Capturing, Sharing, Retrieving and Comparing Learning Experiences in a Ubiquitous Learning Environment

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Abstract

This paper proposes a personal learning assistant called LORAMS (Link of RFID and Movies System), which supports the learners with a system to share and reuse learning experience by linking movies and environmental objects. These movies are not only related to classroom activities but also to daily experiences. Therefore, you can share these movies with other people. LORAMS can infer some contexts from objects around the learner, and search for shared movies that match with the contexts. We think that these movies are very useful to learn various kinds of subjects. We did several experiments in order to evaluate LORAMS. The target of some experimenters was to record movies and link objects while the target of other experimenters was to learn using LORAMS and to try doing a task. We got the result that the learner's performance of doing a task while using LORAMS is better than doing a task without its assistant.

1. Introduction

Ubiquitous computing [1] will help organize and mediate social interactions wherever and whenever these situations might occur [2]. Its evolution has recently been accelerated by improved wireless telecommunications capabilities, open networks, continued increase in computing power, improved battery technology, and the emergence of flexible software architectures [3]. With those technologies, CSUL (Computer Supported Ubiquitous Learning) is realized, where an individual and collaborative learning in our daily life can be seamlessly included.

One of the most important ubiquitous computing technologies is RFID (Radio Frequency Identification) tag, which is a rewritable IC memory with non-contact communication facility. This cheap, tiny RFID tag will make it possible to tag almost everything, replace the barcode, helps computers to be aware of their surrounding objects by themselves, and detect the user's context [4]. Also RFID tag is one of the important technologies to implement tangible user interface [5], which allows to map the physical objects and their information into the virtual world.

We assume that almost all the products will be attached with RFID tags in the near future, where we will be able to learn at anytime at anyplace from every object by scanning its RFID tag.

The fundamental issues of CSUL are

(1)How to capture and share learning experiences that happen at anytime and anyplace.

(2)How to retrieve and reuse them for learning.

As for the first issue, video recording with handheld devices will allow us to capture learning experiences. Also consumer generated media (CGM) services such as YouTube [http://www.youtube.com/] helps to share those videos. The second issue will be solved, by identifying objects in a video with RFID so that the system can recommend the video which can solve learner's current problem.

This paper proposes LORAMS (Linking of RFID and Movie System) for CSUL. There are two kinds of users in this system. One is a provider who records his/her experience into videos. The other is a user who has some problems and retrieves the videos. In this system, a user uses his/her own PDA, which equipped with RFID tag reader and digital camera, links the real objects to the corresponding objects in a movie, and shares the movie with other learners. Scanning RFID tags around the learner enables us to bridge the real objects and their information into the virtual world. LORAMS detects the objects around the user using RFID tags, and provides the user with the right information in that context.

As for related works, there are two kinds of educational applications using RFID tags. The first type is the applications that can identify the objects on a table and support face-to-face collaboration. For example, EDC (Envisionment and Discovery Collaboratory) [6] and Caretta [7] consist of a sensing board and objects with RFID tags such as house, school, etc. Detecting objects on the table enables the systems to show a simulation such as urban planning. Also TANGO (Tag Added Learning Objects) system supports learning vocabularies [8]. The idea of this system is to stick RFID tags on real objects instead of sticky labels, annotate them (e.g., questions and answers), and share them with others. The tags bridge authentic objects and their information into the virtual world.

The second type is the applications that can detect the learner's location using RFID tags that allows the system to track the learner's positions and to send the right messages to the right learner. eXspot [9] is an example of this type of application, which is designed for museum educators, it can capture the user's experiences at a museum for later reflection. This system consists of a small RFID reader for mounting on museum exhibits, and RFID tag for each visitor. While using RFID, a visitor can bookmark the exhibit s/he is visiting, and then the system records the visitor's conceptual pathway. After visiting the museum, the visitor can review additional science articles, explore online exhibits, and download hands on kits at home via a personalized web page.

There are also many related works to make the annotation and the keywords to the video in order that the system can provide only the videos that the user requires [10, 11, 12]. However, a lot of human costs and time are necessary for these methods of producing videos. In 2005, Yamamoto and Nagao developed one system in which the viewer puts the annotation of the video contents, and the production person's load is decreased. The accurate intelligence is added to contents by artificially giving the annotation [13]. In contact to those systems, LORAMS does not need to make annotations manually. Therefore, most of the students stated that it is very easy to link physical objects and video.

The idea of a "life-log" or personal digital archives is a notion that it can be traced back at least within 60 years [14]. The idea is to capture everything that ever happened to us, to record every event we have experienced and to save every bit of information we have ever touched. For example, SenseCam [15] is a sensor augmented wearable still camera and proposed to capture a log of the wearer's day by recording a series of images and capturing a log of sensor data. Reviewing this information will help the wearer to recollect aspects of earlier experiences that has subsequently been forgotten and form a powerful retrospective memory aid. While SenseCam employs a stills camera, LORAMS uses a video for capturing the experiences. Therefore, LORAMS helps to understand how to do something from a video, comparing to SenseCam.

In this way, RFID is very useful for identifying objects precisely. LORAMS system utilizes the full advantage of RFID to capture, share and reuse personal experiences for ubiquitous learning.

2. LORAMS

2.1. Features

The characteristics of LORAMS are as follows:

(1) Learner's experience is recorded into a video and the video is automatically linked to the real objects in the scene by scanning their RFID tags. Therefore, it does not need to add keywords or annotations into a video and is easy to make an index of the video to be shared with other learners.

(2) Learners can find suitable videos by scanning RFID tags around them without entering keywords of real objects.

(3) Based on the ratings of the learners and the system, the results are listed.

There are three phases for LORAMS as follows:

(i) Video recording phase:

(ii) Video search phase:

(iii) Video replay phase:

Video recording process requires PDA, RFID tag reader, video camera and wireless access to the Internet. First, a user has to start recording video at the beginning of the task. Before using objects, the user scans RFID tags and the system automatically sends the data and its time stamp to the server. After completing the task, the user uploads the video file to the server and the server automatically generates SMIL (Synchronized Multimedia Integration Language) file to link the video to the RFID tags.

On the other hand, video search and replay processes require PDA, RFID tag reader, and RealPlayer software. The user scans RFID tags around him/her and/or enters keywords of the objects, and then the system sends them to the server and shows a list of videos that match the objects and keywords. Moreover, the system extracts a part of the video that matches with these objects. The video is replayed.

2.2. User Interface

In recording phase, the user sets up the information on the RFID reader such as port number and code type, and enters the experiment name and user name. When the user uses an object, s/he pushes "start" button and scans the RFID of the object. Also, when the user finishes the work using the object, s/he pushes "end" button and scans RFID of the object. The RFIDs and the time stamps of the scans are sent to the server by pushing "send" button. As shown in the right of figure 1, the RFIDs are linked to the video.

Users can create their own user id and password before using LORAMS and a video file can be uploaded through the web page.
As shown in figure 2, by scanning RFID tags of physical objects and/or entering keywords in (A), the video search will be started. LORAMS searches for videos and lists them in an appropriate order. The list in (C) shows the videos that have been registered recently.

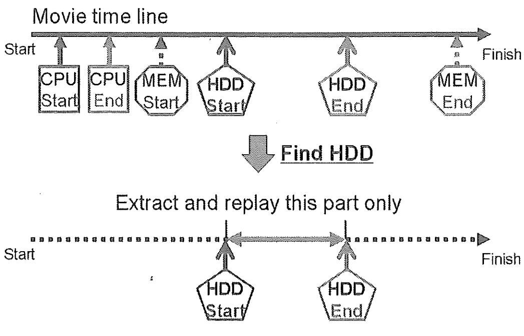

Figure 1: Video time line.

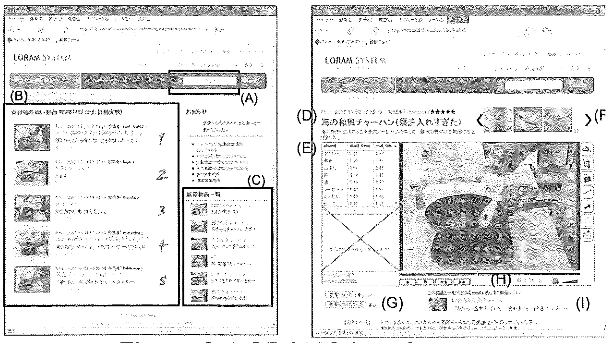

Figure 2: LORAMS Interface

By selecting a video from the list (B), the video playback window will appear. The video title, the author's name, and the recorded date are shown in (D), all the objects are listed in (E) in order of time. By clicking an item in the list, the system will jump to the video segment that includes the selected item. Pictures of the items are shown in (F). By clicking once on the pictures, the system will playback the video segments that include the selected item. By pushing a button in (G), the user can rate the video by the scale from 1 to 5. The playback can be adjusted using the tool bar in (H) such as fast-forward. The similar videos to the current video are listed in (I).

The system has an annotation function for adding information on videos. Where not only a video provider but also video viewer can make an annotation, a lot of information can be shared from different perspectives. We believe that this information could be useful for learning.

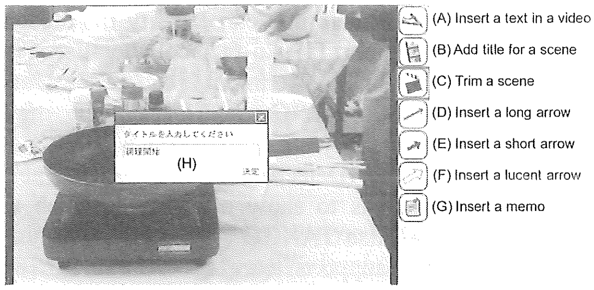

Figure 3: Annotation interface.

The system provides the following annotation function using the icons in the right side of the video window (as shown in figure 3):

(A) The user can insert a text into a video picture.
(B) The user can add a title to a scene by selecting the time period.
(C) The user can trim a scene by selecting the time period.
(D), (F), (G) The user can insert an arrow into a video picture.
(G) As a memo, the user can insert a URL of a web page, an image, and/or a file into a video picture.

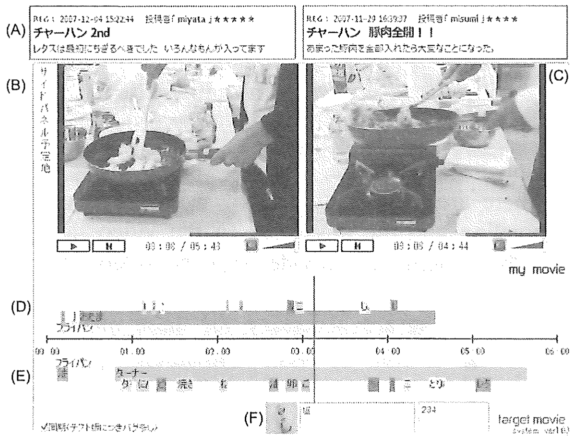

Figure 4: Interface for comparing two videos.

User can compare two different videos in the window as shown in figure 4. For example, the left one is a video of an expert, and the right one is a video of the user after watching the expert's video. The tile of the video is shown in (A) and the video is replayed in (B). The timeline of the left video is shown in (D) and that one of the right video is (E). In figure 4, the user can find that the timeline (E) is longer than the timeline of expert (D) and the performance of the user is not good enough. On the timeline, a colored rectangle shows an object that the user used at a certain time. If the mouse cursor is over the colored rectangle, the system will show the picture of the corresponding object in (F). Since the same object has the same color, the user can easily recognize when the object was used in the two videos.

2.3. System configuration

We have developed LORAMS, which works on a Fujitsu Pocket Loox v70 with Windows Mobile 2003 2nd Edition, RFID tag reader/writer (OMRON V720S-HMF01), and WiFi (IEEE 802.11b) access. The reader/writer is attached on a CF (Compact Flash) card slot of PDA. The tag unit can read and write data into and from RFID tags within 5 cm distance, and it works with a wireless LAN at the same time. The LORAMS program has been implemented using Embedded Visual C++ 4.0 and PHP 5.0.

The server application consists of the following modules:

(1) Database entry: It stores the RFID reading time stamp into the DB.
(2) Database: This system uses My SQL server as a database.
(3) Database search: This module matches videos with keywords and RFID tags.
(4) SMIL generation: After finding the segments that contain the keywords and RFID tags, this module generates SMIL files for each segment.

2.4. Ranking method

This system employs the following equation to rank the search results in order to provide the right information

$$I = \sum_{i=1}^{5} w_i x_i$$

Where,

X_1: subjective value given by the provider and $0 \le X_1 \le 1$;
X_2: objective value given by the user (learner), it is the average of the users' rates and $0 \le X_2 \le 1$;
X_3: the number of the key-objects in the video / the number of the key-objects given by the user;
X_4: the period of at least one of the key-objects shown in the video / the length of the video;
X_5: the period of all key-objects shown in the video at the same time / the length of the video;
W_i : the rating weight defined by the system administrator and $\sum_{i=1}^{5} \text{Wi} = 100$;

Key-object is the object that contains the keywords and/or RFID tags data given by the user.

3. Experimentation

We conducted the evaluation to measure how LORAMS can support the ubiquitous learning. The task was cooking fried rice as shown in Figure 5. We choose fried rice because it could be cooked in a short time so the students could cook it more than one time.

3.1. Experimentation design

Twenty one students from the department of computer science in the University of Tokushima were involved in this experiment, 8 undergraduate students, 8 first-year master course students, and 5 second-year master course students. Each of them was given 10 minutes to cook.

Before starting the task, it was explained to them how to use the cooking tools, PDAs, and RFID tag readers. 5 tools, 8 seasonings and 17 ingredients such as salt, pepper, egg, oil, pan, chopsticks, rice, onion, green pepper, sausage, soy sauce and carrot were prepared and attached to different RFID tags. According to the pre-questionnaire, the students' experiences about cooking were evaluated and they were classified into expert or non-expert groups. There were eleven students in expert group, who had the enough experience to cook, and ten students were in inexpert group who had shortage of the cooking experience.

In the first day of the experiment, all students cooked fried rice while recording videos. In the second day, they watched the videos and made annotations into the videos of the others using LORAMS. In the third day, inexpert group cooked fried rice again and compared the videos using LORAMS.

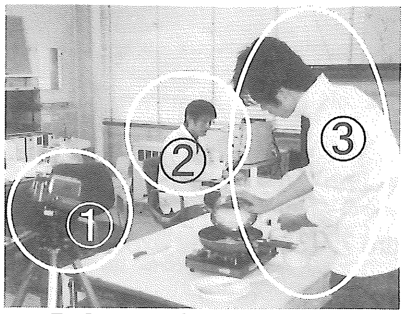

Figure 5: Scene of the experimentation.

Table 1: Results of questionnaires.

No.	Questionnaire	Ave	SD
Q1	Was it useful to watch a video using LORAMS for cooking?	4.3	0.59
Q2	Was it easy for you to recognize your mistakes and the differences with other persons using LORAMS?	4.6	0.47
Q3	Was it easy to use the interface for comparing videos?	4.1	0.86
Q4	Is it easy to learn something by comparing videos?	4.1	0.93
Q5	Overall, was it easy to reflect your mistakes on the next time using this system?	4.6	0.51
Q6	Overall, do you want to register and share your video using LORAMS?	4.0	1.00
Q7	Overall, do you want to use this system again?	4.4	0.71

3.2. Result

During the experimentation, 31 videos were registered in LORAMS. As shown in Figure 6, the average time for recording video was 4 minutes and 50 seconds, the maximum was 6 minutes 59 seconds, and the minimum was 2 minutes 55 seconds. Also the average time for encoding and uploading video was 1 minute and 44 seconds, the maximum was 2 minutes 28 seconds, and the minimum was 1 minute. Thus, the time for encoding and uploading was one third of the video recording time for cooking. Therefore, we believe that the waiting time is not so long for the users of LORAMS.

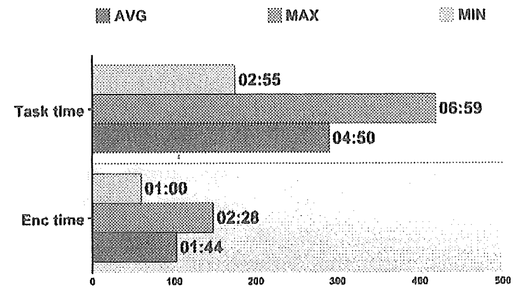

Figure 6: Task and encoding time.

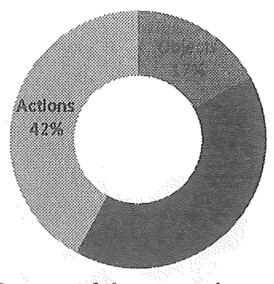

Figure 7: Scene of the experimentation.

The Questionnaire result is illustrated in table 1. For Q1, it was a comparatively good result. Even that the cooking video was recorded by non-professional people, it was helpful for cooking.

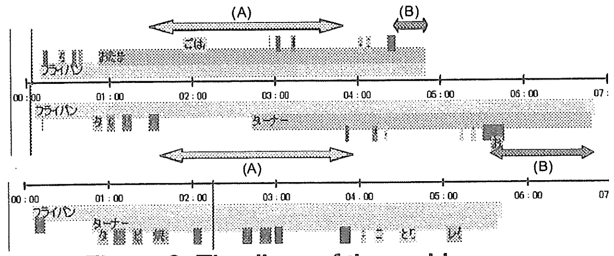

Figure 8: Timelines of three videos.

The result of Q2 was very good. We found that most of the student could recognize his/her mistakes and differences with another person by comparing their videos. The students found the difference in objects (17%), timing (41%), and actions (42%) as shown in figure 7. They learnt, for example, a green pepper and the carrot should be put earlier than rice, the rice becomes crisp if it is mixed with an egg before putting into a pan, and how to use a pan.

From Q3, it was easy for most of the students to use the interface for comparing videos, because we explained to them how to use it before staring the evaluation. However, it is necessary to improve the interface more.

The results of Q4 and Q5 were that, most of the students could easily find a refinement for the next time.

From Q6, and Q7, most of the students would like to share their videos and to use LORAMS again. However, a few students did not want to share their videos in case of the failure of cooking.

Here, we focus on a student and compare the video timeline and the objects. In figure 8, the first timeline represents the video of an expert and the second represents the student's video. There are two differences between the two timelines. First, the student did not put any ingredient into a pan as shown in (A). Second, the student took more than 3 times the time used by the expert to complete the cooking in (B). Therefore, the student's fried rise was burnt.

The student recognized what was wrong by watching the videos again. The timeline of the second cooking trail is shown in the third timeline in figure 8. According to the diagram, the cooking was improved by comparing with the second video, and the two problems mentioned above were solved. Therefore, LORAMS is a useful tool to share and compare videos.

After the experiments, the students made the following comments:

(1) We should take care about the heat of the gas oven.
(2) All things are fried quickly.
(3) We can use different ingredient.
(4) We should take care of the order of adding ingredients into the pan.

4. Conclusion

Ubiquitous computing will be integrated into everyday objects and activities and support not only to provide the right information at the right time at the right place but also to capture, share and reuse human's experiences.

This paper proposes a ubiquitous learning environment called LORAMS (Link of RFID and Movies System), which supports the learners with a system to share and reuse learning experience by linking videos and environmental objects. The system has the following features:

(1) Without any text annotation, the learner can find the suitable scenes that include the objects around the learner.
(2) The system recommends the learners the suitable

videos for watching and comparing according to the numerical ranking methods that are proposed in this paper.

(3) The system allows the learners to share knowledge through making annotations into videos.

The evaluation was conducted by twenty one University students and showed the following results:

(1) The students could learn how to cook different kinds of fried rice by watching videos using LORAMS.

(2) Most of the students agreed to the ranking of the search results and the video recommendation for comparison.

(3) Overall, it was easy to find your mistake or difference by the comparison and to reflect on the next time using LORAMS. Also most of them wanted to use the system again.

Because this experiment was conducted in a short term, we will make a long-term experiment again.

In future work, we will improve the user interface and ranking methods based on the students' comments. Also we will apply LORAMS to other domains, for example, checking upon cars such as oils, battery, and tires, second language learning for the people who are living in a foreign country, surgery operations and chemical bioreactor experimentations. We believe LORAMS can be applied many domains for those who need different kinds of skills in their everyday life. Finally, ubiquitous computing society is not still realized currently, but we believe we should start to design learning environments in the future society.

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References

[1] Abowd, G.D., and Mynatt, E.D. "Charting Past, Present, and Future Research in Ubiquitous Computing", *ACM Transaction on Computer-Human Interaction*, Vol.7, No.1, pp.29-58. (2000).

[2] Lyytinen, K. and Yoo, Y. "Issues and Challenges in Ubiquitous Computing", *Communications of ACM*, Vol.45, No.12, pp.63-65. (2002).

[3] Sakamura, K. and Koshizuka, N. "Ubiquitous Computing Technologies for Ubiquitous Learning". *Proceeding of the International Workshop on Wireless and Mobile Technologies in Education*, IEEE Computer Society, pp. 11-18. (2005).

[4] Borriello, G. "RFID: Tagging the World", *Communications of the ACM*, vol.48, No.9, pp.34-37. (2005).

[5] Ishii, H., and Ullmer, B. (1997). "Tangible bits: towards seamless interfaces between people, bits and atoms", *Proceedings of the SIGCHI conference on Human factors in computing systems*, pp.234 – 241.

[6] Arias, E., Eden, H., Fischer, G., Gorman, A. and Scharff, E. "Beyond Access Informed Participation and Empowerment", *Proceedings of the conference on Computer Supported Collaborative Learning (CSCL '99)*, pp 20 - 32. (1999).

[7] Sugimoto, M., Hosoi, K., and Hashizume, H. "Caretta: A System for Supporting Face-to-face Collaboration by Integrating Personal and Shared Spaces", *Proceedings of CHI2004*, ACM press, pp.41-48. (2004).

[8] Ogata, H., and Yano, Y. "Context-Aware Support for Computer-Supported Ubiquitous Learning", *Proceeding of the International Workshop on Wireless and Mobile Technologies in Education*, IEEE Computer Society, pp.27-34. (2004).

[9] Hsi, S. and Fait, H. "RFID Enhances Museum Visitors' Experiences at the Exploratorium". *Communications of the ACM.* Vol. 48, No. 9, pp.60-65. (2005).

[10] Davis, M. "An Iconic Visual Language for Video Annotation". *Proceedings of IEEE Symposium on Visual Language*, pp. 196-202. (1993).

[11] Nagao, K., Shirai, Y., and Squire, K. "Semantic Annotation and Transcoding: Making Web Content More Accessible", *IEEE MultiMedia*, Vol. 8, No. 2, pp.69-81. (2001)

[12] Smith, J. R. and Lugeon, B. "A Visual Annotation Tool for Multimedia Content Description", *Proceedings of SPIE Photonics East, Internet Multimedia Management Systems*, Vol.4210, pp.49-59. (2000).

[13] Yamamoto, D., and Nagao, K. "Web-based Video Annotation and its Applications", *Journal of the Japanese Society for Artificial Intelligence,* Vol.20, No.1, pp.67-75. (2005).

[14] Bush, V. *As we may think.* Atlantic Monthly. (1945).

[15] Hodges, S., Williams, L., Berry, E., Izadi, S., Srinivasan, J., Butler, A., Smyth, G., Kapur, N., and Wood. K. "SenseCam: A retrospective memory aid", *Proc. of UbiComp 2006*, pp. 177–193. (2006).