Knowledge Awareness Map for Computer-Supported Ubiquitous Language-Learning

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Abstract

This paper describes a computer supported collaborative learning (CSCL) in a ubiquitous computing environment. In the environment called CLUE, the learners provide and share individual experience and interaction corpus and discuss about them. This paper focuses on the design, implementation, and evaluation of knowledge awareness map. The map visualizes the relationship between the shared knowledge and the current and past interactions of learners. The map plays a very important role for finding peer helpers, and inducing collaboration.

1. Introduction

Ubiquitous computing [1] will help in the organization and mediation of social interactions wherever and whenever these situations might occur [11]. Its evolution has recently been accelerated by improved wireless telecommunications capabilities, open networks, continuous increase in computing power, improved battery technology, and the emergence of flexible software architectures. With those technologies, an individual learning environment can be embedded in daily real life.

The main characteristics of ubiquitous learning are shown as follows [2,3]:

(1) Permanency: Learners never lose their work unless it is purposefully deleted. In addition, all the learning processes are recorded continuously everyday.

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

(3) 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.

(4) 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.

(5) 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 notice the features of problem situations that make particular actions relevant.

Moreover, ubiquitous learning can be Computer Supported Collaborative Learning (CSCL) [16] environments that focus on the socio-cognitive process of social knowledge building and sharing.

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[7]. A ubiquitous computing environment enables people to learn at any time and any place. Nevertheless, the fundamental issue is how to provide learners with the right information at the right time in the right way. This paper tackles the issues of right time and right place learning (RTRPL) in a ubiquitous computing environment.

Especially, we focus on language learning as an application domain of this research, because language is strongly influenced by situations. There are two different kinds of users of this system: one of them is an overseas University Student in Japan, who wants to learn Japanese Language; the other is a Japanese Student who is interested in English as a second language and plays an important role as helper for the overseas student. The learners with PDA (Personal Digital Assistant) store and share the interaction corpus (useful expressions) and experience that are linked to any place in everyday life. Then, the system retrieves past interaction and experience based on the current context, and provides each learner with the right expressions at the right place. For example, if the learner enters a hospital, then the right expressions at that place are provided at that time for RTRPL. It is very important to encourage not only individual learning but also collaborative learning in order to augment practical communication among learners and accumulation of expression.

In order to induce collaborative learning, this paper proposes Knowledge Awareness (KA) map that visualizes KA information for ubiquitous learning environments. The map helps learners to mediate and recognize collaborators in the shared knowledge space. On this map, the system identifies learning-companions who can help solving a problem. The characteristics of the map are:

(1) Visualization of objects in the map and expressions as educational materials,

(2) Visualization of the links between expressions and learners to induce collaboration,

(3) Recommendations of appropriate collaborators on KA map to help find suitable partners.

We are developing an open-ended collaborative learning support system, which is called CLUE (Collaborative-Learning support-system in Ubiquitous computing Environment) [14,15]. CLUE is a prototype system for KA map and facilitates to share individual knowledge and to learn through collaboration.

2. Knowledge Awareness Map

2.1 What is knowledge awareness?

KA is defined as awareness of the use of knowledge [12,13]. In a distance-learning environment, it is very difficult for the learner to be aware of the use of other learners' knowledge because the learner cannot understand their actions in the remote site beyond Internet. KA messages inform a learner about other learners' real-time or past-time actions (look-at, change, and discuss), which have something to do with knowledge on which a learner was or is presently engaged. Some examples of KA messages are "someone is changing the same knowledge that you are looking at", "someone discussed the knowledge which you have inputted." These messages make the learner aware of someone:

(1) Who has the same problem or knowledge as the learner;

(2) Who has a different view about the problem or knowledge; and/or

(3) Who has potential to assist solving the problem.

Therefore, the messages that are domain independent, can enhance collaboration opportunities in a shared knowledge space, and make it possible to shift from solitary learning to collaborative learning in a distributed learning space.

KA messages are classified into two dimensions: time and knowledge separation. KA message of type same time (ST) informs the learner that other learners are doing something at the same time that the learner is using the system. By using learners' past actions, KA message of type different time (DT) provides the encounters beyond time. KA message of type same knowledge (SK) is a message about other learners' activities related to the same knowledge that the learner is looking at, discussing, or changing. This type is available for learners to find partners who have the same problem or knowledge. KA message of type different knowledge (DK) enhances collaboration possibility with another learner (1) who has had something to do with the learner's interests; or (2) who has different expertise from the learner's interests.

For example, the message of type STSK "Who is looking at the knowledge?" shows the existence of learners who are looking at the knowledge that the user is looking at. By this message, the user may start to discuss on the knowledge. Likewise, the message of type DTSK "Who changed the knowledge since I have last looked at?" facilitates to start a discussion about the change of the knowledge. Moreover, the message of type STDK "What knowledge are they discussing?" is useful to join into discussions that interest the learner.

KA has a close relation with learner's curiosity. Hatano and Inagaki [10] identified two types of curiosity: particular curiosity (PC) and extensive curiosity (EC). EC occurs when there is a desire for learning that makes the learner's stock of knowledge well balanced by widening the learner's interests. PC is generated by the lack of sufficient knowledge, and it is very useful because the learner can acquire detailed knowledge. KA message of type SK excites PC, and KA message of type DK satisfies EC. For example, a message of type STDK stirs up the learner's EC by attracting his/her attention to particular knowledge when is focused on nothing. Moreover, the message of type STDK leads the learner to collaboration by arousing the learner's PC.

2.2 Knowledge Awareness map

Knowledge Awareness Map graphically displays KA information. This map provides learner with a clear grasp of some learners around knowledge that is separated from the learner looking knowledge. With this, the learner can seek for other learners as discussion companion interactively.

2.2.1 Learner's profile

The system obtains the learner's profile from two sources:

(1) The learner's action log: e.g., the number of visit to the location;

(2) The learner's explicit registration.

The learner's actions in an open-ended learning environment can be classified as follows: (A) entering a new location, (B) entering a new expression, (C) making a link to a WWW page, (D) asking a question, (E) answering a question, (F) modifying an expression, (G) participating in a discussion, and (H) looking at an expression. These eight actions are one of the sources of the learner's profile. However, it is difficult to detect the interest of the learner only from his/her actions. Therefore, it is necessary that the learner register his/her own interests on the knowledge.

2.2.2 Strategy for recommending peer learners

When the learner asks a question and is seeking for a helper, the system recommends from one to three persons. The type of the learner who participates in collaboration is shown below:

(1) Questioner: This learner has some questions and requires collaboration.

(2) Answerer: This learner answers the question of the questioner.

(3) Participant: This learner is interested in the question and wants to join the collaboration.

The system recommends to the questioner an answerer who can help problem solving and some participants by using the following information:

(1) The login situation of learners:

Because it is a real-time discussion, the system selects only logged-in users as candidates.

(2) The profile of each learner:

Although the profile consists of the number of access actions to the knowledge, the system has to evaluate totally. If the total number of (A)-(D) actions of a learner is larger than that of (E)-(H) actions, then the system considers the learner as an answerer. Otherwise, the learner is considered as a participant. The larger the total of a learner's actions, the more the learner is preferred to join the collaboration.

(3) The current action of learner:

The system gives a high priority to learners who are doing nothing (idle) in the learning environment. This consideration activates passive learners by stimulating their intellectual curiosity.

This paper proposes the level of interest (LOI) as follows:

$$LOI = \frac{\text{No. of the learner's actions to the expression}}{\text{Max No. of other learner's actions to the expression}}$$

The range of LOI is from 0.00 to 1.00.

2.3 Visualization of KA

A link in KA map shows the relationship between expressions and learners. The length (L) of a link means the strength of the relationship and it is calculated by the following equation:

$$L = D(2 - LOI)$$

where, D is a default value of link length.

The range of L is from D to 2D. If a learner is very interested in a page, the link length (L) between the page and the learner is short and close to D.

3. Implementation of CLUE

We have developed the prototype system of CLUE, which consists of a server and clients. Each learner’s client of CLUE is a Toshiba Genio-e PDA with Pocket PC 2002, Personal Java, GPS (Global Positioning System), and wireless LAN (IEEE 802.11b). Especially, we selected this device to use GPS and wireless LAN at the same time. The server program has been implemented with a java servlet via Tomcat.

3.1 Information in CLUE

Based on [1], CLUE deals with the following information:

Who: Current systems focus their interaction on the identity of one particular user, rarely incorporating identity information about other people in the environment. As human beings, we tailor our activities and recall events from the past based on the presence of other people. CLUE identifies not only the current user but also other users surrounding him/her. CLUE provides the right information after interpreting their user-models. Especially, usage of Japanese Language is modified according to the listener. For example, we, Japanese people use different level of polite expressions depending on the age of other people.

What: The interaction in current systems assumes either what the user is doing or leaves the question open. Perceiving and interpreting human activity is a difficult problem. Nevertheless, interaction with continuously worn, context-driven devices will likely need to incorporate interpretations of human activity to be able to provide useful information.

When: With the exception of using time as an index into a captured record or summarizing how long a person has been at a particular location, most context-driven applications are unaware of the passage of time. For example, the learner might get the right expressions at the certain time, e.g., morning.

Where: In many ways, the "where" component of context has been explored more than other items. Of particular interest is coupling notions of "where" with other contextual information, such as "when.

Why: Even more challenging than perceiving "what" a person is doing, is understanding "why" that person is doing it. Using "why" information, the right expressions could be provided to the learner.

3.2 System configuration

CLUE has the following modules:

Learner model: This module has the learner's profile, such as name, age, gender, occupation, interests, etc, and the comprehensive level of each expression. Before using CLUE, the learner enters those data. In addition to this explicit method, CLUE implicitly detects learner's interests according to the history of visits. Moreover, this system records whether the learner understands expressions.

Environmental model: This module has the data of objects, rooms and buildings in the map, and the link between objects and expressions. For example, (Post office, location (x, y), "I'd like to buy a stamp.") means the post office is located at (x, y) on the map and that expression is often used there.

Educational model: This module manages expressions as learning materials and dictionaries. The teacher enters the basic expression for each place. In addition, learners can add pictures and/or movies into the database. Those multimedia data helps learners understand the situation where another learner was. Both learners and the teacher can add or modify expressions during the system use.

Communication support: This server manages a BBS (bulletin board system) and a chat tool, and stores their logs into a database.

Location manager: This module stores each learner's location into the database.

Adaptation engine: This module recommends to the learner the suitable expression and KA map.

Communication client: This is a client of BBS and chat.

Location sensor: This module sends the learner's location from GPS to the server automatically.

Information visualization: This module shows KA map to the learner.

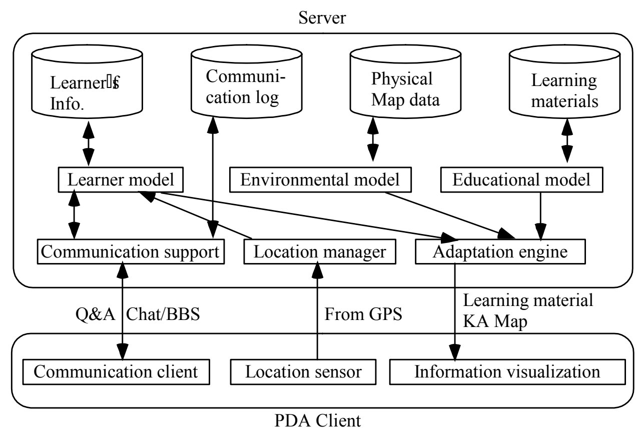

Figure 1. System configuration.

3.3 Recommendation of Learning Materials

When the learner is walking around, CLUE presents expressions in a given order determined based on the following conditions:

(1) The expression is frequently used at the learner's present location.

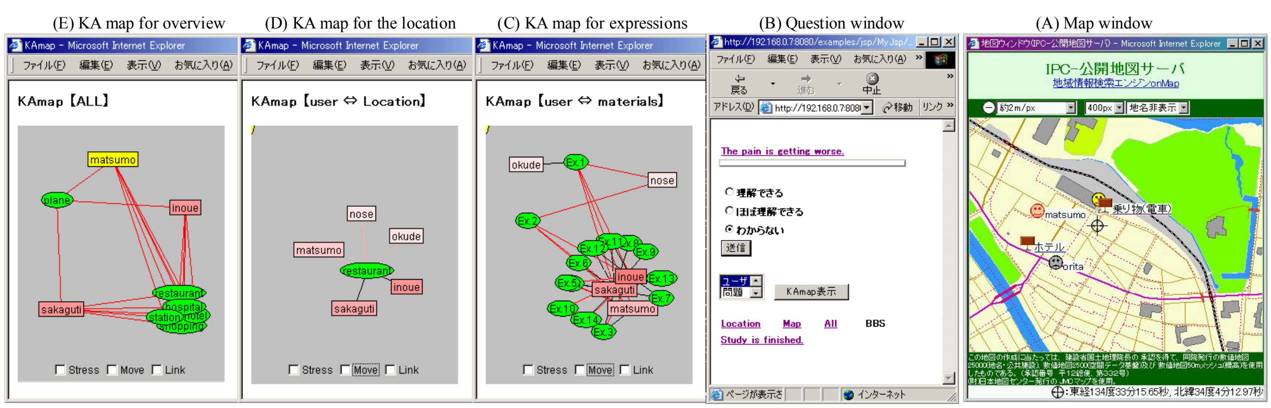

Figure 2. Screen snapshots of CLUE.

(2) The learner has never learned the expression.
(3) Most of other learners have already learned the expression.
(4) The level given by a teacher for the expression is appropriate for the learner's level.

Condition (1), (2) and (3) are derived from the learner's information. Condition (4) is derived from the learning materials and the learner's level that is detected by the right answer rate of the learner at that moment. The more conditions an expression meets, the higher the order of the expression will be. In this way, CLUE presents the right expression at the specific place.

3.4 Interface of CLUE

Interface of the collaborative learning environment of CLUE is shown in Figure 2. The map window (A) shows the current location of each learner. The face icon on the map means the learning status of each learner. For example, if a learner has a problem or question, the face turns into a fad one. By clicking the face icon, it is possible to send a message to the learner corresponding to the icon. In addition, a rectangle icon on the map shows a landmark where a teacher or a learner gives some expressions, or where they communicate with each other. If a learner enters an expression at one place for the first time, then a new landmark is created in the map. By cling the rectangle icon, the user can see the web page of the place (e.g., the hospital), the expressions that are used in the place, or the communication logs about either the expressions or the place. Users can also register their positions at any time if GPS does not work. For example, it might come out when big buildings surround them, or when they are inside a building.

If the learner approaches certain place, the window (B) appears, which shows an English useful expression for that place. If the current user has already learned all the expressions for that place, the expressions do not appear. If the learner can correctly answer the Japanese expression corresponding to the English one, the next expression will appear. Otherwise, the learner will be given the same expression the next time he/she comes to the place.

If the learner has a question about the expressions, the window (C) shows the relation between expressions and other learners. The color of an oval icon shows the level of difficulty given by a teacher for one expression. Moreover, the color of a rectangle icon shows the level of proficiency of the learner. The more correct-answers the learner gives, the higher is the level. From this KA map, the learner can find a suitable person to ask the question.

If the learner has a question about one place, the window (D) shows other people who have visited it, and the window (D) shows the relation between people and all the places on the map.

4. Experimentation

The simulation of the use of CLUE was held as an initial experimentation. Three undergraduate students and three master course students were arranged as test subjects for the initial evaluation of CLUE system. They, Japanese people, were very interested in ESL (English as the Second Language). We selected 89 English and Japanese sentences as learning materials from the online dictionary called Eijiro [6]. These sentences are useful expressions at specific places, for instance, a hospital, a restaurant, a shopping store, a hotel, etc. We mapped those places into the buildings of our campus. Some overseas students who spoke English were at each spot and had a talk with the learners, based on the learning materials. Then CLUE tried to provide each user with the right expression when approaching to the specific place.

An outside wireless antenna was established in our University, and the campus was assumed a small town. Each student walked during a week through the campus with a PDA with a wireless LAN and a GPS. At the first day of this experiment, all the students took a pre-test. Then for a week half of them, group X, learned with CLUE, and the others, group Y, learned English based on papers. After that, all of them took a post-test. The contents of the post-test and the pre-test were different, but both tests were derived from the 89 sentences.

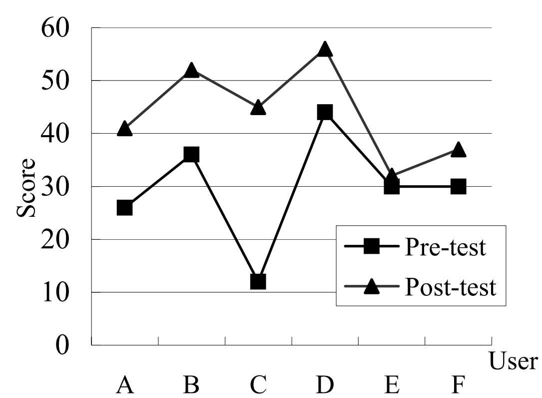

Figure 3. The score of each user.

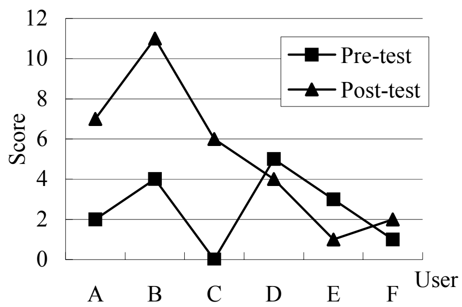

Figure 4. The score of the test in a hospital.

4.1 Results of the examination

Figure 3 shows the score of each user in the pre-test and the post-test. Users A, B, and C in group X learned English with CLUE, and users D, E, and F in group Y learned without CLUE. The average increase of the score between the pre-test and the post-test is 21.3 in group X, and 7.0 in group Y. It might be because the members in group X could discuss about the specific topic among them. Within the discussion, they might acquire words, idioms, and sentences in addition to the learner materials. Compared to group X's activities, group Y learned individually without discussion. Especially, the score of post-test of group X increased more than that of group Y as shown in Figure 4. We think that is because the group X discussed about the expressions at the hospital where they had known only a few expressions. Therefore, CLUE was very useful to induce discussions, and to broaden and solidify their knowledge.

Table 1: The results of questionnaires.

No.	Question	Ave.
Q1	Did CLUE provide the right information at the right place?	5.0
Q2	Did CLUE ask a question at right way?	4.3
Q3	Did you understand KA map easily?	4.0
Q4	Do you think KA map very useful?	4.6
Q5	Was the map window necessary for you?	4.3
Q6	Do you think CLUE very helpful for language learning?	4.6
Q7	Do you think CLUE very useful in the class if you were a teacher?	4.3
Q8	Do you think CLUE easy to use?	4.0
Q9	Do you want to keep using CLUE?	4.6

4.2 Results of the questionnaire

The effectiveness of CLUE was evaluated with a questionnaire. The users of CLUE gave a score between one and five to each of nine questions, with one being the lowest, and five being the highest. The average of score was 4.4. Table 1 shows the results of the questionnaire. According to question (1) and (2), the users were quite satisfied with the information provided by CLUE.

In terms of KA map, question (3) and (4) show that KA could be provided in the appropriate way. One of the learners commented that KA map is easy enough to understand. Another learner commented that KA map could not be understood easily if there were many nodes. For that reason, we will try to improve the visualization of KA. From the results of question (6) and (7), we found that CLUE played a very important role for enhancing learning. Through discussions, users were able to teach and learn from each other, and most learners replied that they had a feeling of achievement. The question (8) shows that the user interface of CLUE should be improved. Finally, question (9) shows that most of the users were interested in CLUE.

5. Related Work

Researchers in the educational systems area are attempting to provide technological support for cooperative and collaborative learning advocated by educational theories [18]. This paper focuses on an open ended and collaborative learning environment. For this situation, CoVis [5], CSILE [17], WebCamile [9] and Belvedere [19] have been developed. CoVis focuses on making a collaboration process visible. CSILE and WebCamile support knowledge building for the creation of knowledge. Moreover, Belvedere that is a networked software system was implemented to provide learners with shared workspaces for coordinating and recording their collaboration in scientific inquiry. In such environments, distributed expertise and multiple perspectives enable learners to accomplish tasks and develop understandings beyond what any could not achieve alone. Therefore, it is very important for learners to collaborate with each other. However, little attention has been given to the technical support for inducing collaboration in distributed leaning spaces connected via Internets.

In computer supported cooperative work (CSCW), awareness is one of the most interesting topics, which can increase communication opportunities in a distributed workspace. Dourish and Bellotti [4] defined awareness as "understanding of the activities of others, which provides a context for your own activity." In CSCL (computer supported collaborative learning), Knowledge Awareness (KA) have been proposed to bridge learners who are interested in the same knowledge and to create effective collaboration in a distance learning environment [12, 13]. KA gives learner information about other learners' activities in a shared knowledge space. Its messages are, for instance, "someone is looking at the same knowledge that you are looking at", "someone changed the knowledge which you have inputted." These messages of KA encourage collaboration by exciting learner's curiosity and by active learning. Sharlok (Sharing, Linking and Looking-for Knowledge) has been developed as a testbed of the KA. Sharlok is an open-ended and collaborative learning environment that integrates a knowledge-building tool with a collaborative interface tool. Sharlok allows learners: (1) to share their respective knowledge in its shared knowledge space, and to explore this knowledge space freely, (2) to make hypertext links between relevant knowledge, and (3) to collaborate about shared knowledge in an ad hoc group at real time. Evaluation of Sharlok showed that KA encouraged collaboration by exciting learner's curiosity and that KA effectively induced collaboration. In this paper, we described how to adapt KA to ubiquitous learning.

6. Conclusions

This paper describes a computer supported collaborative learning (CSCL) in a ubiquitous computing environment. In the environment called CLUE, the learners provide and share individual knowledge and other knowledge on the WWW, and discuss about them. This paper focuses on the design, implementation, and evaluation of knowledge awareness map. The map visualizes the relationship between the shared knowledge and the current and past interactions of learners. The map plays a very important role for finding peer helpers, and inducing collaboration. In the future, we will try to evaluate CLUE.

It is possible to reuse the conversational data that is stored during the system's use in a digital city. The learner can learn language by walking through a digital (virtual) city without moving in the real one. Moreover, the entertainment function like a video game will be added in order to keep high the learner's motivation. RFID tag will help computers to be aware of learners' location in the buildings.

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