Research on Adaptive Mobile Collaborative Learning System

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Abstract. Adaptive learning system supports more personalized learning and improves learning outcome. Mobile learning gives learners new learning mode that learners can learn in anywhere and at any time. People can easily achieve success by collaborative learning. So this paper proposes a common model of adaptive mobile collaborative learning system (AMCLS). The AMCLS has six parts which are Learner Model, Collaborative Learning Model, Domain Model, Adaptive Recommend Model based on Context-Aware, Evaluation Model and Presentation Model. The AMCLS can provide the appropriate learning contents and learning paths to learners according to their characteristics, learning context-aware, devices, time and location. Besides, it also provides better collaborative learning mode to help learners to accomplish their collaborative learning more efficiently.

Keywords: Adaptive learning system · Mobile learning · Collaborative learning system

1 Introduction

The core of E-Learning is the construction of Online learning system, but currently, there are some problems of these Online learning system: (1) the learning resource of these systems provided to all learners are the same. That mean these systems cannot provide personal and intelligent service to learner according to his personality and his real demand, (2) learner easily feels exhausted and alone because these systems haven't better interactive function to support the communication between teachers and students, as well as between students and students, (3) these systems don't support mobile learning so that these system can't meet the demand the learner who wants to learn in anywhere, at any time. For these reasons, the utilization of these Online learning system is lower and even most systems are free.

Adaptive learning is thought as "the learning process provides each learner a unique learning experience according to learner's personalities so that the learner can get higher learning achievements, learning satisfaction, learning effectiveness and so on." [1, 2]. Mobile learning is a fashion and newer learning mode, which is called as "learners can study through content and social interactions by using several different kinds of mobile electronic devices" [3]. That means learners can learn by the use of mobile devices in anywhere and at any time [4]. Collaborative learning is that two or more learners come

B. Zou et al. (Eds.): ICPCSEE 2017, Part II, CCIS 728, pp. 414–423, 2017.
DOI: 10.1007/978-981-10-6388-6_34

together to be groups to study [5]. Collaborative learning is not same as individual learning, learners engaged in collaborative learning capitalize on one another resources and skills (asking one another for information, evaluating one another ideas, monitoring one another work, etc.) [6]. Therefor the research is meaningful that combine adaptive learning and mobile learning, as well as collaborative learning to construct adaptive mobile collaborative learning system (AMCLS) to realize learner's personalized, collaborative and mobile learning more effectively.

2 Related Work

The development of Adaptive Mobile Collaborative Learning System is based on the construction of system mode. Actually, there were many Adaptive Learning System (ALS) mode developed for various purposes of education. Adaptive Hypermedia Architecture (AHA) is a Web-based adaptive hypermedia system, which can support on-line courses with different adaptive features, such as conditional explanations and links [7]. The AHA consists out of three models: user model, domain model, adaptive model. The user model represents the users' knowledge and preferences. The domain model defines the aspects of the application which can be adapted or which are otherwise required for the operation of the adaptive system. The adaptive model contains all rules which are concerned with the relationships which exist between the representation of the users (the user model) and the representation of the application (the domain model) [8]. Henze and Nejdl introduced a logical characterization for the definition of adaptive educational hypermedia systems (AEHS) as a quadruple (DOCS, UM, OBS, AC): DOCS (Document Space) describes documents and knowledge topics; UM (User Model) stores, describes, and infers individual user's information, knowledge, preferences; OBS (Observations) observes individual user's knowledge state and interactions with the system for updating UM; AC (Adaptation Component) contains rules for the describing the adaptive functionality of the system.

The research of adaptive mobile learning system (AMLS) began in 2009. Researchers did their AMLS mostly with the views of location-based [9], content adaptive and device adaptive [10], Ontology-based, furthermore, only small number of developed system were just apply in English course learning. Actually, there are some problems needed to do further research, such as how to construct and present mobile learning content according to the characteristics of a variety of different device, how to acquire learner' learning context-aware efficiently, how to improve mobile user's experience, etc.

Collaborative Networked Learning is stated as "Collaborative Networked Learning (CNL) is that learning which occurs via electronic dialogue between self-directed co-learners and learners and experts. Learners share a common purpose, depend upon each other and are accountable to each other for their success. CNL occurs in interactive groups in which participants actively communicate and negotiation meaning with one another within a contextual framework which may be facilitated by an online coach, mentor or group leader." [11]. Due to the numerous technological resources available to students and tutors, collaborative learning is usually supported by computers in what is known as computer supported collaborative learning (CSCL). One of

the main challenges when designing a learning experience with collaboration is that of structuring the overall learning process as to trigger productive argumentation among students.

3 Adaptive Mobile Collaborative Learning System Model

According to the characters of ALS, M-learning and CNL, this paper proposes a structure of Adaptive Mobile Collaborative Learning System (AMCLS) is shown in Fig. 1. The model contains 6 parts, namely Learner Model, Collaborative Learning Model, Domain Model, Adaptive Recommend Model Based on Context-Aware, Evaluation Model and Presentation Model.

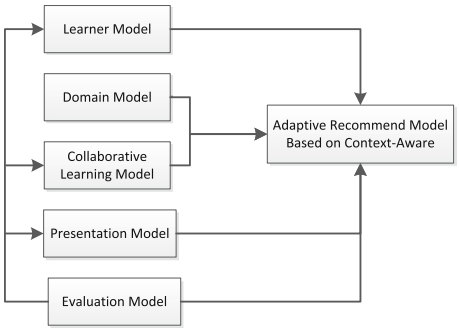

Fig. 1. Structure of adaptive mobile collaborative learning system

3.1 Learner Model

The Learner model which is the most important component of AMCLS as it stores all the information about the learner determines the accuracy and reliability of the penalization implementation. The Learner Model (LM) mainly describes learner's characteristics, such as learning style, cognitive level, interesting, automotive and collaborative learning abilities, and etc. In addition, a learner behavior diagnostic model should be instructed which can modify LM dynamically by detecting individual learning status, collaborative learning status, and knowledge mastering situation etc. The LM structure is shown in Fig. 2.

Among those factors, learning styles has been recognized by researchers as being important factors [12]. Learning styles help learners understand their own strengths for more efficient learning. Keefe indicated that learning style is both a characteristic which indicates how a student learns and likes to learn, as well as an instructional strategy informing the cognition, context and content of learning. Previous studies have reported that

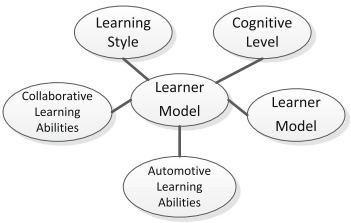

Fig. 2. LM structure

students' learning performance could be improved if proper learning style dimensions could be taken into consideration when developing adaptive learning systems [13, 14].

This study combines the explicit access with implicit access to estimate learner's learning style. Firstly, using learning style questionnaire for get learning style explicitly, meanwhile initializing learning style model, and then amend and improve the learning style model constantly by digging Netware learning behaviors with Bayesian Network (BN) so that the estimate learning style is most similar learner's real learning style.

(1) **Explicit access method**

There are several different learning style models including Kolb, Honey and Mumford, and Felder and Silverman [16]. Among these various learning styles, the Felder–Silverman Learning Style Model (FSLSM) developed by Felder and Soloman [17] have been recognized by many researchers as being a highly suitable model for developing adaptive learning systems [15]. The FSLSM contains the Index of Learning Style (ILS) questionnaire for evaluating learning styles. There are four dimensions in FSLSM and each learner is characterized by a specific preference for each of these dimensions: sensitive/intuitive dimension (how information is processed), active/reflective dimension (how information is presented), visual/verbal dimension (how information is input), and sequential/global dimension (how information is understood), [16] (see Table 1). Therefore, this study utilizes the FSLSM to investigate learning style explicitly.

Table 1. Felder-Silverman learning dimension and learner characteristics

Learning dimension	Learner characteristics	
Processing	Active: Retain and understand information best by doing something active with it such as discussing it, applying it, or explaining it to others	Reflective: Prefer observation rather than active experimentation. Tend to think about information quietly first
Perception	Sensor: Like learning factors, often like solving problems by well-established methods and dislike complications and surprises. Patient with details and good at memorizing facts and doing hands-on work. More practical and careful than intuitors	Intuitive: Prefer discovering possibilities and relationships. Like innovation and dislike repetition. Better at grasping new concepts and comfortable with abstractions and mathematical formulations. Tend to work faster and more innovative than sensors
Input	Visual: Remember best what they sees from visual representations such as graphs, chart, pictures and diagrams	Verbal: More comfortable with verbal information such as written texts or lectures

In order to detect both the preference and the degree of preference of learners for each dimension, the Index of Learning Styles (ILS) has been developed by Felder and Soloman [17]. ILS is a 44 item questionnaire aimed at identifying the learning styles according to FSLSM.

(2) **Implicit access method**

After obtain the basic learning style by FSLSM, we will use Bayesian networks (BNs) to represent and detect students' learning styles according to their behaviors in the adaptive learning system. A BN is a compact, expressive representation of uncertain relationships among parameters in a domain. A BN is a directed a cyclic graph where nodes represent random variables and arcs represent probabilistic correlation between variables [18]. Figure 3 is a BN model which describes the learning style.

We model the four dimensions of Felder's framework according to Fig. 1. Each dimension with a variable in the BN will be modeled. The values these variables can take are sensory/intuitive, active/reflective, visual/verbal, and sequential/global respectively.

Bayes' theorem is the mathematical model underlying BN. Bayes' theorem is shown in Eq. (1), which relates conditional and marginal probabilities. Bayes' theorem yields the conditional probability distribution of a random variable A. Assuming we know information about another variable B in terms of the conditional probability distribution of B given A, and the marginal probability distribution of A alone. Equation (1) reads: the probability of A given B equals the probability of B given A times the probability of A, divided by the probability of B.

$$P(A/B) = \frac{P(B/A)P(A)}{P(B)} \tag{1}$$

Bayesian network can be noted by B = <G, θ> which represents the joint probability distribution on a random variable set $X = \{X_1, X_2, \ldots, X_n\}$, where G denotes a directional graph with no cycles with its nodes to be random variables (e.g. Xi as random variable and $\prod_i$ as respective parent variable). Bayesian network is structured

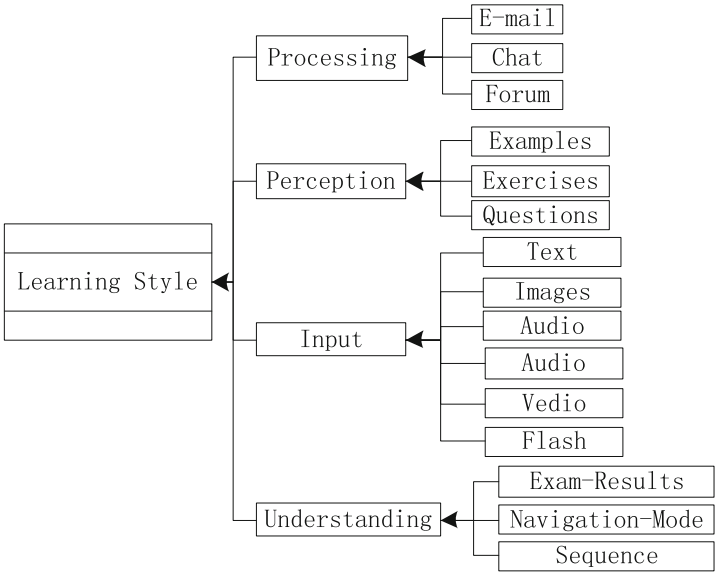

Fig. 3. BN model which describes learner's learning style

according to Markov independence equations. Set of variables which define the conditional probability distribution $P(X_i|\prod_i)$ for each random variable X_i is denoted by θ assuming that the variable has a parent variable $\prod_i$. Joint probability distribution of the variable X is defined by network structure which identifies the conditional independence of X and the set P which is the local probability distribution for each variable. Absence of an edge between two nodes indicates the conditional independence. Having the network structure the joint probability distribution can be written as follows:

$$P(x_1, x_2, \ldots, x_n) = \prod_{i=1}^{n} P(x_i \Pi_i) \tag{2}$$

where, for each variable xi, $\prod_i\{x_1, x_2, \ldots, x_{n-1}\}$ is a set of variables of which xi is conditionally dependent.

Therefore we construct a BN model by building a directed a cyclic graph that encodes assertions of conditional independence. We can induce the joint probability distribution of K by utilizing the chain rule of probability as follows by giving a domain $K = \{K_1, K_2, \ldots, K_n\}$ and an ordering on the variables $(K_1, \ldots, K_n)$,

$$P(k_1, \ldots, k_{n/\varepsilon}) = \prod_{i=1}^{n} P(k_i/v_1, \ldots, k_{i-1,\varepsilon}) \tag{3}$$

where, for every K_i, there will be some subset $\Pi_i \subseteq \{K_1, \ldots, K_n\}$ such that K_i and $\{K_1, \ldots, K_n\}$ are conditionally independent given Π_i. That is,

$$P(k_i/k_1, \ldots, k_{i-1,\varepsilon}) = P(v_i/\Pi_{i,\varepsilon}) \tag{4}$$

3.2 Collaborative Learning Model

Collaborative Learning Model (CLM) can recommend some learners with similar learning characteristics to learners according to social network analysis method (SNA) and the learner model, and on this basis, constructing effective collaborative learning commodity. CLM also contains some collaborative learning methods and algorithm to help students collaborate more effectively with their peers, maximizing individual student and group learning. Figure 4 is the collaborative learning model.

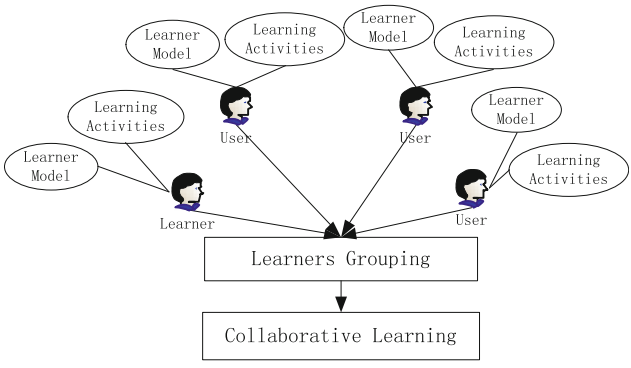

Fig. 4. Collaborative learning model

3.3 Domain Model

We mainly combines Ontology and Topic Maps technology, as well as some classic knowledge model such as Dublin Core, IEEE LOM, CELTS-3, to Constructing domain model according to ultra-brief characteristic of mobile learning material. There are two steps to accomplish the construction of Domain Model:

(1) Building ontology library based on domain knowledge. Domain ontology library can provide normalized annotated words and reference standard which is used to mark documents base on ontology,
(2) Accomplish Semantic annotation of documents with Topic Maps standards and construct document logic view, then save these information into Topic Maps annotation library with XTM format which is convenient to build link relationship between concept semantic and document resource on indexing.

3.4 Adaptive Recommend Model Based on Context-Aware

The function of adaptive recommend model based on Context (ARMBC) is recommend appropriate learning content and learning path to learner on the basis of LM and context-aware. The context is stated as the time, the location, the circumstances and the device. The time contains two parameters which are real date-time and learning progress. The location indicates the learner's geographic location. The location-awareness of the AMCLS can be employed to sense the current geographic location of the mobile learner who processes the mobile device being used to conduct mobile learning. So the location-based learning contents can be implemented to enhance the contextual interaction for learners in a mobile learning environment. Location-based learning contents are those learning objects that are tied with particular locations. When a mobile learner is physically at or near a particular location, the learner could be assigned to conduct location-based learning activities. The circumstances contain some information such as noise, seat, climate, space, light, etc. The device contains the display performance, storage performance, bandwidth, operating system, etc. The Adaptive Recommend Model Based on Context-Aware is showed in Fig. 5.

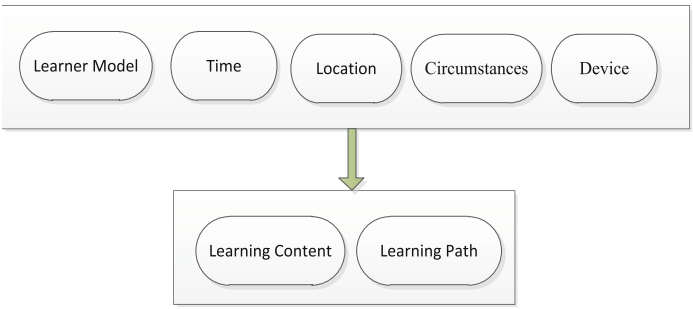

Fig. 5. Adaptive recommend model based on context-aware

According to Fig. 4, Adaptive Recommend Model Based on Context-Aware Adaptation Mechanism is represented in Eq. (5),

$$R(LC(i), LP(i)) = S(LM(i), T(i), L(i), C(i), D(i)) \tag{5}$$

where S is the mathematical representation, R(LC(i), LP(i)) is the output of the ARMBC adaptation mechanism representing the appropriate learning contents and appropriate Learning path. LM(i) is the Learning Model, T(i) is the input representing the time constrains, L(i) is the input representing the location constrains, C(i) is the circumstances, D(i) is the mobile device constrains.

3.5 Presentation Model

The presentation model contains a transformation engine which can transform the learning resource learner request into proper format and then sent them to learner's mobile terminal according to characteristics of heterogeneous devices and the circumstance of the network. That mean this process can shield the difference of terminal equipment and the complexity of the he environment and reduce the external interference factors on the pan in the study. In order to accomplish the target, we considered 5 factors: (1) adaption of media size and file size: the differences of terminal screens will induce the difference of the media size and file size appropriate to the devices. For example, the proper image size of hand-phone is 25 * 25 pixels, while the proper image size of PAD might be 120 * 120 pixels. (2) Layout adaption of learning resources. Layout mainly is decided by two elements: screen size and distinguishability. The layout mode of the same resources will be different with several different size of screen. (3) Network adaption: the request come from terminal will be sent to server through network and then the terminal will receive some data come from server at good network condition. On the contrary, the engine will search for these data automatically saved into the database in online station when the terminal send request at the worse network connection status.

3.6 Evaluation Model

We will construct evaluation model with two factors: knowledge acquisition and ability level, on this basis build adaptive exercises library. There are four steps to accomplish learner's evaluation: (1) the evaluation model will predict the situation of learner's knowledge according to the learners' learning track, prediction learners' knowledge, (2) selecting some exercises with appropriate difficulty to compose paper according to predicted results, and then execute the test, (3) at the end of test, the evaluation model will combine the data come from learner's answer and the whole learning progress to analyze the learner's knowledge defects by design data mining algorithm (K-Means, Apriori, Naive Bayes, etc.), (4) design learning assistant agent to guide student to learn these knowledge that the learner hasn't grasp.

4 Conclusion

Adaptive learning provides a personal learning to learner. Mobile learning give learner's new learning mode that the learner can learn in anywhere and at any time. Collaborative learning, unlike individual learning, people engaged in collaborative learning capitalize on one another resources and skills (asking one another for information, evaluating one another ideas, monitoring one another work, etc.). People can easily achieve success by collaborative learning. This paper proposed a common model of adaptive mobile collaborative learning system (AMBCLS). The AMBCLS can provide the appropriate learning content and learning path according to learner's characteristics, time, location, context-aware and device. Meanwhile, the system also provide better collaborative learning environment and many efficient collaborative learning mode and method to help learners to accomplish their autonomic and collaborative study more efficiently. But we don't verify the model of AMBCLS through actual teaching experiment, we will execute some experiments to prove the effectiveness of the model, at the same time to find the shortage of the model, and then improve the model constantly.

Acknowledgment. This work was supported by Chongqing Municipal Education Commission (Nos. KJ1400512, 152017 and yjg152001).

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