Linking Physical Objects and Videos toward Computer Supported Ubiquitous Learning

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Abstract: This paper proposes a personal learning assistant called LORAMS (Linking 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 kind of classes' experiments but also daily experiences movies. 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. Then we did evaluation experiments. The target of some experimenters is to recode movies and link objects while the target of other experimenters is to learn using LORAMS and to try doing a task. We could get a result that the performance of doing a task 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 [7]. Its evolution has recently been accelerated by improved wireless telecommunications capabilities, open networks, continued increases in computing power, improved battery technology, and the emergence of flexible software architectures [12]. 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 [3]. The features of RFID tag are as follows:

(1) Non line-of-sight reading: RFID is not necessary for line-of-sight reading like a bar code. In addition, the distance range for RFID reader is longer than bar code scanning range.
(2) Multiple tag reading: Unlike a bar code reader, RFID unit can read multiple tags at the same time. This feature enables counting the number of objects in a second. That is the reason one of the key applications of RFID is supply-chain management.
(3) Data rewritable: RFID has a memory chip that can be rewritten using an RFID unit. In the mean time, the data of bar code is not changeable.
(4) High durability: Tags are very sturdy from vibrations, contamination (dust and dirt), and abrasion (wear). Hence, tags can be permanently used.
(5) Ease of maintenance: There are two types of RFID tags. One is passive, which is without any battery. The power comes from the reader unit. Therefore, passive tags can be used permanently. The other one is active, which contains batteries and has a longer range than passive ones.

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 in CSUL are:
(1) how to capture and share learning experiences that happen at anytime and anyplace; and
(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 videos in similar situations as the situation where the learner has a 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 video. The other is a user who has some problems and retrieves the video. The idea of this system is that a user has his/her own PDA with RFID tag reader and digital camera, and links real objects and the corresponding objects in a movie and shares them among other learners. Scanning RFID tags around the learner enables bridging 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. On one hand, there are applications that can identify the objects on a table and support face-to-face collaboration. For example, EDC (Envisionment and Discovery Collaboratory) [2] and Caretta [14] 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 the simulation such as urban planning. Also TANGO (Tag Added learNinG Objects) system supports learning vocabularies [10,11]. The idea of this system is that the learner sticks RFID tags on real objects instead of sticky labels, annotate them (e.g., questions and answers), and share them among others. The tags bridge authentic objects and their information in the virtual world.

On the other hand, detecting learner's location with RFID tags allows the system to track the learner's positions and to send the right messages to the learner. eXspot [6] 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. 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.

In this way, RFID is very useful for identifying objects precisely. This paper takes full advantage of RFID to capture, share and reuse personal experiences for ubiquitous learning.

2. CSUL

2.1 What is CSUL?

CSUL (Computer Supported Ubiquitous Learning) is defined as a ubiquitous learning environment that is supported by embedded and invisible computers in everyday life. Figure 1 shows the comparison of four learning environments [7]. The CAL (Computer Assisted Learning) systems and ITSs (Intelligent Tutoring System) using desktop computers are not embedded in the real world and difficult to move. Therefore, those systems hardly support learning at anytime and anywhere.

Compared with Desktop Computer Based Learning (DCBL), the concept of Computer Supported Mobile Learning (CSML) is to increase the learners' capability to physically move their own learning environment. CSML uses lightweight devices such as PDA (Personal Digital Assistant), cellular mobile phones, and so on. Those mobile devices can connect to the Internet through wireless communication technologies, that enable to learn at anytime and anywhere. For example, there are a lot of commercial products that provide Podcast contents to support mobile language learning. In this case, computers are not embedded in the learner's surrounding environment, and they cannot seamlessly and automatically obtain information about the context of his learning. Therefore, they cannot provide suitable information for the learner's context.

In Computer Supported Pervasive Learning (CSPL), computers can obtain information about the context of the learning from the learning environment where small devices such as sensors, pads, badges, RFID tags and so on, are embedded and communicate mutually. CSPL environments can be built either by embedding models of a specific environment into dedicated computers, or by building generic capabilities using computers to inquire, detect, explore, and dynamically build models of the environments. EDC and Caretta are considered as CSPL. However, the availability and the usefulness of CSPL are limited and highly localized.

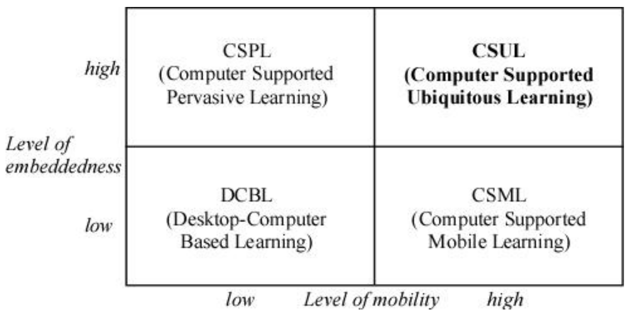


Figure 1: Ubiquitous learning. (Based on [7])

Finally, CSUL has integrated high mobility with pervasive learning environments. While the learner is moving with his mobile device, the system dynamically supports his learning by communicating with embedded computers in the environment. TANGO is considered as CSUL environments. This system allows learners to move with their PDAs and to communicate with the surrounding objects through RFID tags. As for the broad definition of CSUL, it includes both CSPL and CSML.

2.2 Features

The main characteristics of CSUL are shown as follows [7,8]:

a) Permanency: Learners never lose their work unless it is purposefully deleted. In addition, all learning processes are recorded continuously every day.

b) Accessibility: Learners have access to their documents, data, or videos from anywhere. That information is provided based on their requests. Therefore, the involved learning is self-directed.

c) Immediacy: Wherever learners are, they can get any information immediately. Thus, learners can solve problems quickly. Otherwise, the learner can record the questions and look for the answer later.

d) Interactivity: Learners can interact with experts, teachers, or peers in the form of synchronous or asynchronous communication. Hence, the experts are more reachable and the knowledge becomes more available.

e) Situating of instructional activities: The learning could be embedded in our daily life. The problems encountered as well as the knowledge required are all presented in their natural and authentic forms. This helps learners to notice the features of the problem situations that cause particular relevant actions.

The use of ubiquitous computing tools within a situated learning approach is recommended to facilitate the students' attainment of curricular content, technology skills, and collaboration skills. Therefore, we believe that it is very important to support learning in everyday life with ubiquitous computing technologies.

3. LORAMS

3.1 Features

The characteristics of LORAMS are as follows:

(1) Learner's experience is recorded into a video that is linked with RFID tags of real objects. The video can be shared with other learners.

(2) Learners can find suitable videos by scanning RFID tags and/or entering keywords of real objects around them.

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

There are three phases for LORAMS: video recording, video search, and video replay phase. Video recording process needs 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 generate SMIL (Synchronized Multimedia Integration Language) file to link the video and the RFID tags.

On the other hand, video search process needs PDA, RFID tag reader, and real player. 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 the list of the videos that include the objects and keywords. The video is replayed with RealPlayer.

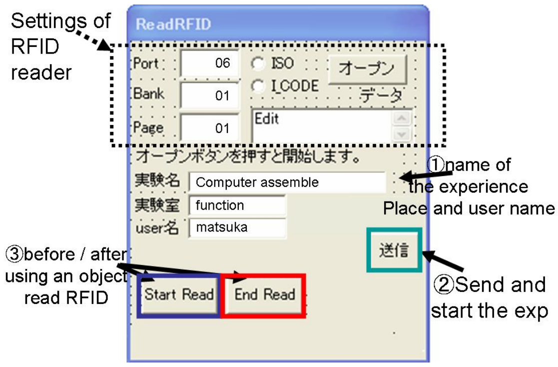


Figure 2: Interface for the recording phase.

3.2 User Interface

In recoding 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 figure 2, the RFIDs are linked to the video as shown in figure 3.

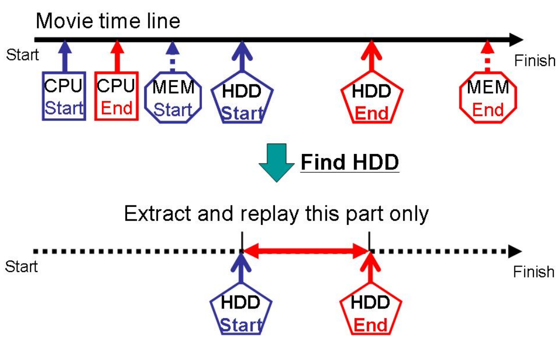


Figure 3: Interface for the recording phase.

Figure 4 shows the user interface for video search. First, the user scans RFIDs and/or enters keywords in (A). Then, the system shows the result in (B) and the use selects one of the videos. By pushing the replay button (C), RealPlayer automatically appears and plays the selected video. The objects in the video are listed below the movie area in (D).

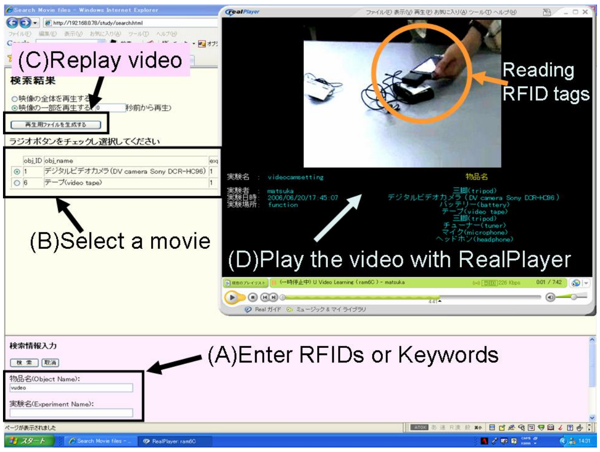


Figure 4: Interface for video retrieval.

3.3 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. RFID tag 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 with Embedded Visual C++ 4.0.

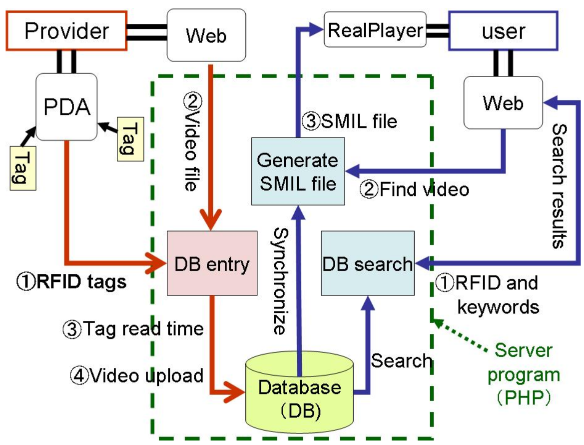


Figure 5: System configuration.

As shown in figure 5, there are four modules in a server computer:

Database entry: Time stamps in reading RFID tags are stored in DB through this module. After completing the task, the provider will upload the video. At that time, this module will link the video and the time stamps.

Database: This system uses My SQL server as a database.

Database search: This module enables finding a suitable video by keywords and RFID tags.

SMIL generation: After finding the segments that contain the keywords and RFID tags, this module generates SMIL files for each segment.

3.4 Ranking method

A ubiquitous computing environment enables people to learn at any time and any place. The challenge in an information-rich world is not only to make information available to people at any time, at any place, and in any form, but specifically to say the right thing at the right time in the right way [6]. This system employs the following equation to rank search results in order to provide the right information. A key object means the object that contains the keywords and/or RFID tags given by the user.

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

X1: subjective value given by the provider;

X2: objective value given by the user (learner);

X3: # of the key objects in the video / # of the key objects given by the user;

X4: period of at least one of the key objects shown in the video / the length of the video;

X5: period of all the key objects shown in the video at the same time / the length of the video;

There are two kinds of rating elements. On one hand, subjective rating consists of two ratings: one is given by the provider (x1) and the other is the average value by all the users who saw the video (x2). Those values are expressed by integer: one is minimal and five is maximal.

On the other hand, objective ratings are given by video data. There are three values for this rating; X3 shows how many key objects are shown in the video and X4 is the segment length that contains the key objects in the video. The longer period the key objects that the user scanned appears in a video, the higher this value is.

4. Experimentation

We conducted the evaluation to examine how LORAMS can support ubiquitous learning. The tasks were installation some devices to personal computers as shown in figure 4.

4.1 Experimentation design

Eleven students in the department of computer science in the University of Tokushima were arranged for this experiment. Although they have already learnt theories of computer architectures at the classroom, they have never been taught how to assemble a computer in practice. Each of them was given 30 minutes to complete one of the following tasks:

Task 1- Plug a Hard Disk Drive 40 GB as a Master device and a CD-ROM as a Slave drive using one IDE cable.

Task 2- Plug a Hard Disk Drive 30.7 GB as a Master device and a CD-ROM as a Master drive.

Task 3- Plug an AGP VGA card 32 MB and 2x128 MB RAM.

Task 4- Plug an AGP VGA card 16 MB and 1x256 MB RAM.

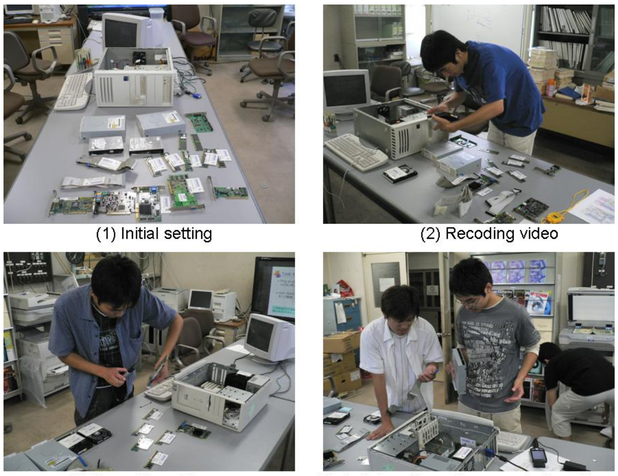
Before starting the task, they were explained about the devices and how to use PDA and RFID tag reader. All devices were attached with different RFID tag as shown in table 1. According to the pre-questionnaire, five students had an experience to complete the above tasks and six students did not have.

Table 1: Objects and IDs used in the experiment.

Object ID	Object name
4F303032	SDDR RAM Hunix 256 MB
4F303034	SDDR RAM SEC 128 MB
4F303033	DDR RAM NANAYA 256 MB
4F303036	VGA SST MPF 39V512 -(16 MB)
4F303038	Hard Disk Drive Maxtor IDE 40 GB
4F303039	Hard Disk Drive IBM IDE 30.7 GB
4F303130	CD ROM Drive LG
4F303133	IDE Data Cable double
...	...

4.2 Results

First, all the students executed a task to make a video using PDA and RFID. In this phase, the students could use a web search engine like Google without LORAMS. As a result, five expert students and one inexpert student could complete the task. After that, the six inexperienced students executed a task with LORAMS and five students could complete the task. After one month later, the six students were asked to complete the same task without any help, i.e., they were not allowed web page browsing, LORAMS, or asking other people. As a result, the entire students successful completed the task.



(1) Initial setting (2) Recoding video (3) Searching video (4) Collaboration with a peer in the video.

Figure 6: Scene of experimentation.

Table 2: Results of questionnaires.

No	Questionnaire	Ave	SD
1	Is it so easy for you to read RFID tags, record a video and complete the task at the same time?	3.4	0.85
2	Is it so easy for you to make a link between RFID and movie?	3.5	1.71
3	Do you think that the recorded videos are very useful for the beginners to complete the task?	4.3	0.67
4	Do you think the extracted video is effective for learning?	4.5	1.21
7	Was it easy to find the suitable movie using this system?	4.0	1.10
8	Overall, is it easy for you to use this system?	3.7	0.52
9	Overall, do you think this system is useful for learning?	4.5	0.30
10	Do you want to use this system again?	4.3	0.67

The achievement rates (AR) and time (AT) in each phase were shown in figure 7. The AR increased by using LORAMS from 33.3 % to 83.3%, and the AT decreased. This means that LORAMS can help the students learning how to install some parts to the computer. Also the AR became 100.0% after one month. This means that the students kept the skill and knowledge that they had acquired with LORAMS.

The students filled the questionnaires after the experiment. The result is shown in table 2. According to Q1 and Q2, recording phase is not so bad for the students. However, they commented that they sometimes forgot scanning tags and felt bothersome for scanning.

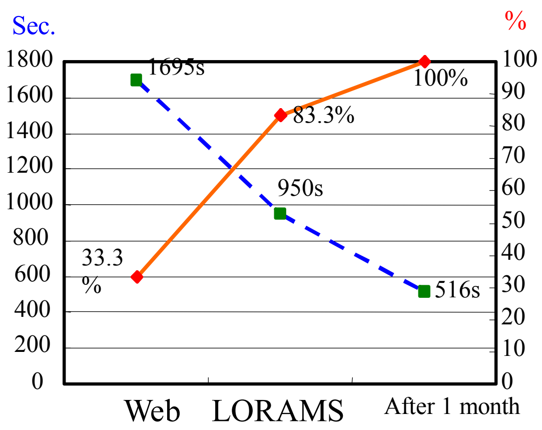


Figure 7: Achievement rate and time in each task.

5. Conclusion

This paper proposes a ubiquitous learning environment called LORAMS, which supports the learners with a system to share and reuse learning experience by linking movies and environmental objects. The evaluation showed that students acquired skills for assembling computers and LORAMS is useful for learning. In future work, we will apply LORAMS to other domains, for example, cooking, chemical operations and bioreactor experimentations.

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