Interactive Location-based Game for Supporting Effective English Learning

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Abstract—**Many non-English speaking countries regard English as the most important second language. Therefore, developing modern assisted-learning tools that can support effective English learning is a critical issue in the English-language education field. With the fast development of wireless positioning techniques, the location-based game has been considered as a novel type of game and it has high potential to support context-aware learning. Accordingly, this study proposes a novel game-based English learning system with context-aware interactive learning mechanism which can appropriately provide a corresponding game-based English learning scene to the learner's handheld device based on the learner's location context. The proposed system aims to construct a mixed reality game learning environment that integrates virtual objects with real scenes in a university library. The preliminary experimental results reveal that the proposed learning mode provides likely benefits in terms of promoting learners' learning interests, increasing learners' willing to learning English.**

Index Terms—***Wireless positioning technology, Context-aware English learning, Neural networks, Mixed reality game***

I. INTRODUCTION

Currently, there are more and more location-based experiences occurring in our daily lives, such as locations-based information services, location-based games, and location-based ubiquitous learning [1][2]. Taking the location-based information services as example, Maccoll *et al.* (2002) presented a system and infrastructure to allow local visitors to explore the physical space of the museum using handheld computers and the visitors can share a museum co-visiting experiences via either World Wide Web or 3-dimensional graphics [3]. Moreover, the location-based game "touch space" designed with mixed reality (MR) can make players have more fun while playing the game [4]. The savannah [5] is a strategy-based adventure game where a virtual space is mapped directly onto a real space. This game makes players explore the varied terrain of the savannah and discover the resources that lions need to survive. In the ubiquitous learning applications, our previous study proposed a personalized context-aware ubiquitous English vocabulary learning system [6] which can exploit appropriate context based on learners' location, leisure learning time, and individual abilities to adapt learning contents towards learners for promoting the learning interests and performance.

"The situational learning approach" [7] proposed that "context" is an important factor in the language learning process and it can enhance the learner's learning interest and effect. In other words, the meaningful knowledge is constructed only when learning process integrates with society culture and life-context. Dey [8] proposed four main types of contextual information including identify, time, activity, and location for building context-aware applications. Therefore, this study proposes a novel game-based English learning system with context-aware interactive learning mechanism for promoting English learning performance and interests. The proposed system makes use of existing WLAN infrastructure to carry out learner's location context detection, then provides a corresponding mixed reality game relating to English learning based on individual learner's location for learning English more funny.

II. LITERATURE SURVEY

A. Game-based Learning

Computer games are becoming a popular medium and an increasing number of educators are investigating their educational potential. Research in game-based learning emphasizes the natural learning process that happens within the

game. Games that encompass educational objectives and subject matter are believed to hold the potential to render learning of academic subjects more learner-centered, easier, more enjoyable, more interesting, and, thus, more effective [9][10]. Game-based learning are actually e-simulations of working situations, where 'game' usually mainly means interactivity, in which the learner is asked to develop strategies (marketing, communication or behavior strategies according to the context-based scenario) to reach a certain result [11]. Researchers have argued that playing computer games gives learners a ''mental workout''; that the structure of activities embedded in computer games (as opposed to the game content) develops a number of cognitive skills [12].

B. Situated Learning Theory

In the year since cognitive apprenticeship was first introduced, there has been extensive research toward developing learning environments that embody many of learning principles. Several well-known learning strategies have been developed; in particular, the situated learning. Dewey created a situated learning environment in his experimental school by asking students to design and build a clubhouse [13], a task that emphasizes arithmetic and planning skills. Besides, Driscoll [14] proposed general suggestions in accordance with the teaching for situated learning: (a) Teachers can supply complicated circumstances to cope with the authentic activities; (b) Teacher can supply the opportunities of social negotiation as a necessary part of learning; (c) Teachers can help students learn to think reflex; (d) Teachers can lay stress on student-centered instruction. Collins [15] also gives suggestions for teachers when developing methodology for situated learning. There are parts of the advices: (a) Students' learning attitude, skills, and knowledge should be acquired from real situations, so they can apply what they learn; (b) Lead students to self-examine and see if what they have done is effective; (e) Have students carry out tasks and reflections on a constant basis so that they can strive for perfection. Thus, this study devotes to offer a real participation in a library environment as well as develop a novel game-based English learning system with context-aware interactive learning mechanism to promote learners who can self-examine and learn more English language skills in the daily life.

III. System Design

A. System Architecture

The proposed system aims at enhancing learners' impression and interests of learning English and increasing the performance of English learning based on the situational learning approach [7] supported by WLAN positioning techniques. Figure 1 shows the system architecture of the proposed game-based English learning system with context-aware interactive learning mechanism. As a learner logs in the proposed system, the system will provide some clues that learners must identify via English listening comprehension ability to understand where he/she should go to proceed the location game based English learning. After that, the locating detecting agent detects the learner's location based on the WLAN positioning techniques in a schoolyard environment, such as library, sport ground, and restaurant, etc. According to the learner's location, the game agent provides a suitable mixed reality game to the individual learner for English learning.

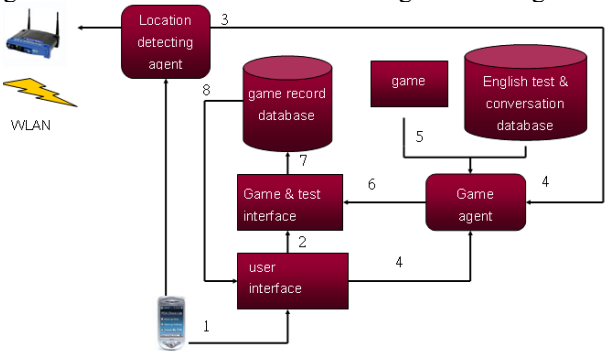


Figure 1. The system architecture of the proposed game-based English learning system with context-aware interactive learning mechanism

B. Learner Location Detection Techniques

This study employed the indoor WLAN positioning techniques to develop positioning scheme for location game based English learning because WLAN has been widely installed in most public or school environments.

1. Experimental Environment

The game scene is established on the first floor of the National Taiwan Normal University (NTNU) Library. The layout of this floor is shown as Fig. 2. Four access points were installed at this floor and learners use PDA with wireless access functionality as mobile device for location game based English learning. This floor is partitioned into six learning blocks and coded from 0000 to 0201. The signal strengths of four APs were adopted as features for WLAN positioning.

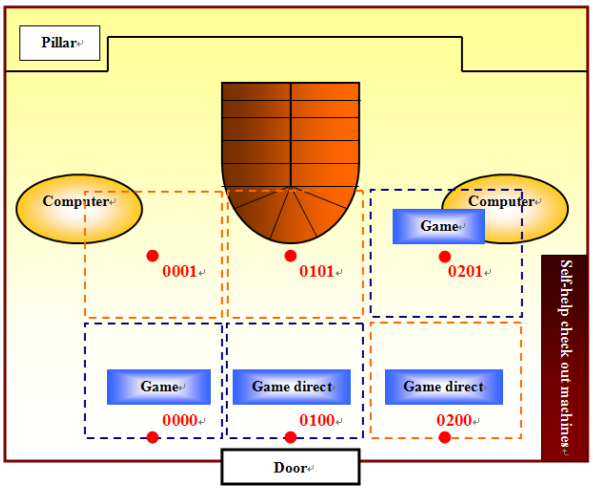


Figure 2. Six planning locations for English learning in the NTNU library

2. Wireless Positioning Technology

Detecting the location context is an important function in this study. After analyzing the advantages and disadvantages of several positioning techniques and considering the limitations of real world environments, this study employed the neural-network-based WLAN positioning technique to develop a positioning service based on the wireless network existing in a schoolyard because WLAN has been widely installed in most schoolyards to provide wireless Internet services. Compared with the RFID, infrared and ultrasound positioning techniques [16], WLAN has the lowest positioning infrastructure costs. Furthermore, this study employed a back-propagation neural network, a machine learning technique, to induce the mapping relationships of the collected signal strength information with learner location. Subsequently, the trained back-prorogation neural networks were used to predict learner positions in accordance with the positioning inducing knowledge. The following subsections introduce the employed back-propagation neural networks and their applications. Moreover, the procedures used to detect learner location are detailed.

3. The Employed Back-Propagation Neural Networks

The BP neural network is used to construct a classification model for mapping signal strength features into corresponding locations in this study. A BP neural network is a supervised learning model and it contains the learning phase and recall phase. In the learning phase, the BP neural network learns how to map the input data to the output data and determines the weights of connected neural nodes. Then the weights are used to compute the output of new coming data for the purpose of prediction in the recall phase. Figure 3 shows the architecture of the used neural network with single hidden layer. The signal strength of each AP is served as the input and the outputs represent the corresponding locations.

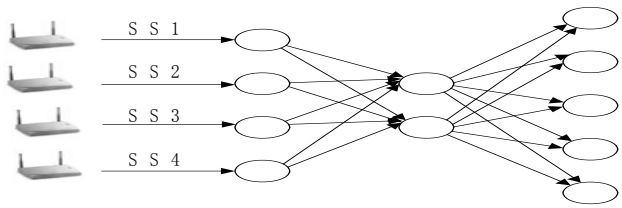


Figure 1. The learning architecture of the employed BP neural network with single hidden layer

4. Filtering Noisy Training Data

In this study, the first floor of National Taiwan Normal University (NTNU) Library is divided into six areas and 200 records of signal strengths are sampled from each area. Hence, there are totally 1200 records of signal features collected and applied as training data for training the applied back-propagation neural networks. However, for some reasons such as multi-path, and refraction, the signal therefore generates irregular fluctuation and becomes as noisy data. Therefore, it is essential to apply noisy data filtering mechanism to eliminate noisy training data. Once the better training data is generated after filtering out noisy data, the learning effect of neural network can be obviously promoted.

The noisy data filtering mechanism proposed in this study is based on the concepts of mean and bias in the statistics analysis. The steps of filtering out training data are elaborated as follows:

Step 1. Computing the mean $\{M_1, M_2, M_3, M_4\}$ of all signal feature vectors $\{SS_1, SS_2, SS_3, SS_4\}$ in each area.

Step 2. Computing the bias of each data record against the mean according to the following formula and denoted as $\{K_1, K_2, K_3, K_4\}$:

$$K_i = \frac{SS_i - M_i}{M_i} \quad (1)$$

Step 3. Normalizing the bias $\{K_1, K_2, K_3, K_4\}$ of each data record into $\{F_1, F_2, F_3, F_4\}$ based on the following formula:

$$F_i = \frac{1}{K_i^{\,2} + 1} \quad (2)$$

To obtain qualified training data, the threshold of F_i is set to 0.85 in this study. The record that all values in vector $\{F_1, F_2, F_3, F_4\}$ are greater than or equal to 0.85 will then be preserved as training data, the others are filtered out.

5. Location Detection

This study utilizes indoor WLAN to estimate learner location. By measuring the signal strengths emitted by each AP, the location is used to infer learner context. The location detection involves two stages, as described below:

- **The first stage (off-line phase)**

To establish the radio map database, plenty of signal strength samples were gathered to construct a neural network classifier model for inferring signal strengths into corresponding geographic locations. Each record represents the signal strength values emitted from *n* APs and their corresponding locations, and can be stored using the following format: $\{SS_1, SS_2, SS_3, SS_4, \ldots, SS_n, Location\}$. During the data collection, some locations may have weak or even no signals because of long distances between the mobile side and the APs, or blocks of walls. Since the signal strength ranged from –30 dBm to –100 dBm, the signal strength value was assigned to –100 dBm for the location where no signal strength was detected.

- **The second stage (on-line phase)**

The back-propagation neural network model established during the first stage is implemented and installed on the learner mobile side (PDA). When a learner initiates the positioning service, the trained neural network model implemented in the learner locating agent immediately identifies the location of the learner according to the signal features detected by the learner's mobile device.

C. The Mixed Reality Game Design

In order to make learners to feel like in the real environment while playing the location-based game for English learning by handheld devices, the game backdrop must be dynamically changed according to the learner's movements. The study adopted NTNU library as learning scene for designing location game based English learning system. The English learning contents integrated with the developed game include English dialogue for mission hint, key vocabularies for vocabulary learning, and a final test related to the learning contents for assessing the learning performance. In this game, learners will be assigned a mission for finding out a specified book in the NTNU library through location-based game interaction processes. In the location-based game interaction processes, learners' English listening comprehension and vocabulary abilities can be enhanced via achieving the assigned game mission.

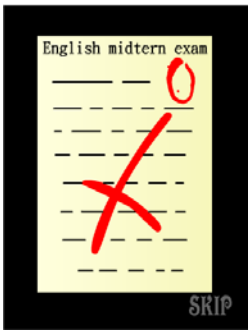
In order to enhance the long-term memory of English learning, the designed game provides a summative test at the end of the game learning process. The learner is asked to recognize the English vocabularies that appear in the game learning processes through the multiple-choice tests. In the summative test, each multiple-choice question contains four vocabularies, and the learner has to identify the wrong one. The system also provides right answers for the incorrect testing responses, thus unfamiliar vocabularies can be enhanced.

IV. THE IMPLEMENTED SYSTEM PROTOTYPE ON PDA

Figure 4(a) shows the user interface of the proposed game-based English learning system with context-aware interactive learning mechanism. At the beginning, learners are asked to input legal accounts for identifying their identifications. Figure 4(b) shows the welcome information after a learner logins. Next, the game mission shown as Fig. 4(c) is presented to individual learners. Fig 4(d) shows the hint information for guiding learners to conduct learning in library. After learners go to the library, the system will detect the learners' locations and switch game procedure to the corresponding backdrop. Figures 4(e) and 4(f) show the proposed system switches the game procedures to the corresponding learning backdrops according to the learner's position, respectively. Figure 4(g) shows that the avatar asks learner to find out an assigned book which lies in the library. The learner must find the card catalogue to know which floor the book is located by computer in the library. In this work, the system will guide the learner to move to the right position where the computer is located. Figure 4(h) shows the hint message for guiding learner to move to the right direction. Then, Fig. 4(i) shows the hint message for guiding the learner to go forward for the right computer location. Figure 4(j) shows the avatar gives the learner a special weapon as a reward after the learner inputs the right card catalogue. Finally, the final test is performed to evaluate the learning outcomes of individual learners. Figure 4(k) shows the final test message. Figure 4(l) shows that the monster is attacked by a weapon if the learner gives the right answer in the final test; otherwise, the learner will be punished by the monster if he/she replies incorrect testing answer. Figure 4(m) shows that the learner is punished while he/she gives wrong answer in the final test After performing the final test, the proposed system will displays a hint clue shown as Fig. 4(n) for guiding learner to the next learning location for another learning mission.

(a) The user login interface

(b) The welcome information after learners login



(c) The learning mission description for the designed game

(d) The hint information for guiding learners to the learning location "library"

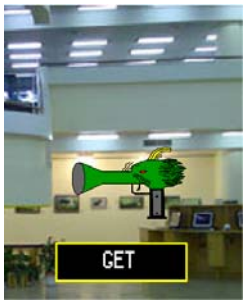
(e) The corresponding learning backdrop for the coded learning position "0100"

(f) The corresponding learning backdrop for the coded learning position "0000"

(g) Game mission descriptions that learner must understand by English listening comprehension ability for finding out an assigned book in the NTNU library

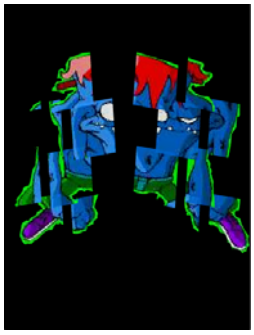
(h) The hint message for guiding learner move to the right direction where the computer is located for searching assigned book

(i) The hint message for guiding learner go forward where the computer is located for searching assigned book



(j) Getting the weapon as the reward due to good learning performance

(k) The final test message



(l) Punishing monster while learner gives right answer in the final test

(m) Punishing learner while learner gives wrong answer in the final test

(n) The hint clue for guiding learner to the next learning location

Figure 4. The implemented game-based English learning system with context-aware interactive learning mechanism

V. EXPERIMENTS

A.. The Accuracy Rate of WLAN Positioning

The trained back-propagation neural network model for WLAN positioning in the National Taiwan Normal University Library is implemented on the PDA device. The experiment of WLAN positioning was conducted three

times under different environment conditions and the experimental results are listed in Table I. The testing accuracy rates of WLAN positioning are 71.72%, 74.83%, and 88.34% under three different conditions, respectively. The accuracy rate of the first time experiment is the lowest one among three experiments because a lot of people were being in the library while conducting this experiment. This condition influences the accuracy rate of WLAN positioning. By contrast, the third experiment result obtains the highest accuracy rate since the installed locations of four APs were appropriately adjusted and few people were being in the library while conducting this experiment. Based on the experimental results mentioned-above, we found environment factors influence the accuracy rate of WLAN positioning. Therefore, how to improve the accuracy rate of the employed WLAN positioning scheme for supporting location game based English learning should be further investigated.

TABLE I.
THE ACCURACY RATES OF WLAN POSITIONING

Experiment	Accuracy rate
1	71.72%
2	74.83%
3	88.34%

B. The Questionnaire Investigation From Learners

To evaluate the learner satisfactory degree while using the proposed system for English learning, ten graduate students from the department of Industrial Education of National Taiwan Normal University were invited to test the system, then these students were invited to fill out a questionnaire listed in Table II. These ten students include six males and four females, and the average age is 21 years old. The average year of learning English is 6.25.

The questionnaire involves five question types including satisfactory degree, easy-to-use, entertainment level of the game, English learning effect and intention. Each question type is consisted of three to four questions. In terms of the satisfactory degree, 90% students agreed that the proposed system is helpful to English learning. Moreover, 80% students thought the proposed system is easy to use and the game procedure is affluent for English learning. Additionally, the remaining 20% students encounter some problems including the wrong presentation of the backdrops due to the incorrect positioning results, and lack of the experiences of using pocket PC. In addition, 90% students thought the proposed system for English learning is fun and 80% students thought the context-aware interactive learning mechanism in the proposed system can promote learning effects while learning English. Finally, the questionnaire also asked the students whether they have willing to keep on using this system for English learning and recommend the others to use this system. This study found that 90% students agreed this question. Overall, most students agreed that the proposed game-based English learning system with context-aware interactive learning mechanism is a useful learning tool for promoting the performance and interests of English learning.

TABLE II.
THE QUESTIONNAIRE RESULT FROM TEN GRADUATE STUDENTS OF NTNU

Question Type	Agree	Disagree & others
Satisfactory degree for English learning	90%	10%
Easy-to-use	80%	20%
Entertainment of the game	90%	10%
English learning effect	80%	20%
Intention	90%	10%

VI. CONCLUSION AND FUTURE WORK

In this study, the indoor WLAN positioning scheme based on back-propagation neural networks was developed for supporting the proposed location game based English learning system. The testing accuracy rate of the employed WLAN positioning scheme is up to 88.34% and this accuracy rate is enough to provide correct location context for the proposed system. According to our preliminary experiments, the proposed game-based English learning system with context-aware interactive learning mechanism can promote learners' interests and increase their learning motivations. Besides, our preliminary experimental results also reveal that learning English based on learners' location contexts has high potential to enhance long-term memory of the acquired vocabularies. Therefore, the proposed system is not only a novel learning mode for English learning, but also provides benefit in terms of increasing the worth of playing game.

REFERENCES

[1] Benford, S., Rowland, D., Flintham, M., Drozd, A., Hull, R., Reid, J., Morrison, J., Facer, K. "Life on the edge: supporting collaboration in location-based experiences," Proceedings of ACM CHI 2005 Conference on Human Factors in Computing Systems, Portland, 721-730, 2005.

[2] Hwang, G. J. "Criteria and strategies of ubiquitous learning," *Proceedings of the IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing*, vol. 2, 72-77, 2006.

[3] MacColl, I., Millard, D., Randell, C., & Steed, A. " Shared visiting in EQUATOR city," *Proceedings of the ACM Conference on Collaborative Virtual Environments*, 88-94, 2002.

[4] Cheok, A. D., Yang, X., Ying, Z. Z., Billinghurst, M. & Kato, H. "Touch-space: mixed reality game space based on ubiquitous, tangible, and social computing," *Journal of Personal and Ubiquitous Computing*, 430-442, 2002.

[5] Facer, K., Joiner. R., Stanton, D., Reid, J., Hull, R. & Kirk, D. "Savannah: mobile gaming and learning," *Journal of Computer Assisted Learning*, vol. 20, no. 6, 399-409, 2004.

[6] Chen, C. M., Li, Y. L. & Chen, M. C. "Personalized context-aware ubiquitous learning system for supporting effectively

English vocabulary learning," *IEEE International Conference on Advanced Learning Technologies*, 628-630, 2007.
[7] Hornby, A. S. "The situational approach in language teaching (I)(II)(III)," ELT Journal, vol. 4, 98-104, 121-8, 150-6, 1950.
[8] Dey A. K., *Providing Architectural Support for Building Context-Aware Applications*. Unpublished PhD Thesis, Georgia Institute of Technology, 2000.
[9] Papastergiou, Marina "Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation," *Computers & Education*, vol. 52, 1-12, 2009.
[10] Freitas, Sara de & Griffiths, Mark "Online gaming as an educational tool in learning and training," *British Journal of Educational Technology*, vol. 38, no. 3, 535-537, 2007.
[11] Pannese, Lucia & Carlesi, Maria "Games and learning come together to maximise effectiveness: The challenge of bridging the gap," *British Journal of Educational Technology*, vol. 38, no. 3, 438-454, 2007.
[12] Robertson, Judy & Howells, Cathrin "Computer game design: Opportunities for successful learning," *Computers & Education*, vol. 50, 559-578, 2008.
[13] Naiman, N., Frohlich, M., Stern, H. H., & Todesco, A., *The good language learner*. Toronto: Ontario Institute for Studies in Education, 1978.
[14] Driscoll, M.P., *Psychology of learning for instruction. Needham Heights*. MA: Allyn & Bacon Press, 1999.
[15] Collins, A., Goal-based scenarios and the problem of situated learning: a commentary on Andersen, 1994.
[16] Kupper, A., *Location-based services: fundamentals and operation*. John Wiley, 2005.