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Web-Based Collaborative Learning System and Its Key Techniques

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Abstract

On the basis of concept, characteristics and related work of collaborative learning, this paper proposes an intelligent web collaborative learning system prototype based on multi-agent technology. At first, the paper introduces a collaborative learning framework which supporting group learning and illustrates the whole learning process. Secondly, the paper presents some key issues to implementation of the virtual learning environment, such as intelligent grouping, automatic question answering, knowledge management, and opinion mining. Preliminary learning practice shows that it is a practical and efficient way.

Keywords: *collaborative learning; multi-agent technology; intelligent grouping; automatic question answering; knowledge management; opinion mining*

1. Introduction

The rapid progress in Information and Communication Technology (ICT) brings significant influences as well as a lot of new opportunities in higher education systems. As a new means to provide educational contents to students anytime and anywhere, distance education system is studied from all aspects in [l-3].

Collaborative learning is a learning method that uses social interaction as a means of knowledge building. This concept has been around a long time. It is a student-centered approach that requires students working together to accomplish shared learning goal and to maximize their own and their group members' achievements. This approach matches with the philosophy of contemporary perspectives on learning and teaching aiming to promote higher achievement, more positive interpersonal relationships and greater psychological health, resulting in graduates being cooperative, caring, reflective, critical and creative [4].

The typical characteristics of collaborative learning are listed briefly as follows [5]:

- Shared knowledge between teachers and students.
- Shared authority between teachers and students.
- Teachers as mediators.
- Heterogeneous groupings of students.

On the basis of the experiences from our series web-based course, Introduction to Artificial Intelligence in these years, this paper presents an intelligent web collaborative learning system. In this virtual environment, the paper studies overall architecture, the key technologies and implementations.

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The remaining of the paper is structured as follows: in Section 2 the state of the art in this research field are stated. The system design and implementations of intelligent web collaborative learning system are introduced in Section 3, and the last section summarizes the paper's work and draws some conclusions.

2. Related Work

C. Ramstein, who is considered one of the first researcher in this field, presents his solution in Coopdraw [6-7]. Guizzardi *et al*. investigate the relationship between teachers and students in an environment where everyone can teach and learn. They take an agent-based perspective on system architecture, where agents play a crucial role in supporting the effectiveness, flexibility and personalization of the whole process. Following, we apply an agent-oriented modeling approach illustrated with the means of AORML, which proved to be very efficient [8]. Mustapha considers the roles of an agent in an educational environment to be the following: to monitor, control and catalyze the social knowledge building among the community of learning [9]. According to Aroyo and Kommers, agents can influence different aspects in educational systems. They supply new educational paradigms, support theories and can be very helpful both for learners and for teachers in the task of computer-aided learning [10]. Khaing Moe San *et al*. use mobile agent as a personal agents to assist the students and the human tutor. An artificial tutor agent partially tries to replace the human during student interaction [11]. Thibault Carron *et al*. split the teacher's observation activity into multiple sub-processes, each of them aiming at observing (waiting for) a special event. Due to the large number of sub-processes and the fact that they occur on several computers, the necessity to delegate and automate part of this observation process leads us to consider an agent approach. An agent approach offers enough flexibility to choose when and what to observe through a collector agent, to change the abstraction level of the traces collected via a structuring agent and possibly to observe the result from different views thanks to a visualization agent. This combination of three specialized agents may be represented solely as an "observer agent" [12].

In China, there also exist many researchers in this field in recent years. G.-H. Li and H.-Y. Wang propose an agent-oriented collaborative learning architecture and consider teaching process control and learners' interaction [13]. L. Gao *et al*. propose an agent-based intelligent collaborative learning supporting system model-ICLS-agent to slove collaborative learning evaluation, question & answer efficiency and knowledge management [14]. F. Yin and J.-M. Zhang presents a model of layered multi-agent learning system based on knowledge level of learners. The model gave a better solution to some general problems existing in the learning system, such as out-of-order or disorder, population interaction effect, personality, costs of communication [15]. K.-R. Lai and C.-H. Lan present an assessment agent that models collaborative learning as multi-issue agent negotiation using fuzzy constraints for peer assessment. The proposed method aggregates student marks to avoid the subjective judgments and unfair assessments. Experimental results indicated that students and instructors generally acknowledged the peer assessment as a valuable process for enhancing student critical thinking skills and improving learning performance [16].

Since 2007, more related works are proposed in this field [17-23]. Chung Hsien Lan and *etc.*. adopt the specific assessment issues that include Creativity, Completeness, Execution, and Security, and extend the assessment agent by considering the effect of learning styles [18]. In order to provide a way to interoperate knowledge among the heterogeneous systems, Elisa Boff details the Social Agent, an agent to improve student's learning stimulating his interaction with other students, specially how this agent exchange bayesian knowledge among AMPLIA agents [19]. [17, 20, 22, 23] present multi-agent approaches to collaborative learning system from respective ways. In [21], Dirk Frosch-

Wilke and *etc.*. propose and discuss the application of a Petri Net-based reflective framework to change cooperative learning processes during execution.

3. System Design and Implementations

3.1. System Structure Design

In our system, a collaborative learning framework which supporting group learning is shown in Figure 1.

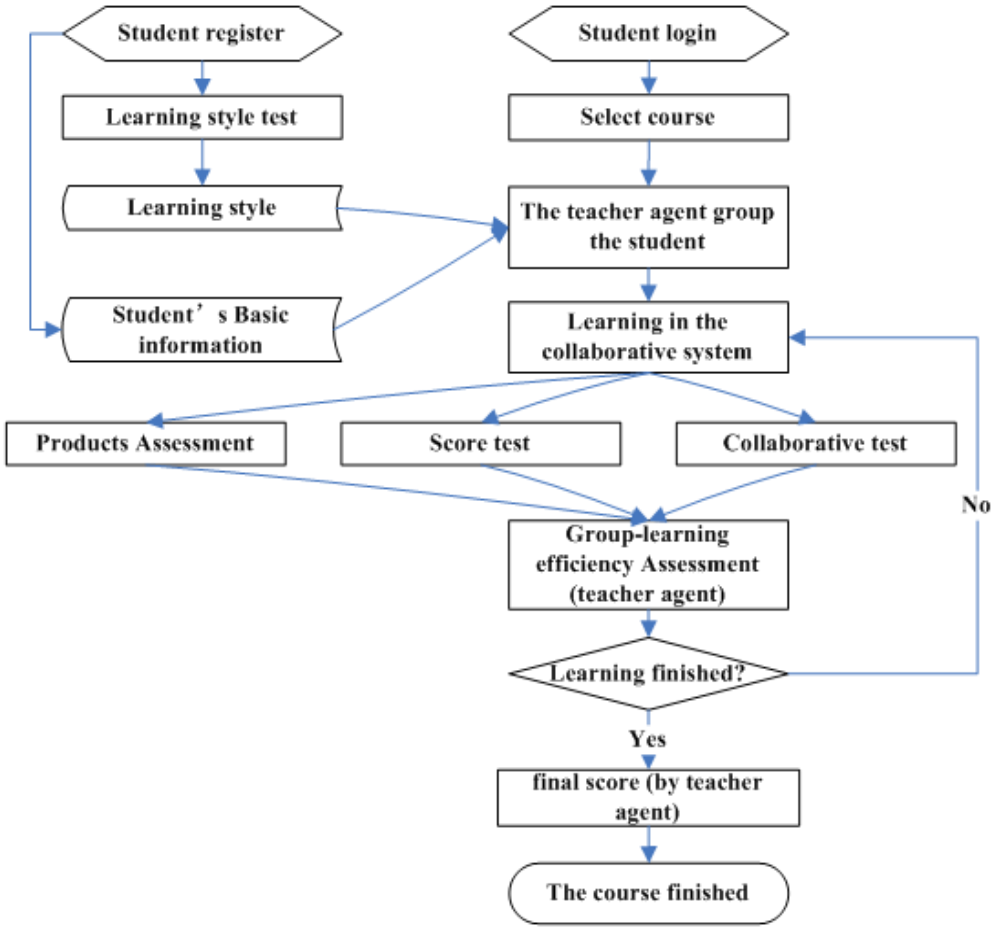

Figure 1. System Operation Flow Chart

From Figure 1, we can see the whole learning process: The system checks the student's learning styles and ability when he (or she) firstly login; divides the students into groups on the basis of students' learning styles and ability when they choose course; after the grouping, the teacher agent shows the overall goal of the course firstly, then guide the students to study according to students' learning styles and the teaching strategy in the knowledge base; once a student encounters with problems during his(or her) study (no matter the problem about collaborative learning skills or about the content of the courses), he (or she) can ask the teacher agent for help, and the teacher agent can also let the mission action agent query relevant resolving to help the students solve problems initiatively by monitor the students' problems in the collaborative learning; during the collaborative learning, the teammates discuss in a group, some students may be not active, the teacher agent can detect these problems and urge the students' intercommunion. In the whole process of the collaborative learning, teacher agent can serve the students actively.

To facilitate the processes mentioned above, teacher agent is designed as an e-tutor to do some work for the teacher. The teacher agent can work on the web server, and its functions are to answer the students' questions online, to monitor the communications among the students, to evaluate the efficiency of the group learning, *etc.*. On the other hand, student agent and student's information database are designed for every student, which will be created when a student finishes registration. The student information database includes student's basic information like name and age, and personality information like learning style and ability, and course grade, behaviors records on the internet, *etc.*. According to this personal information, the student agent can arrange proper learning plan and assist the student to make some modifications for the study.

3.2. Intelligent Grouping

Grouping is an important thing. The quality of the grouping will influence the students' learning quality straightly. Firstly, grouping strategy should be dynamic and flexible. In different periods of collaborative learning, different grouping strategies should be taken into consideration according to different learning tasks and learning requests. Secondly, from the viewpoint of learning sustainability, it is not appropriate to change teammates frequently.

We can use many strategies to divide students into groups, by the grade, or by the interest, or by the learning styles. For example, in instructive design with the same task, a heterogeneous group will be adopted so as that there exist difference in teammates' gender, score and skill.

The paper uses a grouping method of cluster analysis. In this method, those learners with similar score and skill will be classified into a cluster. After this, several clusters will be obtained. If teammates are chosen from these different clusters, the final collaborative learning groups will come into being. The advantage of the grouping method is of "heterogeneous in group, homogeneous among groups".

In this paper, parameters including four learning styles and score are taken into consideration for grouping. Here, learning styles consists of knowledge acquisition and *etc.*, which can be obtained from Solomon Learning Style Test in course of learners' registration. From this, the paper presents 10 samples shown in Table 1.

Table 1. Samples with 5 Indexes (4 Learning Styles and 1 Score)

Name	Style 1	Style 2	Style 3	Style 4	Score
S1	3	5	-1	-3	85
S2	5	-3	1	-3	68
S3	-3	7	1	3	74
S4	5	-5	-3	-5	59
S5	-1	3	-5	3	40
S6	3	-1	3	-1	82
S7	-5	3	-1	7	39
S8	1	-5	3	5	74
S9	-7	-7	-5	-3	95
S10	5	9	-7	1	77

Because the data formats of above table are different, they cannot be clustered directly. A standardization step like

$$Z = (x - \bar{x}) / \sigma \quad (1)$$

should be done before cluster analysis.

In equation (1), Z stands for normal score, x is original score of a certain learner, $\bar{x}$ is average score (for each index) of all learners, σ is standard deviation. After this transform, average value in each column is 0, square variance is 1, which become comparable data.

After data standardization, Euclid distance can be obtained through

$$d_{ij} = \sqrt{\sum_{k=1}^{m} (x_{ik} - x_{jk})} \tag{2}$$

Here, the paper uses centrobaric approach like to calculate distance among clusters.

$$D_{A,B} = \sqrt{\frac{n_E}{n_E + n_F} D^2_{A,E} + \frac{n_F}{n_E + n_F} D^2_{A,F} - \frac{n_E n_F}{(n_E + n_F)^2} D^2_{E,F}} \tag{3}$$

Of course, the grouping strategies are not unchangeable. We can use different grouping strategies in different courses. Furthermore we can use different grouping strategies in different phases of the same course. If the student disagree the grouping arrangement, the teacher agent can make respective modification.

3.3. Automatic Question Answering

Question Answering is a hot research field in National Language Processing, which includes many kinds of NLP (Natural Language Processing) technology. Question-answering module is an important one of the system.

The QA module mainly consists of three parts: question, information retrieval and answer extraction. The automatic question answering module can be used to reduce the workload of teachers and improve the learning efficiency of students. When a user asks other agent some questions, the agent will search for answers from its own knowledge base according question and keywords, then it will return the answers. If the agent cannot answer the question, then the question can be submitted on line (Google or Baidu). The question should be solved by himself and put it into personal knowledge base. The whole module is shown in Figure 2.

3.4. Knowledge Management

Knowledge management consists of knowledge acquisition, processing, storage and retrieval. The goal of knowledge acquisition is to change hidden knowledge (*e.g.* personal knowledge and skill) into dominant knowledge (data in knowledge base). In this system, knowledge is mainly obtained from two ways: interaction between learners or learner's individual experience. Knowledge processing means to remove invalid data using some filtering criteria like keywords and semantic words, then to store in knowledge base according to certain classifying criteria like knowledge theme, content, time and source, and then to modify knowledge according to certain triggering condition (*e.g.* once collaborative learning finished). Knowledge query means to receive request from learner and to fulfill query task.

To reflect dynamic characteristics of knowledge, especially from learner's answer, an upgrading strategy as follows is used:

$$kc_{n+1} = \begin{cases} \dfrac{kc_n \times n^2 + 1}{n^2 + 1} \\ \dfrac{kc_n \times n^2}{n^2 + 1} \\ \dfrac{kc_n \times n^2 - 2kc_n - 1}{n^2 + 1} \end{cases} \tag{4}$$

Here KC is Knowledge Credibility, which is a function of using times and user's remarks. And n means using time, initial kc0=0, kcn is a value falling into [-1, 1]. When a learner uses a knowledge or answer, he is wanted to present his remark. He can choose good, normal or bad, and the KC to this knowledge will be upgraded according to above equations respectively.

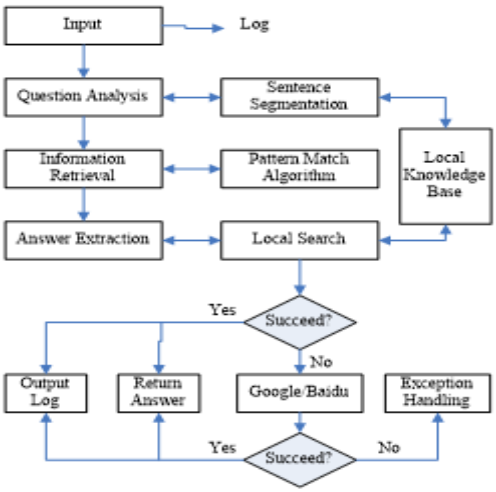

Figure 2. Automatic Question Answering Module of the System

3.5. Opinion Mining

In different stages of collaborative learning, *e.g.*, team grouping, learning task assigning, learning task implementation and efficiency assessment, learners can realize group collaboration and achieve learning goals through online chatting, email and *etc.* Numerous ideas exchanging ways will lead to a great deal of valuable information. As to these information materials, traditional information extraction (IE) methods and information retrieval (IR) methods cannot provide good solution.

The system is trying to do coarse-/fine-granularity opinion mining using hot techniques in natural language processing (NLP) field, opinion extraction and sentiment classification. In detail, the system analyzes sentiment orientation (positive /neutral /negative) in various interactive web pages. Then the system extracts concrete objects and aspects from sentence- or phrase-level. So the system can implement scalable mining tasks.

4. Conclusion

The goal of the research presented in this paper is to develop a simple and practical system to assist students in the collaborative learning process at any time of their convenience.

To facilitate distance learning, on the basis of concept, characteristics and related work of collaborative learning, this paper proposes a practical and efficient way based on multiagent technology. At first, the paper introduces a collaborative learning framework which supporting group learning and illustrates the whole learning process. Secondly, the paper presents some key issues to implementation of the virtual learning environment, such as intelligent grouping, automatic question answering, knowledge management and opinion mining. Our educational practice verifies the validity of the system. However, we still need do further work to improve this system. For example, we should use more precise agents to fulfill special task. Opinion mining is a hard task, and we should spend more time on it in our future work.

On the other hand, it would be a mistake to conclude that current and forthcoming developments can make intelligent collaborative learning system to replace human teachers. Given the fact that learning is a complex cognitive activity, learners cannot rely solely on machines when capturing and mastering knowledge of a certain domain. Agents are useful tools in the sense that in many cases improve the learning effectiveness.

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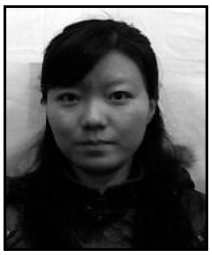

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