Collaborative Virtual Learning Environment Using Synthetic Characters

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Abstract. This research work not only proposes a deep insight to initiative and vivid concept modeling which makes use of several techniques like flash animation, rolling image-based introduction, virtual experiment, etc., but also explores the potential integration of synthetic characters with virtual learning environment to better simulate the social interaction and social awareness. Through analysis of constructivist learning theory, we present a new learning strategy with pedagogical agent. Based on this strategy, we take CG course in practice as an example to implement our multi-user application for individual learning and collaborative learning. Experiment results show that learning attraction, especially some difficult concept understanding, is very inspiring, and learning result is hopefully improved.

Keywords: Collaborative Virtual Learning Environment; Synthetic Character; Social Interaction; Constructivist Learning Theory; Knowledge Visualization.

1 Introduction

Virtual Reality (VR) has been proposed as a technological breakthrough that holds the power to facilitate learning. Knowledge visualization for learning materials and social interaction among learners are two critical factors for advanced learning on web-based immersive education. The application and development of VR technology in education has enriched the form of teaching and learning in current educational strategy. VR teaching system not only provides rich teaching patterns and teaching contents, but also helps improve learners' ability of analyzing problem and exploring new concepts.

Web-based learning environment characterized by its significant feature of convenience has shown its remarkable usage and advantages in distance education. Using a network supported computer, learners can learn everywhere at any time. At the same time, efforts from the development of communication and collaborative technology on international level[1,2] promotes open learning greatly. However, open curricula in world wide universities remains a big problem on knowledge sharing. Real

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experience of sharing learning resource and exploring deepened knowledge are seldom implemented in traditional collaboration learning environment which overlooks the importance of the right visualization for different concepts and seeks seldom efforts for social interaction in learning activity. The objective of this paper proposes a potential technique to improve this situation using collaborative virtual learning environment (CVLE).

Knowledge visualization and social interaction among learners are two critical factors for advanced learning on web-based learning. Excellent first concept understanding is very important for learners to learn new concepts. Correct first understanding not only helps avoid mistakes in deepen learning, but also save time. Thus, the skill of correct visualization knowledge concept is particularly important. To achieve this goal, modeling concepts from existing textbooks is not adequate for lack of related knowledge understanding. In our experiment, we seek help from computer graphic experts both from local university and educational bureau to gain right advice on modeling concepts.

The social context of the learner is a factor in determining the success or otherwise of study [3]. We believe there are two important factors in social interaction. One is communication and the other is cooperation. Communication is particularly effective over the net for educational purpose that helps learners exchange ideas and share information. Through communication, each learner's thoughts, experiences, knowledge resource and knowledge result can be shared to the whole learning group. Cooperation [4] is a method by which small groups of students incorporate a co-operative task structure, a co-operative incentive structure and a collaborative motive to produce collaborative behavior. Realistic simulation of social interaction and social awareness in such environment enhance learning attraction and help learners construct deepen understanding for new concept.

An overview and brief evaluation to previous research work, theoretical foundation from constructivist learning theory and using synthetic character to implement social interaction are presented in Section 2. Section 3 introduces the implementation of CoVLE system, a virtual learning environment running on local university network for CG study. Some important feedbacks from students are reported in Section 4 and planned improvements according to these feedbacks are described. Finally we draw a conclusion for collaborative virtual learning environment.

2 Collaborative Virtual Learning Environment

2.1 Objective of CVLE

E-Learning is now popular accepted among young generation. Present open courses or instructional resources are organized in 2D forms, such as text-based instruction, meaningful images and simple flash animation for concept meaning which are all

simply redesigned from traditional textbook. New improvements for present E-Learning application includes following points:

Diverse Showcases of Concept
Learning is an active process in which the learner uses sensory input and constructs meaning out of it [5]. Different showcases of knowledge provide an all-aspect view of new concepts for learners.

Natural and Meaningful Visualization of Knowledge
Learning is contextual. People do not learn isolated facts and theories in some abstract ethereal land of the mind separate from the rest of their lives. A correct reflection for specified concept and its related knowledge help learners grasp concepts in a contextual environment.

Learning by Doing
There is really only one way to learn how to do something and that is to do it. For training courses, collaborative virtual learning environment overcome the unpractical situation for learners by actually performing.

Social interaction and Social Awareness Simulation
Learning is a social activity. Collaboration in virtual learning environment provides a shared space for different learners study together, thus learning activities can be acted intimately associated with connection to other participants.

We summarized a well-modeled 3D learning environment featured as followings that meets items 1, 2, 3.

a. Honest 3D concept representation in a learning world.
b. Exploring and interacting with the learning environment.
c. Real-time feedback.
d. Multi-media assisting for interesting learning.
e. Pedagogical methods for knowledge mental construction.
f. Offering plentiful learning program as well as providing meaning construction tool.

An honest collaborative learning environment meets the requirements of item 4, which provides a virtual place where learners can ***meet*** and support space communication in realistic simulation among dispersed learners.

2.2 Theoretical Foundation from Constructivism

J.Piaget defines constructivism as a cognitive theory of objectivism [6,7]. Cognitive theory believes that knowledge is separated from the learner, and study is the result of stimulation and response.The relationship of virtual learning environment to constructivist learning theory is that the theory provides a theoretical analysis for

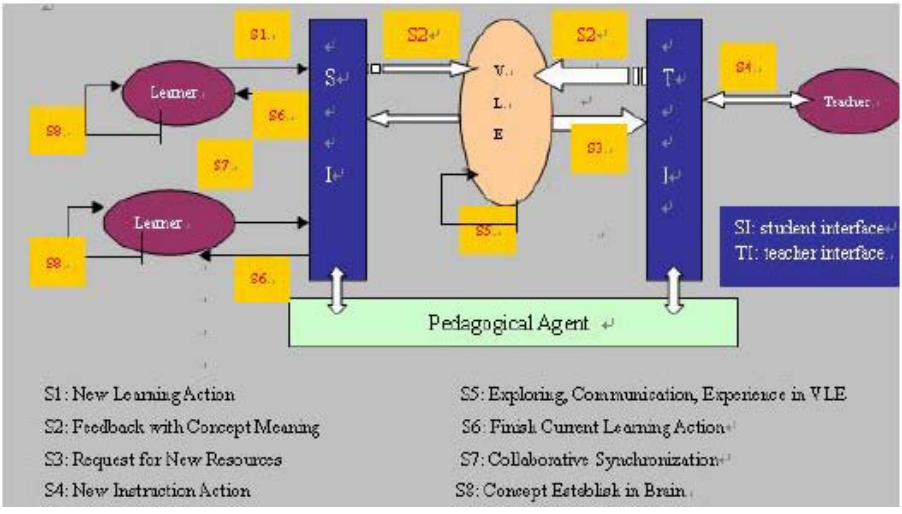


Fig. 1. Learning pattern based on constructivist learning theory

designing immersive 3D learning environment [8].Figure 1 shows the pattern we build for constructivist learning theory.

Learner Module: Individual learner gets learning resources from virtual learning environment, acquiring knowledge by meaningful construction. Group learners can also communicate with each other in synchronous or cooperative mode. Student interface offers support for various activities.

Teacher Module: The teacher sets teaching target and designs teaching content with the help of Teacher Interface. It also helps them enrich specified learning materials which will be represented in the VLE.

Virtual Learning Environment: This 3D learning environment is an abundant knowledge library which embodies the course principle. Components are including simulated entity, motion entity, artistic processing entity, information entity and self-adapting assistor.

Pedagogical Agent: Pedagogical agent helps learners experience learning actions in a learning environment. It finds out the right condition that intentionally interested by learners and decides which condition to notify. Pedagogical agent remains active once it has been assigned to specific learner. A common procedure for a pedagogical agent's state change can be divided into five steps: state analysis, goal generation, motivation generation, action selection and execute.

2.3 Integration with Synthetic Character for Social Interaction

Human beings are social creatures. Much of our intelligence derives from our ability to manipulate our environment through collaborative endeavors. Most exsist computer

programs and interfaces do not explore advantages of such manifestly human talents and interests, leaving broad avenues of human-computer communication unexplored [9]. We believe realistic social interaction and social awareness can enrich potencial possibilities for virtual learning envionment on the web.

Kline [10] believes virtual creatures whose behavior, form and underlying architecture not only informs our understanding of the natural intelligence displayed by animals and ultimately ourselves, but that also touches a person interacting with them on a profound personal level. Communication in social interaction and social awareness for learner representation requires not only simple avatar-like gesture modeling but also autonomous reflection and behavior change to outside stimuli and internal state changes. Therefore, we can employ both synthetic character knowledge and honest representation of behavior generation. At the beginning, 4 different level of learner representation are divided according to different level of autonomous ability.

- **Virtual Puppet** supports simple gestures control.
- **Virtual Participant** is equipped with a simple mind for action selection according to outside stimuli.
- **Virtual Character** enables both outside stimuli and internal perception.
- **Advanced Character** can do learning.

Robert [11] present thoughtful brain architecture for synthetic character which can adopt to above division assigning different level of skill. It is composed of six sub-systems with one internal memory. (see table 1)

Table 1. Virtual Brain Concept Sub-systems

Sub-System	Functions
Sensor	Acting as the enforcer of sensory honesty.
Perception	Helping each character assign a unique "meaning" to events in the world.
Proprioception	Emulating proprioception and extend it to include many forms of self-awareness, including awareness of emotional state and of self-action.
Memory	Maintaining a list of persistent *PerceptMemory* objects that constitutes the character's "view" of the current context.
Action	Deciding which action(s) it is appropriate to perform.
Navigation& Motor	The Navigation System typically functions by overriding the motor commands passed down by the Action System. In some cases this command is for an explicit Navigation task, such as "APPROACH."

The advantage of this architecture is that data flow can be processed correctly and efficiently in a top-down model like a real brain working flow. World events take the

form of a uniformed data record. Interpretation to each data record depends entirely on the sensory and perceptual abilities of character. However, how to choose the right level autonomous for learner in a collaborative virtual learning environment remains unexplored, although we know that virtual puppet attracts most learners' interests, this level of capacity on autonomous do not meet the requirements of social interaction. Further research results should gain from pedagogy theory and psychology learning theory.

3 CoVLE: Implemented System Using VRML and Java Techniques

3.1 System Architecture

Bowser-based technique is first implemented for learners' convenient access using VRML and JAVA [12,13,14,15].A web-based system architecture is implemented to support the functions such as: active learning process, text-based communication, white board as a shared cyberspace, collaborative mechanism, friendly user interface, extra learning tools and an online CG material database. In addition, tools enabling students and teachers to choose or upload additional CG material are also provided by this platform. CoVLE adopts client/server type architecture. VRML browser plug-in is used to render 3D scene using Blaxxun Contact plugin [16]. Java graphic interface is a human-machine interface designed according to constructivism learning tool kit, which includes personal Information, upload resource, course maker, course modify, learning course, 3D chat room, shared whiteboard etc. Communication tool supports synchronized message delivering. Event Dispatcher dispatches all the request events to server (such as

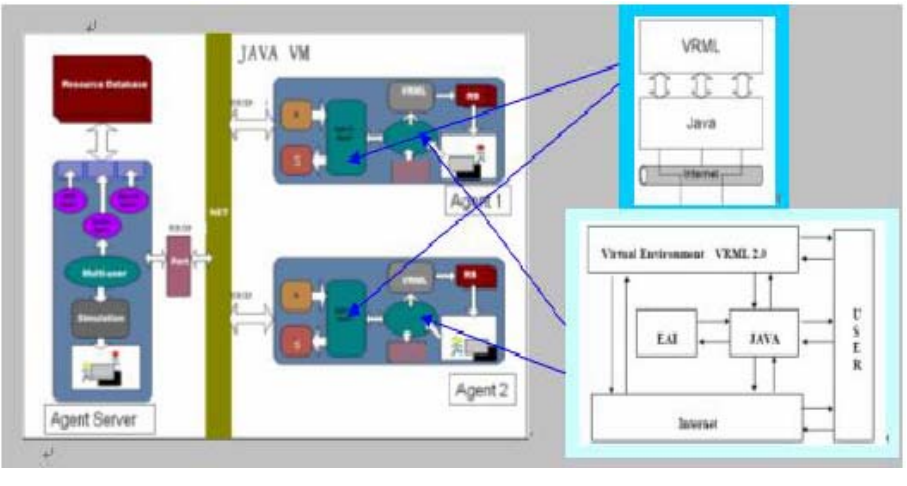
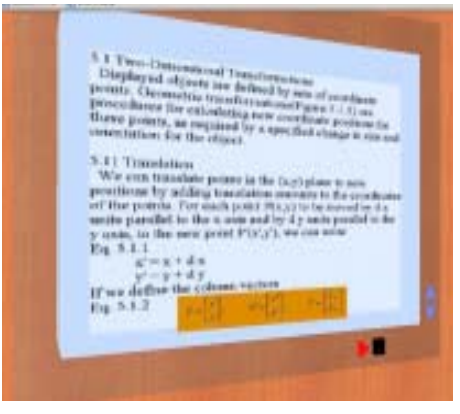


Fig. 2. Collaborative VLE architecture using VRML

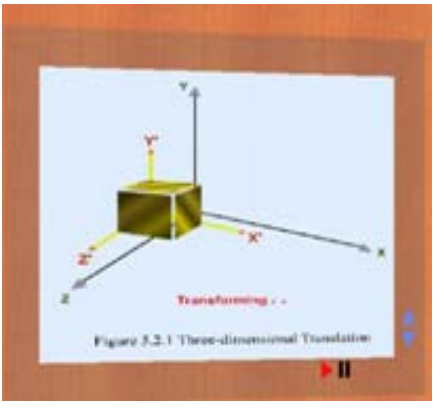
request for login, request for download resource, request for synchronization) or get event from server (such as get user information, get resource etc).

Limitation includes following points:

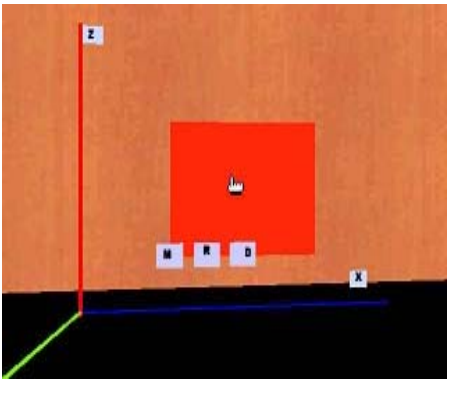
- Compatible difficulty: Since Microsoft and IBM have a long way to cooperate, VRML plug-in embedded in Microsoft IE is not fully supported and sometimes we meet run-time errors for unknown reason.
- Debug difficulty: Present free toolkit for debug Java Applet is not available.
- Low Quality on rendering: Though VRML has an advantage on net-worked 3D environment, the low quality breaks away from the honest rule to visualize knowledge.



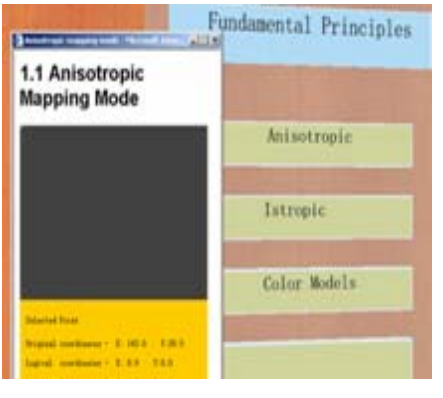
(a) Image_Text



(b) Flash Animation



(c) Virtual Experiment



(d) Interactive Aalgorithm

Fig. 3. Implemented four showcases in CoVLE

3.2 System Implementation and Feedback

Four Showcases:
Image text: Narrative text is converted to images. Learners can control the sequence of the image by up/down button. First room of each chapter house contains image text of each chapter. Some pictures are also showed in this way.

Flash Animation: Animation is used to clearly show the results of the instruction resource. It can also be used to substitute page rolling. Learners standing before the animation window are greatly impressed.

Virtual Experiment: Virtual experiments give learners an opportunity to experience. CG course virtual experiment can mimic a real situation of interest.

Interactive Algorithm: Computer graphic algorithms are the most difficult part to learn. Representation of direct algorithm results after learners' interaction with the interface gives learners another chance to enjoy what they are studying..

User Interface

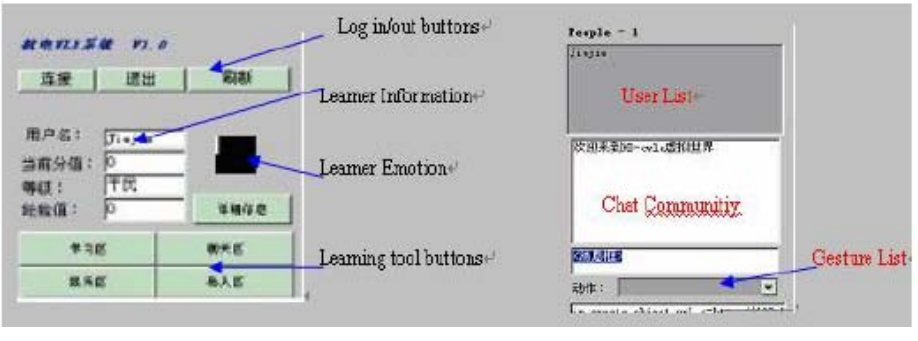


Fig. 4. Chinese Interface for control learning process in CoVLE using Java Applet

Nonverbal Communication
Nonverbal communication is essential for understanding learning and experience among the group learners. As we interact with people, we are interpreting what they are saying verbally and nonverbally in order to understand what they are communicating. Gestures and facial expressions are two important nonverbal communication tools for communication process. At present, we implement gesture control for expressing common feelings. 4 gestures are supported according to common usage in learning process. They are: nodding, disagreement, approve, laugh. Further research on nonverbal communication in learning actions should be analyzed.

(a) Gesture expression for concept deny

(b) Three avatars are exchange ideas

Fig. 5. Two Nonverbal communication examples

4 Feedback

Most of the learners show a big interest in the learning environment we built, except for those that feel dizzy while experiencing of controlling character acting in a 3D environment. Learning results are hopefully improved since learners focus on the excellent four showcases of the CG algorithm introduction, theoretic simulation and algorithm results interaction. However, learning effectiveness from learner's feedback is not as good as we expected. Through the simple web pages and Java examples, learners grasp the concepts well and with short time, while in the virtual CG world they are not so better. The reasons are that in 3D world, there are many things users can do such as chatting, walking. They are not willing to focus much more attention to their learning.

5 Conclusion

Web-based learning environments are becoming very popular. How to integrate VR technique into Web-based learning environment seems a big challenge. Constructivist learning theory, as a philosophy of practical online learning, provides a theoretical analysis for designing honest collaborative learning environment on the web. This paper centers on knowledge visualization for learning materials and social interaction among learners. We take CG algorithm course in practice as an example to implement our multi-user application supporting both individual learning and collaborative learning. We summarize following points that should improved in future work:

a. Support concept visualization
b. Limiting learner's unnecessary activity in order to reinforce learning effectiveness.
c. Improving synchronization in virtual experiment to simulate social interaction.
d. Providing virtual sound for immersive sound call and instruction.
e. Performing psychological and pedagogical analysis according to CVLE.

Evaluation to learning result is a hard job for us. We planned to seek help from local educational researchers to give an investigation and make use of their results. Further theoretical research on educational strategy should get through this experiment. We plan to add an online feedback from each learner's positive response and these feedbacks will be delivered to local psychological experts.

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