

Research Article

An Adaptive System Supporting Collaborative Learning Based on a Location-Based Social Network and Semantic User Modeling

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This paper presents an adaptive e-learning system which supports collaborative learning based on a location-based social network and semantic modeling. In the system, a social network among e-learning learners is dynamically constructed on the basis of the location information of learners using GPS sensors for collaborative learning. In addition, user modeling for semantic social network and adaptive e-learning is supported. For these, a mechanism that supports the construction of a dynamic social network using the location information of smart phones is provided. The user modeling for the construction of a semantic social network and the support of adaptive e-learning considers the information such as the users' achievement, preference, and learning goal. Through this system, e-learners can find mentors who are able to facilitate their learning and create communities for collaborative learning offline and online. The support of a location-based social network service and semantic user model in our system would increase interactions among e-learners and improve satisfaction regarding their mobile learning environment.

1. Introduction

E-learning offers higher education the opportunity to expand the borders of classrooms to include distance learners. E-learning gives an attractive learning opportunity for learners who are restricted by time and space, thus, increasing the number of e-learners. However, there is an issue about the high drop-out rate associated with online courses. While some e-learners thrive on the increased flexibility that the medium provides, others languish in isolation and struggle to get started [1, 2]. Therefore, as colleges continue to attract new online learners, administrators are also trying to find ways to keep them enrolled.

Tinto [3] stresses that academic satisfaction is not enough for some learners who suffer from isolation. The intensity and reciprocity of a social interaction can, together with other factors, result in such drastic measures as learners dropping out of a course. Carr [4] points out that anecdotal evidence and studies by individual institutions suggest that online course completion is much lower than in F2F (face to face) courses. A number of studies have found the retention

of e-learners to be lower than the retention of oncampus learners. Interaction with classmates and the professor is a significant contributor to perceived learning in online courses [1, 5]. Learners who report a high level of interaction report a high level of perceived learning in a course.

The social dimension of learning is also central to the idea of situated learning. Social interaction has always been of great significance to teachers, learners, and others [3]. Learning is a function of the activity, context, and culture in which it occurs, where social interaction is critical. Accordingly, it would be important to boost e-learners so that they can construct a social network among themselves. Through the social network service, learners can have face-to-face meetings as well as online meetings. This social interaction would increase the learner's satisfaction with the course, increasing the probability that the learner will not drop the course [6].

Mobile devices can facilitate social interaction and access to information resources anytime and anywhere [7]. With proper design, applications in mobile devices can also facilitate learning. Currently, there are increasing demands and

interest in location-sensing based services with advancements in smart phones (which have GPS capability), PDAs, Bluetooth, dedicated GPS equipment, and other devices (such as i-Pad, navigation devices, and digital cameras). Mobile social networking is available to users as a consequence of social network services coming to mobile devices, especially smart phones [8].

However, the notion of modeling learners in a social network is very useful if applied to an e-learning system where the learners are physically in different locations and their social life is completely separated from academic life. These learners still need friends, who share the same interests, preferences, or learning experiences, to communicate and collaborate with each other. Therefore, user modeling is required to construct a semantic social network adapted to the special needs and personality characteristics of each learner so that the users' collaboration can be more efficient. That is, social networks are constructed on the basis of semantic user modeling.

This paper proposes a system that supports the construction of a social network service using the location information of the smart phone in mobile learning. This system also provides a mechanism to form a semantic social network among the learners who have similar learning interests, preferences, and learning experience based on user modeling information. Through this system, e-learners can create more effective communities for learning and exchanging help. That is, they can have face-to-face meetings as well as online meetings for collaborative learning. This support of a social network in our system based on location and semantic user modeling would increase interactions among e-learners and improve satisfaction regarding their e-learning learning environment. Consequently, it would make e-learning course completion rates higher.

2. Related Work

2.1. Advantages and Disadvantages to E-Learning. Knowing e-learning advantages and disadvantages helps learners use it effectively as well as select proper online programs for their learning. Thus, it is important to know the merits and demerits of e-learning. E-learning has advantages and disadvantages. Regarding the advantages of e-learning, we can consider following things.

E-learning reduces the learners' travel costs and time to and from school and they can study wherever they have access to a computer and Internet. It supports an adaptive learning to learners. That is, learners may have the option to select learning materials that meet their level of knowledge and interest and work at their own pace. In e-learning, different learning styles are addressed and facilitation of learning occurs through varied activities. In addition, it can improve the self-directed learning ability of learners. In other words, successfully completing online or computer-based courses builds self-knowledge and self-confidence and encourages learners to take responsibility for their learning [1, 4, 5].

The disadvantages of e-learning are as follows. The fact that a real person, to whom one might address questions and

comments, may not be available is a concern. The programs do offer assistance to any learner that needs it, but the type of help may not be as helpful to learners if they are used to one-on-one and face-to-face assistance. This may be a little frustrating. In addition, unmotivated learners or those with poor study habits may fall behind. That is, learners who lack the ability for self-directed learning may face difficult challenges. Furthermore, learners may feel isolated or miss social interaction. Interaction between learners and their peers as well as their instructors is a significant aspect of e-learning. Thus, social interaction seems to be the common denominator among strategies and practices aimed at retaining online learners. To enhance retention of online learners, there should be supports for forming a social network between learners [1, 2, 5].

2.2. Social Network for Learning. Learning is a social network relationship. It is a shared or common experience as colleagues explore a new area and attend classes and lectures together, thereby, gaining a similar view of subject areas. The importance of interpersonal interaction in learning is undoubted. Several learning theories put special emphasis on the effects of interpersonal interaction on learning outcomes [9]. For example, collaborative learning theory assumes that learning emerges through interactions of an individual with others [7]. Constructivism regards learning as a social process that takes place through communication with others. The learner actively constructs knowledge by formulating ideas into words, and these ideas are built upon the reactions and responses of others [10]. Learning communities also give learners the opportunity to meet both social and academic needs simultaneously. Tinto [3] stresses that social affiliations serve as a vehicle through which academic involvement is engaged. This emphasis on the importance of the support provided by peers is seconded by Kinnunen and Malmi [11], among others.

In e-learning based on a distributed learning environment, a social network plays a more important role in support of the learners' learning. Through strengthening connections and inspiring communications among the learners, the learning of the whole community is promoted. Wegerif [12] highlights the importance of the social side of learning when designing a course, more specifically in an asynchronous learning network. Studies of social networks show that a social network exerts its effect on learning processes and effectiveness [12–14].

2.3. Social Networks and Location Sensing Information-Based Social Services. The provisioning of services using location information is known as location-based services (LBSs). There are more and more location-based experiences occurring in our daily lives such as location-based information services, location-based games, and location-based ubiquitous learning [10]. Mobile positioning is a technology of LBS, which can obtain the location of the mobile devices and their users. Mobile users cannot only query their positions and request services based on their current locations but also receive the information that they would be interested

in according to their current position [7]. For example, a passerby can query the information of the nearest coffee shop based on his current location, and the coffee shop can also send an advertisement to a passerby who is within a certain age range and near the shop. Recently, one of the emerging research topics is to utilize the location-awareness of mobile devices to further strengthen mobile-learning. Chen and Tsai [10] proposed a personalized context-aware ubiquitous English vocabulary learning system which can exploit appropriate context-awareness based on a learner's location. Mobile social networking appears to the users as the result of combining a social network service with smart phones. In relation to mobile social networking, a few studies have been proposed. Liao et al. [15] proposed a GPS-data-driven social networking service where people can share life experiences and connect to each other with their location histories. Li and Du [9] proposed a dynamic social networking system which supports location-based services. The system enables the participants with a common interest to communicate and share information with others within a certain geographical range in a decentralized mode.

However, these studies have not considered an e-learning environment. In addition, they have not proposed a practical method of how to use a location-based social network service in a realistic situation. However, our study considers a location-based social network service that effectively supports e-learning. Our system provides a mechanism to form social networks among the learners who take the same online course. Accordingly, e-learners can create communities for learning and have face-to-face meetings for collaborative learning, based on the location information.

2.4. Ontology-Based User Modeling for Social Networks. There are several approaches to representing and storing a user model in a web-based service system [16]. The most obvious is the use of a relational database to store data about the user. Using a relational database offers good performance and several other advantages such as security and data recovery. However, user models of web-based information systems often contain semistructured data as they use an overlay model, which follows the representation of the information space with various characteristics defined for concepts from the domain model. Relational databases are not primarily designed to express semistructured data. Moreover, relational databases are not well suited when frequent changes in data structure need to be performed, which is often the case in user modeling.

Another frequently used approach in the current web-based adaptive systems is the representation of the user model by an XML-based language using the file system that results in sufficiently powerful expressiveness. Reusability and sharing is better than with the database approach, thanks to the platform independence of XML. However, XML as a meta-language defines only the general syntax without formally defined semantics, which leads to difficulties when reasoning.

As an alternative to the above approaches for user modeling, the ontology-based approach has emerged. The benefits

of using ontologies for user modeling and adaptation have been recognized by many researchers nowadays. The advantages leading to the use of ontologies for user modeling come from the fundamentals of this formalism. Ontologies provide a common understanding of the domain to facilitate the reuse and harmonization of different terminologies [17]. They support reasoning, which is considered an important contribution of the ontology-based models. Once user characteristics are in ontological representation, the ontology and its relations, conditions, and restrictions provide the basis for inferring additional user characteristics. For example, considering a user who is a programmer and works for a company that develops web-based applications using Java technologies, we can infer that she is skilled in Java technologies.

3. Adaptive System Supporting Collaborative Learning Based on Location-Based Social Network and Semantic User Modeling

3.1. Construction of Social Network Education Based on Location Information. E-learning is a more flexible and innovative way of learning. Recently, e-learning has become more popular. However, it is difficult to provide interaction services in real time. The existing e-learning methods only provide bulletins for sharing lectures or addressing the needs of study groups. They do not provide various methods for forming a community or a small group among the learners. In particular, it is inefficient compared with face-to-face offline meetings and discussions, and, thus, there exists limitations on collaborative learning.

For this purpose, in this paper, we will collect location-based information through the GPS sensor of a smart-phone. That is, it will support a method that can construct a social education network based on the collected location information of the learners. This method will inform a mobile learner of the current location or location logging information of other learners who are attending the same online course. Based on the location information provided to mobile learners, collaborative learning can be requested of other learners. If other learners in the vicinity are also attending the course, a learner may request to meet them at a specific place for discussion and collaborative learning. Figure 1 explains the basic concepts of this system.

In Figure 1, Learner A executes the online course application on a smart-phone. Learner A requests learning content from an e-learning server. The e-learning server generates additional information from the location information of Learner A and provides it together with the learning content.

The location of Learner A is tracked by the GPS sensing capability of the smart phone. The location information of Learner A is used to help him meet, at a specific place, other people who attend the same course if they are nearby. In this way, e-learning can be extended to face-to-face meetings. In other words, close social relationships between learners can be formed by using smart phones. Learner A sends a message requesting collaboration to the mobile-learning server for a person in the local area who can assist in the course. The

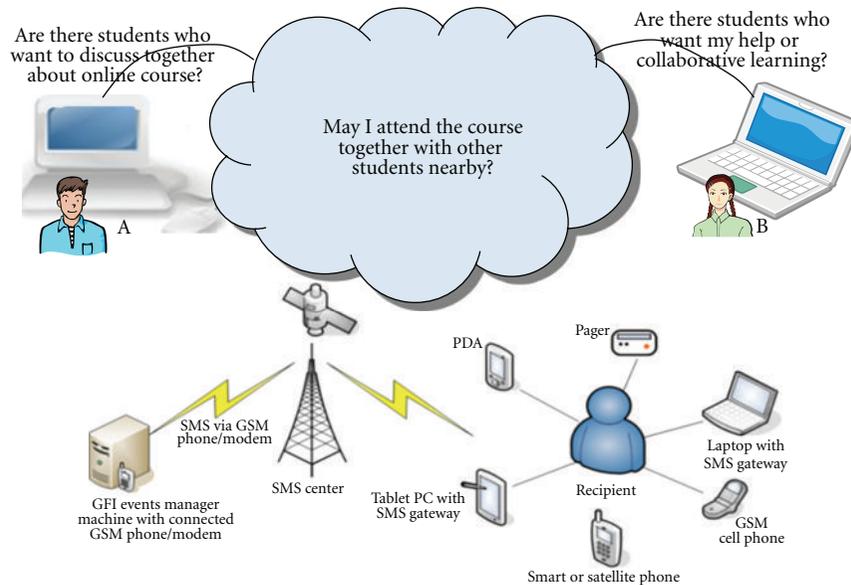


FIGURE 1: Construction of location-based social education network.

mobile-learning server sends the request message it received from Learner A to Learner B. It realizes a real-time social network by receiving a response to the request message.

However, for learning purposes, simply using the location information may not result in an optimal solution for the learning perspective. Therefore, the algorithm for constructing a social network requires further learning factors such as the learner's learning profile, learning style, and learning interests. The learner's learning style is considered an important constructing criterion. Learners with similar learning styles tend to have more interactions with one another during their learning experience. The constructing algorithm also considers a learner's learning interest as the learning criteria in addition to the learner's learning profile. These learning factors are related to user modeling information.

3.2. Semantic User Modeling. User modeling should be considered so as to form a social network for collaborative learning and to support adaptive learning. This study uses ontologies for user modeling that represents the characteristics of each learner. As mentioned in the previous section, the main reason for using ontology-based modeling is because it supports reasoning. The feature of reasoning is useful in providing personalized learning and collaborative learning depending on the learners' characteristics. Figure 2 shows the User Model ontology in the system provided in this study. It includes each learner's learning profile such as learning history, learning level, prerequisite knowledge, learning goals, learning time, and learning context, learning interest and learning style as shown in Figure 2. Learning context includes the operating system, terminal type, and network information for the learner's computer. Learning style is based on the four dimensions suggested by Kay and Lum

[17]. This ontology-based user modeling supports semantic searches as the ontology and its relations, conditions, and restrictions in ontological representation provide the basis for inferring additional user characteristics.

3.3. System Framework. This system supports both personalized learning and collaborative learning. Personalized learning provides adaptively learning content according to each learner's level of knowledge, preferences, and other considerations. Personalization is essential for improved learning experiences. The adaptive learning system we propose provides highly individualized learning content based on ontologies. In addition, the system provides collaborative learning among users. However, it is important for learners to be properly grouped for collaborative learning. That is, learners would need teammates who share the same interests, preferences, or learning experiences. Ontology-based user modeling is useful for grouping learners together in collaborative learning as well as in personalized learning. Finally, this system supports face-to-face collaborative learning based on location-based sensing information.

The architecture of the proposed ontology-based adaptive learning system consists of three main ontologies (Domain, Content Structure, and User Model ontology) and four modules (Learning Content Management, User Model Management, Adaptive Learning Support, Collaborative Learning Support, Location-based Information Management module) as shown in Figure 3.

3.3.1. Learning Content Management Module. The learning content management module manages the repository of learning objects. It inserts a new learning object into the repository or manipulates existing learning objects. Each

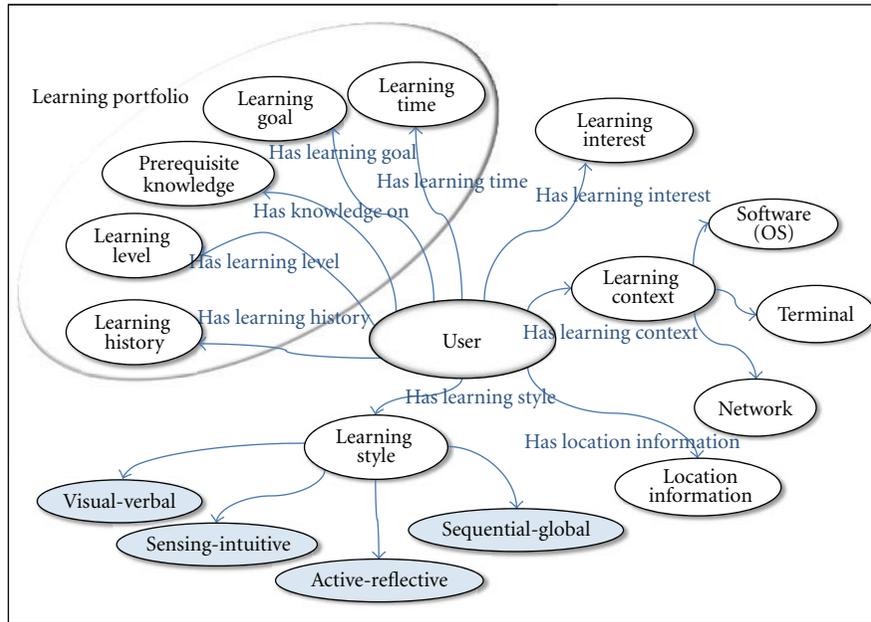


FIGURE 2: User model ontology.

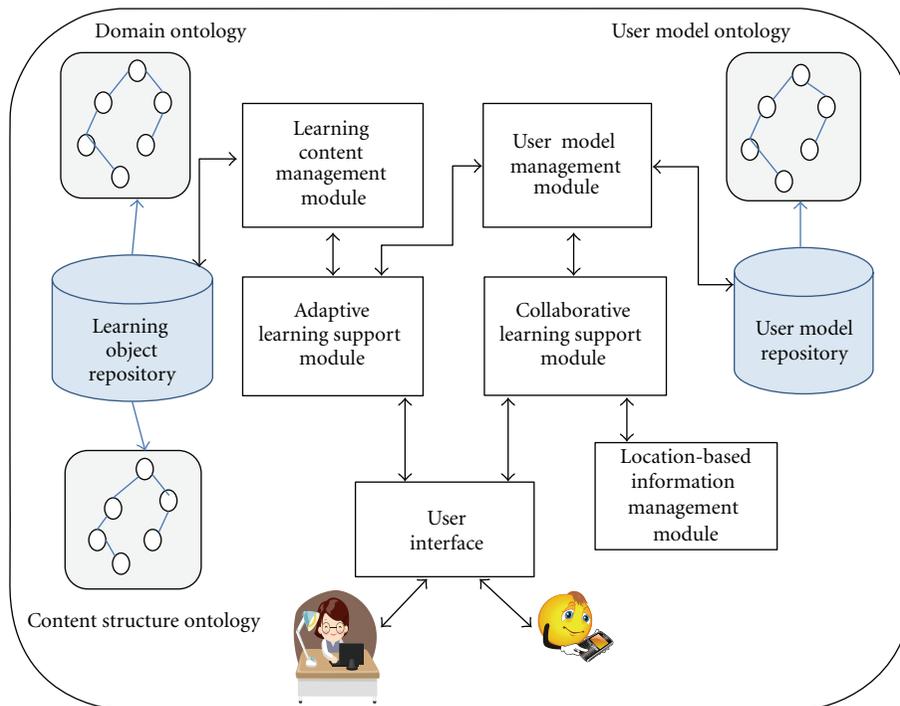


FIGURE 3: System architecture.

constructed learning object corresponds to each learning concept in the hierarchy of the content structure ontology. A parent object generally consists of a number of subchild concepts.

3.3.2. User Model Management Module. This module manages the repository of user models, responding to user

information requests such as inserting into, updating, or accessing the repository.

The learner model is required to provide learners with useful information and can be constructed from learners' learning portfolios. Therefore, the system needs a learner model to track and represent from the learner's learning status. The learner model contains the learning status of every

learning concept and the learning sequences for their goals. Consequently, the learner model can support personalized learning for a specific learner and collaborative learning for peer-consultation. The learner model mainly consists of the learning status of each concept, the learner's learning goal, and learning time. In capturing the learners' learning status for each concept, all clues are generated by analyzing the learners' online learning behaviors and testing the results. The learner's model is built with them.

3.3.3. Adaptive Learning Support Module. This module dynamically generates personalized learning content depending on each learner. In association with the User Model Management module, it diagnoses the knowledge level of a learner based on a questionnaire and learner test results. It also analyzes the learner's learning history, learning context, and learning style. Based on these acquired learner characteristics, it guides the learner's learning process using the most appropriate learning content. We have also defined some inference rules to support adaptive learning.

This module is responsible for presenting personalized learning content according to each learner's characteristics. The system presents adaptive learning content using link-hiding techniques. If it analyses a learner's learning level and considers certain learning content as inappropriate for a learner, the link to that learning content is hidden from the learner. For example, if a learner has not learned about or does not have a good understanding of a concept such as the "Fertilization of Animals," the links to "Internal Fertilization" and "External Fertilization" are hidden so that the learner cannot select those concepts.

3.3.4. Collaborative Learning Support Module. This module supports constructing a social network for collaboration according to the learners' information in User Model ontology. The constructing algorithm creates the learning group for the learners with similar learning profiles and learning interests to facilitate their learning in pursuing their learning objectives. This constructing algorithm refers to an online learning group. Sometimes, learners will want to have face-to-face collaborative learning offline. For this to occur, this module provides constructing location-based social networks with the support of Location-based Information Management module. The constructing algorithm for location-based social networks is learner centric in order to protect online mobile learners' privacy. A learner has to initialize the grouping request for collaborative learning. Otherwise, the learner's location and other data will not be used by the algorithm and shared with other learners. The learner who initialized the grouping request for collaborative learning can request face-to-face collaborative learning and contact other learners who are nearby.

3.3.5. Location-Based Information Management Module. The Location-based Information Management module receives the location information of the learners' smart-phone. The Location-based Information Management module collects the location information of the smart phone when there

is a request for learning content or collaborative learning from a user. It can generate location-based learning information based on the collected location information or location log. Location-based learning information includes the information concerning the area and location where the learning content is being used. For example, it includes the information concerning how many times the learning content is used in a specific place such as a café, restaurant, library, park, and classroom. In particular, it may include the information regarding the specific address of each location (latitude and longitude by GPS as well as information about the administrative district). If the learning content is used frequently in one location, it means that the location is likely to become an appropriate place in which to use the learning content. Therefore, through additional information based on location, the learner can use the learning content more conveniently by finding a place where the learning content is frequently used. Alternatively, the learner can attend the course at a specific place or check whether it is an appropriate place to study or take a quiz.

The system shares the location information of the smart phone of learners who are attending the same course and want to have collaborative learning offline. In this way, the location information of the learners' smart phone located within the preset distance from the learner's smart-phone who requests collaborative learning is searched for and the location-based additional information, including the searched location information, is generated. When there is a request for collaborative learning from a learner, the Location-based Information Management module searches other learners who are near the learner. When a response approving the collaboration request is received, the detailed location information of the requested user's smart phone is sent together with the response to the learner's smart-phone. Algorithm 1 shows the algorithm that executes this process.

The learner's smart-phone application provides real-time service of the received location-based learning information to the learner. The service is made in a social display form combining AR (Augmented Reality) and the location information. The learner selects, among the displayed locations of other learners' smart-phones, those learners with whom he wants to attend the course and those who can provide assistance in the course. To the selected people, a message requesting a learning collaboration, and so forth, is inputted to the learner's smart-phone. The learner of the smart-phone which received the collaboration request may send a response accepting the collaboration request to the system. The system sends the response to the collaboration request to the learner's smart-phone. If the response to the learning collaboration request is acceptance of the request, the system sends the detailed location information of the accepting smart-phone to the smart-phone of the learner. The locations of the learner can be easily recognizable on Google Maps (<http://maps.google.co.kr/>), Naver Map (<http://map.naver.com/>), or Daum Map (<http://local.daum.net/>). Therefore, a face-to-face meeting between an instructor and a learner who are nearby is possible. Furthermore, the additional information on the frequency of a learning collaboration or the frequency of learners visiting

```

/* c.Li DB: Course Learner/Instructor DB */
Get a Request_id
If (the Request_ID == Terminal_ID in course Learner/Instructor DB) then
    Get the Terminal_Location and Course_ID of Request_ID
EndIf
For each record in c.Li DB Where (record.Course_ID == Request_ID.Course_ID)
    Compute the Relative_Location of the Terminal_ID
    If (the Relative_Location <=  $\theta$ ) then
        Get the Terminal_IDs
    EndIf
EndFor
If {Terminal_IDs}  $\neq$  null then
    For each Terminal_IDs where (Relative_Location <=  $\theta$ )
        Send a request for social network to each Terminal_ID
    EndFor
EndIf
If  $\exists$ (acceptance signals for social network from the Terminal_IDs) then
    Send signals with detail location information to the Request_ID
EndIf
    
```

ALGORITHM 1: Location-based information management module’s execution algorithm.



FIGURE 4: The search display of learners and instructors with whom learning collaboration is possible.

a specific place (café, restaurant, library, park, bookstore, etc.) is shared. Learning collaboration helps form social relationships through twitter (<http://twitter.com/>), facebook (<http://www.facebook.com/>), me2day (<http://me2day.net/>), yozm (<http://yozm.daum.net/>), and so forth.

4. Service Scenario

Smart-phones can obtain a more-detailed context awareness in the mobile environment through sensors such as GPS, Bluetooth, Ambient light sensor, Approximate Sensor,

Accelerometer (gravity-sensor, Gyro sensor, CandleFrame, BobbleMonk, Punch Mach, Neon Board), Digital Compass (Magnetic Field Sensor), and WLAN.

The location information obtained by sensing is used to recommend the learners or the instructors located nearby the current location of the learner or to provide a social network service. Figure 4 displays the learners and the instructors located nearby on Naver Map (<http://map.naver.com/>). That is, Figure 4 is the display that searched for among the learners, other learners located within “100 m,” “50 m,” “1 km,” and so forth from the location of the current learner. The

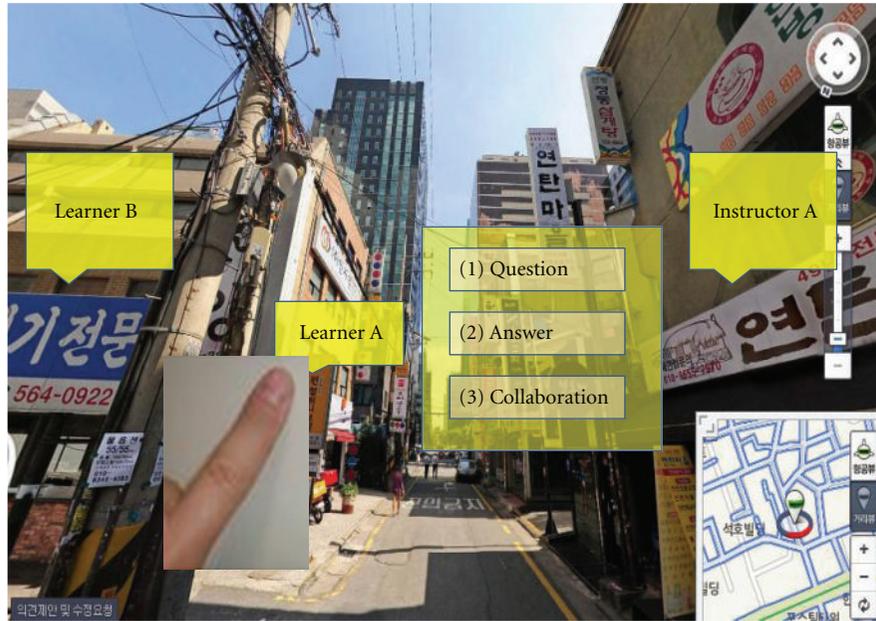


FIGURE 5: Augmented reality based on social learning and location information.

learner can suggest a learning collaboration to the nearby learners or the instructors displayed on the smart-phone. This makes it possible for the nearby learners and instructors to meet face-to-face for learning.

Figure 5 is the screen displaying the learner and the instructor on Naver Map (<http://map.naver.com/>) through Augmented Reality technology. A learner with a smart-phone can realize Augmented Reality through a camera module. By combing Naver Map and Augmented Reality technology, the service helps make it easy to find the learners or the instructors located nearby. Therefore, a social relationship based on location becomes possible. At the same time, it can be extended to social network services such as Facebook, Twitter, Me2day, and Yozm.

For learning in the mobile environment, location information can assist the learner in recommending the best colleagues or selecting the best place for learning from the actual location of the learner. Moreover, it helps in obtaining learning-related information on the Internet through social network services. A mobile learning process such as this naturally leads to meeting other friends face-to-face and solves the problem of isolation in online learning activities in virtual reality. In particular, location-based learning information helps make the learner's personalized learning possible in a context awareness environment.

5. Conclusions

Distribution of smart-phones provides a mobile learning environment. This paper proposes a method for combining the location-based information of smart-phones and e-learning, and realizing an e-learning support system based on location-based social network. The proposed system supports collaborative learning based on a location-based social

network and semantic modeling. That is, a social network among e-learning learners is dynamically constructed on the basis of the location information of the learner using GPS sensors thus enabling face-to-face collaborative learning. In addition, the system offers adaptive help and advice regarding the most effective and productive organization of learners in groups for collaborative learning. This is done so that the users' collaboration can be more efficient. Through this system, e-learners can find mentors who facilitate their learning and create communities for collaborative learning off-line and on-line. The support of a location-based social network service and semantic user model in our system would increase interactions among e-learners and improve satisfaction regarding their mobile learning environment.

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