world environment augmented by a real time contextual awareness of the surrounding objects.

When learners are moving around with their mobile phones, the system sends alerts to the phone as soon as they enter the region of ULLOs according to the GPS data. This view is augmented, associated with a visual compass, and overlapped by the nearest objects in the four cardinal directions. Also, it provides the learners with a list of all surrounding objects. When the learner selects one or more of these objects, the Google map will be retrieved and marked with the learner's current location and the selected objects. Moreover, the system shows a path (route) for the learner to reach the locations of the objects. This assists the learner in acquiring new knowledge by discovering existing ULLOs and recalling the learner's own ULLOs

An important component of the system is the ULL recorder. The current ULL recorder requires learners to capture learning contents (e.g., photos) manually. They might find this troublesome and it might disturb their learning activities. Thus, we have tried to find a better way to log learners' learning content automatically and unconsciously. We found that SenseCam is able to do this. However, the second problem is: Among the very large amount of captured photos by SenseCam, what are the learning contents? After using SenseCam, we found that there are many kinds of context data such as temperature and brightness that can be used to help learners recall the captured objects. Besides, these data can also be used to help us improve our ULL reminders. This is an extra benefit of the passive capture of data.

PACALL

Design

Until now all the work that we have done has been using the active rather than the passive logging mode. This means that learners must record their learning experiences consciously. Compared to the passive mode, in the active mode we are more likely to miss learning chances since we are not necessarily able to record what we have learned, or sometimes we just forget to record it. Therefore, we introduced passive capture in our project with SenseCam and named the proposed system PACALL (PAssive CApture for Learning Logs). In the real world, there are so many things that we have learned but we usually miss the chance to review them; that is, we do not know what we know. Similarity, it is certain that we are not able to learn what we have not noticed. Therefore, we considered this in the learning process.

Since this research is based on our previous work (Ogata et al., 2010) in which we used the active mode to register ULLOs, we need to make it clear how the passive mode differs from the active mode. We compare the features of both in Table 1.

Table 1. Comparison of the active and passive data capture modes

	Passive	Active
Number of photos taken	Many (~3000/day)	Few (<10/day)
Data quality	Poor (by SenseCam, image only)	Good (by Camera /Smartphone/Tablet PC, image with GPS, Video etc.)
Recording time distribution	Continuous	Intermittent
Content completeness	High (user's whole daily life)	Low (only specific scenes)
Consciousness	Unconscious	Conscious, Intentional
Reflection	Strong	Weak
Workload	Low (captured automatically) High (review & upload a large number of photos)	Quite high (capture manually & upload manually)

In the first three rows of Table 1, the two modes are compared in terms of photos. When we use SenseCam, it takes photos automatically and continuously, while in the active mode, smartphone photos can only be taken at the time we intend to. As a result, more photos are taken in the passive mode than in the active mode. However, because of the storage problem and some other technology limitations, photos taken by SenseCam are lower in quality; they are however of sufficient quality to be used as ULLOs.

In the next two rows of Table 1, the comparison is made in terms of learning contents. When we use a camera or smartphone, many learning contents are logged in our spare time such as at lunchtime. However when we use

SenseCam, because the recording is processed continuously, we can get photos whenever and wherever we are. As such, the photo contents cover our complete lives. The content type in the active mode, however, is richer than that in the passive mode because in this research the learning content captured by SenseCam consists only of photos.

In the last two rows, the comparison is related to the learners. In the passive mode photos are taken unconsciously, while in the active mode the learner must take photos consciously. When learners use SenseCam, they must review the whole learning process, and reflect on what they have seen and what they have learned and what they missed learning. This process will help them to remember the contents.

According to this comparison, we can see that the passive mode has many advantages over the active mode for language learning by photos. The quality of the photos is low, but it is still acceptable for our purpose. However the biggest disadvantage is the workload. SenseCam takes photos continuously. Consequently a huge number of photos are produced, and the more photos, the heavier the workload. If this workload is reduced, learners can learn language in the passive mode more easily. This is the key issue of using the passive mode in language learning. In this research, we focus on reducing the workload when reviewing the photos, and propose a system that can filter the photos to help learners review and upload ULLOs easily.

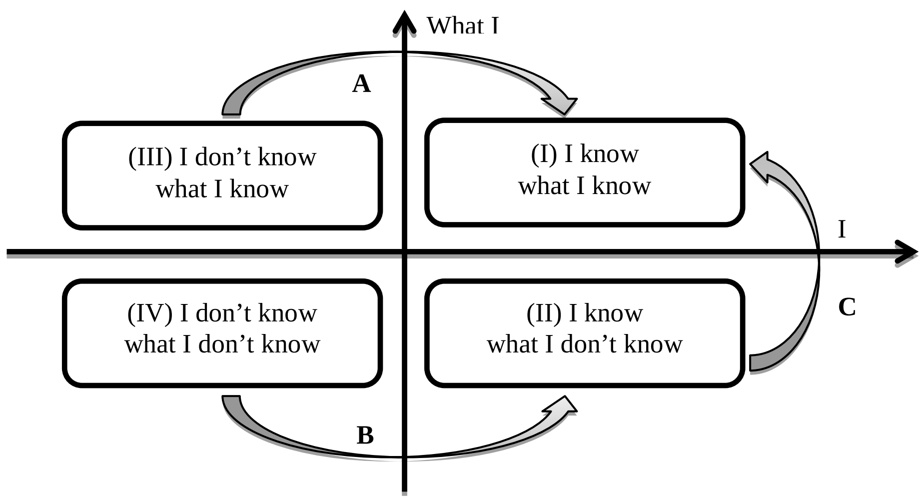


Figure 5. How the passive mode supports learning

Figure 5 explains this process and shows how to support learning in the passive mode. We classify all the objects surrounding us into four groups – "(I) I know what I know," "(II) I know what I don't know," "(III) I don't know what I know," and "(IV) I don't know what I don't know". For example, for non-English speakers, when a learner walks outside and sees a fire hydrant, if he notices it and knows how to say it in English that is status (I). If he does not know how to say it in English, that is status (II). Since he has noticed it, and does not know how to say it, he can learn it from a dictionary or by asking someone else. Then the status will change from (II) to (I), which only happens consciously in active mode.

Another situation is the case when he did not notice it. If he has not noticed the fire hydrant how can he learn it? The answer is that he can't without some form of assistance. Therefore, we would like to encourage learners to use passive mode to support their learning. There are also two kinds of "don't know" situation. In one case, the learner already knows how to say it in English (status III). In this case, captured life-log photos can help him notice this fire hydrant and let him review it. In status IV, captured life-log photos let him know there is an object that he does not know, and then he can have a chance to learn this object (B to C). This is a good way to help learners become aware of what they do not know if they do not notice it.

This system is a sub-system of the Ubiquitous Learning Log, named PACALL. It stands for PAssive CApture for Learning Log. We set the whole capturing process in passive mode. After that, PACALL analyzes all of the captured photos and finds several important ones to help learners determine which are worth recording.

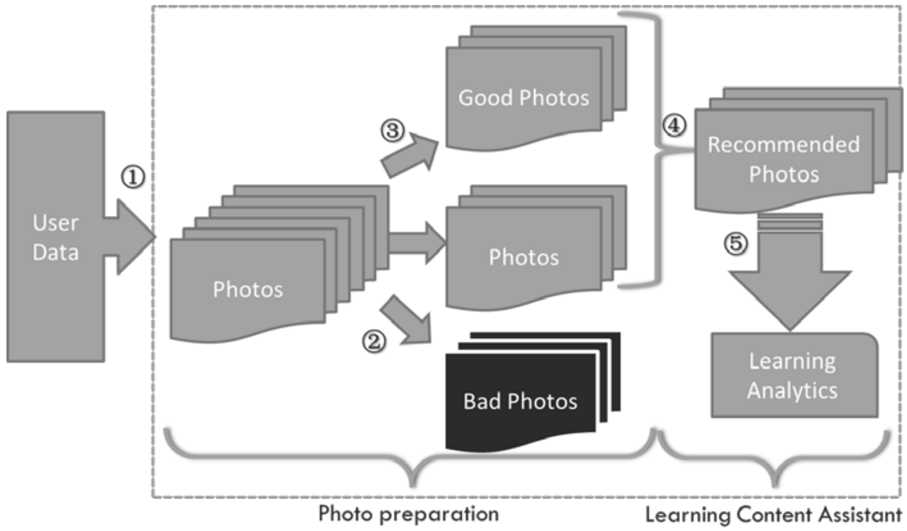


Figure 6. The flow of analyzing captured photos

Figure 6 is the flow of PACALL when analyzing captured photos. It consists of 5 steps: Loading raw data, Filtering bad photos, Finding good photos, Photo recommendation, and Learning analytics. These steps are introduced in detail in the following.

Loading raw data

There are three types of raw data in PACALL: life-log photos, sensor data, and GPS data.
Life-log photos are currently captured by SenseCam. In the future, we plan to apply this system to photos taken by smartphones or compact digital cameras which are far more commonly used. That will be more convenient and useful. Suppose a learner took a trip and took many photos. Then she can use this system to find photos which contain useful learning contents.

The sensor data are recorded by SenseCam, and the GPS data are created by the portable GPS unit.

Filtering bad photos

In this research, a bad photo is defined as a photo that is hardly recognizable or that is a duplicate of other photos.
We define three types of bad photos:
Dark: a dark photo taken with insufficient light.
Duplicate: the photos are duplicated.
Defocused: the photos are blurry and cannot be recognized well.
We use image processing to identify these bad photos. Currently, we are using OpenCV to detect dark photos, and LIRE (a plugin for Lucene) to detect duplicated photos.

Finding good photos

A good photo is defined as one that contains clear objects. We use OpenCV to find good photos mainly by feature detection.

After filtering bad photos and identifying the good photos, the rest are of mediocre quality. Those photos might contain learning contents, although they are not so clear. The top priority is given to good photos and then mediocre ones come next when shown to learners to choose.

Photo recommendation

Once photo sorting is finished, the next stage is learning assistance.
Our challenge is to detect useful information from photos by machine, and recommend photos that contain information. We define four types of recommended photos:
Character photo: a photo that contains characters. These characters are possibly used as learning contents. Here we are using text detection to find these photos.
Face photo: a photo containing a face. Actually, these photos are usually not appropriate for learning content because of privacy issues. However, faces are also information from photos.
Taggable photo: a photo that can be tagged by text. Tags are an important piece of information and can be used as a title of the photo.
ULLO-like photo: If there is a similar photo that was already registered to the SCROLL as a ULLO, it can possibly be used as a ULLO as well.

System interface

In the previous section, we introduced our design of the flow of analyzing photos. In this section, we explain its functionalities (i.e., PACALL Uploader, PACALL Browser and PACALL Recaller) in detail.
PACALL Uploader helps learners upload all the photos after capturing. We have made it easy to upload all the captured photos to the server. Because of the limitation of web technology, this process was not easy in the past. However with HTML5, it became possible. When learners want to upload a whole folder, they can select a photo folder and upload all the photos to the server. Also, the file of sensor data and GPS data will be uploaded.

After uploading the raw data (photos, sensor data and GPS data), the system will analyze all the data and show the results.

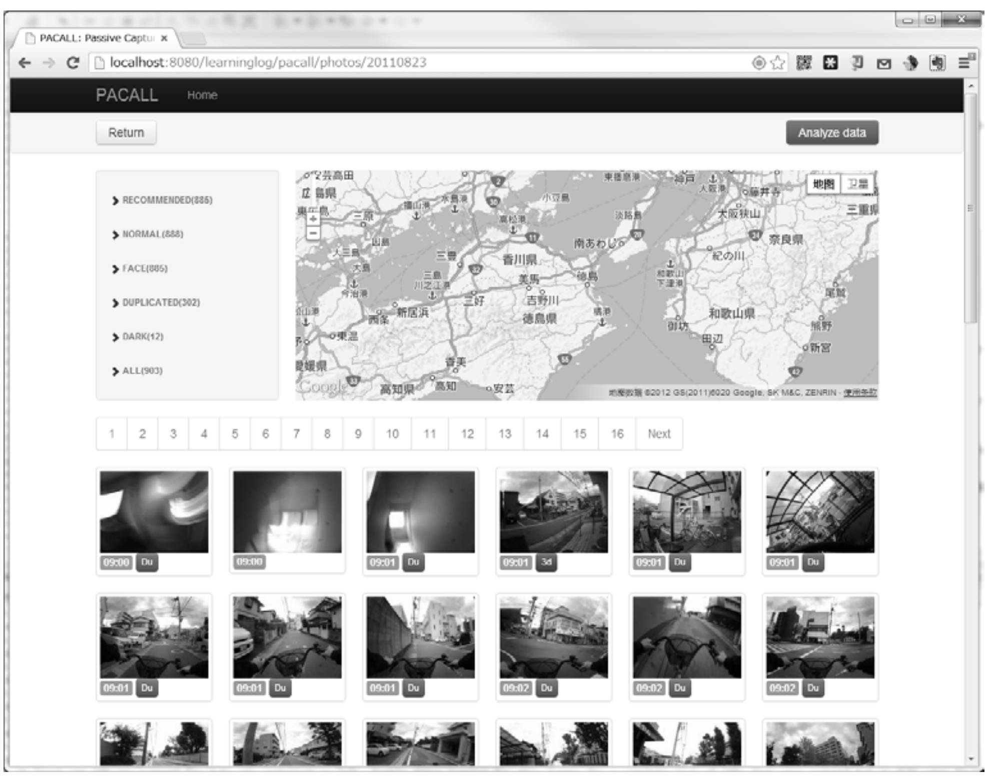


Figure 7. Interface of PACALL Browser

When all the photos are uploaded to the server, the learner can reflect on them with help from PACALL. The PACALL Browser has an interface for browsing all the photos, and it tags photos and provides some information to help the learner find important photos (Figure 7). Currently, we provide three main functions in the browser – PACALL Filter, PACALL Searcher and PACALL Recognizer.

PACALL Filter classifies all the photos into categories such as Manual, Normal, Duplicate, Dark, Face and Recommendation. Here “Manual” means that a photo is taken manually by pressing the manual button of SenseCam. It usually happens when a learner finds something valuable to record. “Duplicate” and “Dark” mean bad photos. “Face” means the photos that contain faces, and “Recommendation” includes Manual, Faces and other good photos that contain information or similar photos that have been uploaded to SCROLL before. Such photos have tags under them such as 3d or 4d meaning that they were uploaded to the system three or four days ago.

When a learner clicks one photo in PACALL Browser, the PACALL Recaller will be opened. The photo and similar photos and sensor data will be shown on this page to help the learner recall the captured content. There is also an “Upload” button on this page. If the learner decides to upload this photo to SCROLL as a ULLO, he/she can click this button, and the photo will be uploaded to the SCROLL system directly and the page will jump to the learning log registration page (Figure 8). Figure 8 shows the interface of ULLO registration in the SCROLL system. On this page, a learner can see the location of the selected photo and other similar photos captured by SenseCam. If there are some similar photos that are already uploaded in SCROLL, they will also be shown on this page. Once “Upload Now” is clicked, the system will ask the user to answer a survey that lets the system know whether he/she knows it and whether he/she noticed this object when it was captured. The data can be used to evaluate our system and help the user analyze his/her learning situation. When an object is uploaded to the system, the SCROLL system will use the “organize,” “recall” and “evaluate” model to help users remember uploaded objects. For example, if a learner uploaded a photo and set the title as 消火栓 in Japanese, but does not know how to say it in Chinese, he/she can send a question along with the uploaded ULLO. SCROLL will send this question to all Chinese users. After receiving answers from them, the user can learn a new Chinese word. In the quiz module of SCROLL, a learner can answer quiz questions that are created automatically from uploaded ULLOs. By answering these questions, the learner’s knowledge will be enhanced.

Figure 8. PACALL Recaller

Evaluation

We have conducted an evaluation experiment for PACALL. This section introduces the method and result of this experiment.

Method

Since this is an initial evaluation experiment, the study group consisted of 4 Japanese university students taking an undergraduate English course. In this experiment, they were asked to upload photos of learned objects along with titles both in Japanese and English. They used three methods of recording the photos. The entire evaluation experiment lasted for 3 weeks and consisted of 3 phases:

Phase 1: SenseCam

During this phase, students were asked to wear SenseCam every day for one week. Every evening, they needed to review all the life-log pictures and choose proper pictures to upload to SCROLL. They were requested to record the time spent.

Phase 2: Tablet PC

In our previous work(Ogata et al., 2012), we compared the learning effectiveness of Tablet PCs and a traditional learning method such as taking notes. It was found that using SCROLL on a Tablet PC was more effective than the traditional learning method. In this experiment, we compare SenseCam with the Tablet PC in terms of log methods, as logging with a Tablet PC is considered as active, while logging with SenseCam is considered as passive.
During this phase, all the students were asked to record and upload the learning log objects every day using a Tablet PC for one week. We used a Samsung Galaxy Tab in this experiment. The operating system of this Tablet PC is Android, and we developed an Android client that can upload the photos to the system conveniently.

Phase 3: SenseCam+PACALL

During this phase, the PACALL system was introduced into the experiment. This phase was almost the same as Phase 1. All the students should wear SenseCam every day for one week. Every evening, they used the PACALL system to classify the life-log pictures and upload the pictures. They were requested to record their time spent. Besides, they were asked to count the number of classifications after all the pictures were uploaded.

Result

Learning chances - Differences in number of ULLOs uploaded per day

We examined the number of uploaded ULLOs among these three learning methods. Figure 9 shows the average number of uploaded ULLOs for each of the four participants.

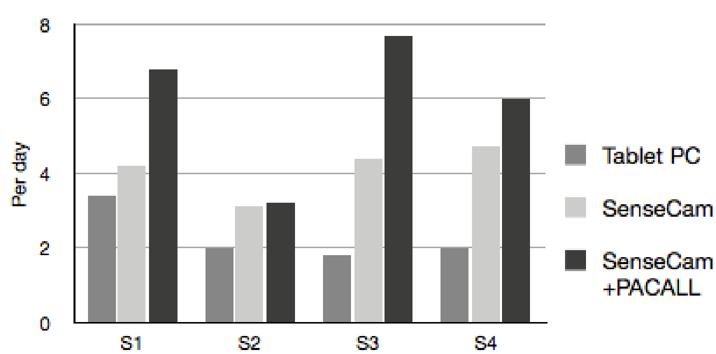


Figure 9. The average number of uploaded ULLOs

In this chart, the horizontal axis shows the four subjects, and the vertical axis shows the average number of ULLOs uploaded by each subject. It shows that they uploaded more photos in the SenseCam and SenseCam + PACALL modes than in the Tablet PC mode. As a result, the passive mode with SenseCam offered them more learning chances than the active mode. Moreover, it is found that PACALL increased the number of uploaded pictures in most cases (except S2). After this experiment, we examined why the number of uploaded pictures did not increase for S2, and then we interviewed him. We learned that at that time he was not so serious about the experiment and just managed to upload 3 pictures a day as a norm. However the result of Figure 11 shows that it took him nearly half the time to review and upload photos in SenseCam + PACALL mode compared with the time spent in SenseCam mode, so it is expected that if he had been more involved and spent more time, the number of uploaded ULLOs would have increased. In normal circumstances in the subjects' daily lives, the pictures captured by SenseCam were similar whether using PACALL or not, and the numbers of uploaded objects were almost the same. However, from the feedback, it was found that PACALL reduced the workload of reviewing life-log pictures. The learners could choose pictures and upload them more quickly. So the number of uploaded pictures using SenseCam + PACALL is larger than that using SenseCam only.

Learning quality - Can learners remember uploaded ULLOs that are taken unconsciously in passive mode?

What is the difference in the learning effect of the active and passive modes? This is the second question that we attempted to answer. Therefore, we gave all the students a test after each phase to see whether they had remembered the uploaded objects. We devised a test consisting of the uploaded pictures and asked them to write down the title of the pictures, then judged their memory, grading them from 0 to 5, where 5 means they remembered clearly and 0 means no recall at all. Figure 10 shows the results.

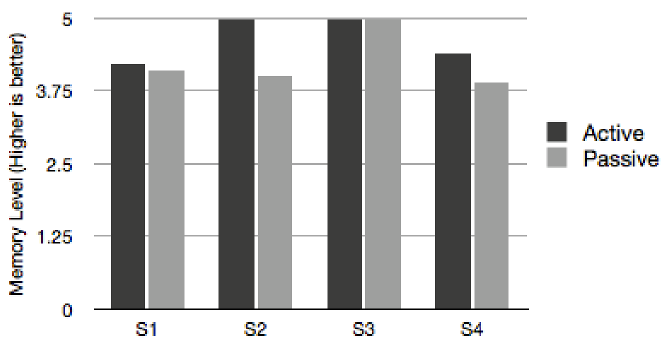


Figure 10. Memory level of active and passive modes

In Figure 10, we can see that the memory level of active mode is a little higher than that of passive mode. In active mode, the learner takes pictures consciously. Naturally the impression of the photos is deeper than that of those taken in passive mode. Besides, the number of uploaded photos in passive mode was larger than that of active mode which might be reflected in their memory level. Therefore this result is understandable. Even though their memory level was lower, when we consider the fact that they registered more photos as their learning logs, we interpret that our system gave them more chances to learn in passive mode. Therefore we believe that the system contributes to their learning.

Workload issue - How much value does the PACALL add to passive learning mode?

We examined how PACALL contributed to reducing the time spent on the whole procedure. We asked students to report the spent time, and Figure 11 shows the result.

This chart clearly shows that the developed system reduced the time spent reviewing the life-log pictures by nearly a half. Of course, the workload in passive mode is higher than that in active mode, but very few learning contents are missed. In the future, we will focus on how to reduce the workload and help learners to reflect on and find good photos more easily.

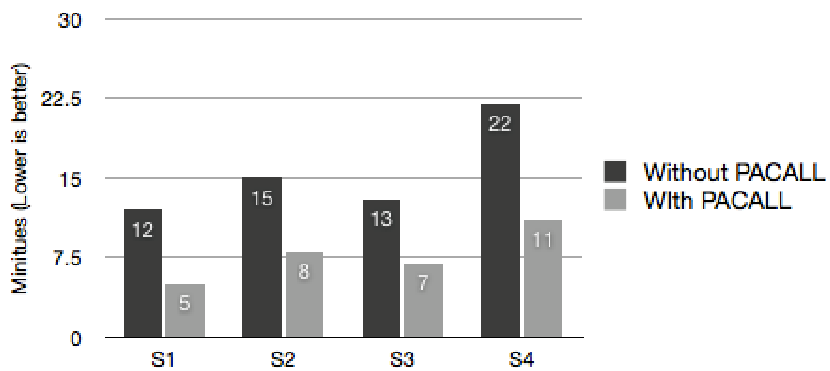


Figure 11. Average time spent with and without PACALL

Feedback

We received some suggestions and feedback from the students which helped us to understand the usage of PACALL and to improve our system. Some typical feedback is listed as follows.

> I think PACALL is easy to use. When I use the SenseCam without PACALL, I must find good photos in the folder from the browser. However when using PACALL, I just select them and click "upload." The time is shown with the photo in PACALL, which is also helpful for selecting photos. Besides, inappropriate photos are already excluded by this system. It also helps.

> It is better to use the Android Tablet PC in conjunction with the PACALL system.

> In the passive mode, the learning contents are recorded even when I do not want to learn anything. On the other hand, in the active mode, photos can only be taken when I want to learn something.

> I feel very embarrassed when using SenseCam.

> The accuracy is not good enough for analyzing blurred photos.

The above comments show that this system is easy to use and the users seem moderately satisfied with the system. In the passive mode the learning contents could be recorded even if learners do not want to learn. In other words, the life-log pictures create more chances to learn vocabulary. However, the learners may feel embarrassed when wearing the SenseCam in public. Moreover, there is a privacy issue which is yet to be resolved. As for the problem of embarrassment, in the future, we believe that the SenseCam will get smaller and look better, and hopefully, learners will not feel so embarrassed wearing it. Besides, the algorithm for classification needs to be improved in the future.

Conclusion

This paper describes a ubiquitous learning log project in Japan called SCROLL. This project was partly supported by PRESTO of the Japan Science and Technology Agency (JST) from 2010 to 2013. It aimed to capture learning experiences in daily life and reuse them for learning and education. Especially, this paper focuses on capturing ubiquitous learning logs using life-log photos, which are automatically taken by SenseCam. We developed a system named PACALL to help learners find learning contents from life-log photos. Also, we took a further step in analyzing life-log photos for the main system. Therefore, PACALL is not only a learning content provider but also a learning content analyzer. Besides, the provided data of PACALL can also be used by the quiz module of SCROLL to determine the proper time for presenting learners with quizzes. We found that there are many useful pieces of information that can be mined from the life-log photos. In the future, we will improve the algorithm of image processing in this system and conduct an evaluation experiment.

Since SCROLL is intended to be used in general domains and for life-long learning, we will apply it to many application domains including foreign language, math, physics, and science education, and conduct a long-term evaluation with a larger sample of subjects. Another area of our future work is learning analytics. We plan to analyze the accumulated data in the learning logs to find learners' learning patterns and learning habits in order to supply more appropriate learning materials in more appropriate places and at more appropriate times to improve the learning effects of the system.

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References

Bush, V. (1945). As we may think. *The atlantic monthly*, *176*(1), 101–108.

Defeyter, M. A., Russo, R., & McPartlin, P. L. (2009). The picture superiority effect in recognition memory: A developmental study using the response signal procedure. *Cognitive Development*, *24*(3), 265–273. doi:10.1016/j.cogdev.2009.05.002

Gemmell, J., Bell, G., & Lueder, R. (2006). MyLifeBits: A personal database for everything. *Communications of the ACM*, *49*(1), 88–95. doi:10.1145/1107458.1107460

Hodges, S., Williams, L., Berry, E., Izadi, S., Srinivasan, J., Butler, A., … Wood, K. (2006). SenseCam: A retrospective memory aid. *Lecture Notes in Computer Science, 4206,* 177-193. doi: 10.1007/11853565_11

Hwang, G. J., Tsai, C. C., Chu, H. C., Kinshuk, & Chen, C. Y. (2012). A context-aware ubiquitous learning approach to conducting scientific inquiry activities in a science park. *Australasian Journal of Educational Technology, 28*(5), 931-947.

Hwang, G. J., Tsai, C. C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Educational Technology & Society, 11*(2), 81-91.

Hwang, G. J., Wu, P. H., Zhuang, Y. Y., & Huang, Y. M. (2013). Effects of the inquiry-based mobile learning model on the cognitive load and learning achievement of students. *Interactive Learning Environments, 21*(4), 338-354.

Hung, P. H., Hwang, G. J., Lin, Y. F., Wu, T. H., & Su, I. H. (2013). Seamless connection between learning and assessment-applying progressive learning tasks in mmobile ecology inquiry. *Educational Technology & Society, 16*(1), 194-205.

Hung, I. C., Yang, X. J., Fang, W. C., Hwang, G. J., & Chen, N. S. (2014). A context-aware video prompt approach to improving in-field reflection levels of students. *Computers & Education, 70*(1), 80-91.

Itin, C. (1999). Reasserting the philosophy of experiential education as a vehicle for change in the 21st century. *Journal of Experiential Education*, *22*(2), 91–98.

Jonassen, D., & Grabowski, B. (1993). Handbook of individual differences, learning, and instruction. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Kawamura, T., Fukuhara, T., Takeda, H., Kono, Y., & Kidode, M. (2007). Ubiquitous Memories: A memory externalization system using physical objects. *Personal and Ubiquitous Computing*, *11*(4), 287–298.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation* (1st ed.). Cambridge, UK: Cambridge University Press.

Ogata, H., Li, M., Hou, B., Uosaki, N., El-Bishouty, M. M., & Yano, Y. (2012). SCROLL: Supporting to share and reuse ubiquitous learning log in the context of language learning. *Research & Practice in Technology Enhanced Learning, 6(2),* 69–82.

Ogata, H., & Yano, Y. (2004). Knowledge awareness map for computer-supported ubiquitous language-learning. *Proceedings of the International Workshop on Wireless and Mobile Technologies in Education* (pp. 19–26). doi: 10.1109/WMTE.2004.1281328

Ogata, H., Matsuka, Y., El-Bishouty, M. M., & Yano, Y. (2009). LORAMS: Linking physical objects and videos for capturing and sharing learning experiences towards ubiquitous learning. *International Journal of Mobile Learning and Organization, 3*(4), 337-350.

Sekai Camera Web. (n.d.). Retrieved September 21, 2011, from http://sekaicamera.com/

Shepard, R. N. (1967). Recognition memory for words, sentences, and pictures. *Journal of Verbal Learning and Verbal Behavior*, *6*(1), 156–163. doi:10.1016/S0022-5371(67)80067-7

Stockwell, G. (2007). Vocabulary on the move: Investigating an intelligent mobile phone-based vocabulary tutor. *Computer Assisted Language Learning*, *20*(4), 365–383.

Susan, S., & White, R. (1994). *The thinking books*. London, UK: Falmer Press.

Wikitude. (n.d.). Retrieved September 21, 2011, from http://www.wikitude.com/

Wong, L.-H., & Looi, C.-K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. *Computers & Education*, *57*(4), 2364–2381. doi:10.1016/j.compedu.2011.06.007

Wood Daudelin, M. (1996). Learning from experience through reflection. *Organizational Dynamics*, *24*(3), 36–48. doi:10.1016/S0090-2616(96)90004-2

Wu, P. H., Hwang, G. J., & Chai, W. H. (2013). An expert system-based context-aware ubiquitous learning approach for conducting science learning activities. *Educational Technology & Society, 16*(4), 217-230.