SOCIAL ANIMATED AGENTS: FUTURE OF INTELLIGENT TUTORING SYSTEMS?

Bogdan-Florin Marin, Axel Hunger, Stefan Werner

University of Duisburg-Essen, Germany
{bmarin|hunger|swerner}@ uni-duisburg.de

Abstract: We present an approach based on the concepts of emotions, tutoring agents and social positions to enhance and support the interaction between users within social learning environments. It advocates the use of artificial agent societies as a complement to human societies and assumes that agents will need to join such a society in order to realise user's learning goals. This work is a more detailed description of the framework presented by Marin *et al.* (2004a).

Keywords: Artificial Intelligence, Software Engineering, Databases.

1. INTRODUCTION

Since human-human communication is a highly effective way of interaction, animated agents are promising candidates to improve human-computer interaction (HCI). Life-like agents may use multiple modalities such as voice, gestures and facial expression to convey information and regulate communication.

A life-like agent can be defined as a computer-based program that performs a particular function and is embodied or manifest audio-visually via a screen-based synthetically or artificially constructed character.

One of the most successful application fields of life-like agent technology is computer-based learning environments where animated agents can perform in a variety of student-related roles, especially as tutor and trainers see (Conati 2002; De Rosis 1999 and Kitamura 2002). The use of animated agents in such environments as a tutoring paradigm can be benefic and increase the learners' motivation. Lester *et al.* (1997) investigate the impact of animated agents along the dimensions of motivation and helpfulness in an interactive learning environment.

Modern Software Engineering in any case signifies teamwork. The worldwide extension of the data networks and continuing globalization add another component software engineering: the development of worldwide distributed teams. According to Hunger (1999) the use of this forward-looking form in university education could make a special contribution to the way in which students work, and are worked with, in future.

This paper aims at highlighting the premises under which animated agents can be pedagogically effective tutors in distance learning environment. The remainder of this paper is organized as follows: next section presents the research goals. Section 3 highlights the state of the art in this research field, while following section presents a conceptual model for our work. Final sections provide the evaluation results and conclusions of this work.

2. CONTEXT AND RESEARCH GOALS

Current distance and open learning devices attempt to mitigate the difficulties encountered by learners when they follow a distance course (Rene-Boullier, 2003). According to her, it is necessary to take account of these difficulties when distance learning is set up, avoiding insulation and a lost of motivation by learners that are the cause of many giving up.

Several major inconveniences can be noticed in distance education like laboratory experimentation/ practice. Usually, during these experimentations students have to be physically present in the university laboratories. A solution to avoid this disadvantage is virtual experimentation: the experiments are simulated and visualized by means of virtual reality (Schmidt, 1999).

Another major issue in distance education concerns tutor's difficulties when he follows up a distance collaborative learning process and in particular those participants who cannot keep up progress with their group-mates. Denis (2003) establishes that tutor ensures different roles with the group of learners when he/she follows a collective activity. In his study he proposes a typology of tutor's roles: the welcome of the learners, the launching of the collective activity, the technical accompaniment, the methodological accompaniment, the self-regulation and meta-cognition.

Biolluz (2001) also believes that tutor encounters several difficulties which are related to the situation of distance learning, and particularly, to the fact that the tutor works like a "blind-man". The first difficulty is that the tutor must reconstitute for himself the puzzle of the learner's activities through the information that the environment provides him. Another difficulty is that the tutor needs to apprehend directly the learner's individual progression when he is engaged in distributed projects, in order to support each learner in the collective task.

Therefore we can conclude that there are two dimensions in the follow-up of collective activities: the first one concerns the whole collective activity, while the second one relates to the individual work in the collective activity.

As a solution for the above mentioned issues we propose a synchronous collaborative environment where the absence of a tutor is successfully replaced by an intelligent agent.

3. RELATED WORK

The common research trend in designing animated agents is to make the life-like or believable (Bates 1994). Life-likeness is supposed to provide the user with the illusion of life and believability should allow users to suspend their disbelief. Due to the fact that characters can be life-like in a "human-like" or an "animal-like" way an ongoing debate concerning whether the life-likeness of characters is more effectively by a realistic or by a cartoon style agents.

The answer to this debate can eventually be given empirically with respect to specific application scenario. For instance, while Blumberg (1996) in his thesis conducts a series of investigations on animal like characters, especially dogs, Thalmann et al. (1997) aim to create virtual humans typically following the realistic approach, even strives for photorealism.

The application of animated agents in the educational sector comes about mainly in the form of personal assistants, user guides, alternative help systems, dynamic distributed system architectures, human-system mediators and others. As a result of all of the changes that have taken place in the educational system, one now sees the increasing emergence of complex and dynamic educational infrastructure that needs to be efficiently managed. Corroborating this, new (types of) educational mechanisms and services need to be developed and supplied.

In particular these services need to satisfy a series of requirements such as personalization, adaptation, support for user mobility, support for users while they are dealing with new technologies, among others. Agents emerge to provide solutions for these requirements in a way that is more efficient when compared to other existing technologies (Aroyo, 1999). According to Aroyo (1999), 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.

In their work Lester *et al.* (1997) provide the result of his investigation on the impact of animated agents along the dimensions of motivations and helpfulness in an interactive learning environment. He coins the notion of 'persona effect' as "[…] the presence of a life-like character in an interactive learning environment – even one that is not expressive – can have a strong positive effect on student's perception of their learning experiences"

Lees and Ye (Lees, 2001) believe that the application of the agent paradigm to CSCW potentially can exchange information more fluid among the participants of groupware systems (as decision-making systems), help in control of the process flows and also supply groupware interfaces. These ideas also are applicable to other domains, such as is the case of interactive learning.

According to Kay (2001), in the first computer-assisted teaching environments the idea was to build "teachers" who could transmit knowledge to the learners. Currently, these types of environments are more geared up for exploration on the part of the learners, designing, building and using adaptive systems as tools. These environments also are being built to give greater responsibility to the learners regarding aspects of the learning process, and especially regarding control of its model, which is the central aspect in the adaptability of the tools.

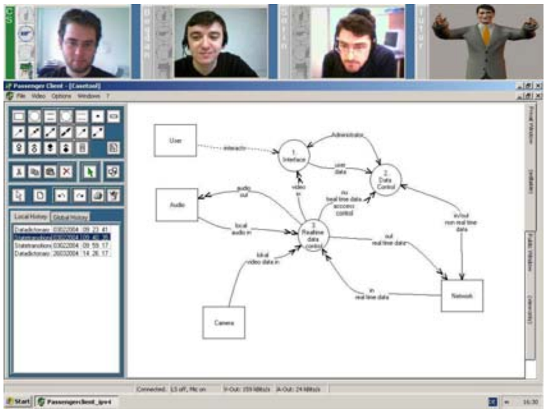

Figure 1. Passenger-Agent Tutor

4. PASSENGER AGENT TUTOR

Enhancing social roles to pedagogical agents can develop a new social-psychological model for animated tutoring agents similar with a human one. In particular humans can easily adjust their behavior based on their role in a socio-organizational setting, where their actions tend to be driven emotions, attitudes and personality.

To exemplify our work we are motivated by the synchronous groupware applications such as Passenger. In order to create an educational environment for the spatially distributed teams, a synchronous groupware called “PASSENGER” was developed at our university throughout the last years. For a full description of the virtual environment called Passenger, where our tutor-agent performs its tasks, the reader is refered back to the work of Marin *et al.* (2004,b).

The roles of the agent – tutor (see Figure 1) within the Passenger groupware are:

- *Selects a model (topic) for session/discussion*: it is through this negotiation of meaning and understanding that learning occurs. Therefore each topic has a tree structure, with nodes that are: first question for the participants, possible answers by participants, agent response to each of these answers. Topics are designed to attract participants into an interactive dialogue and to avoid the “silence” during a Passenger session.

- *Assigns roles to the students*: during the semester the student-teams will experience the entire life-cycle of Software Engineering. The students start with a requirement analysis following the Ward & Mellor approach (Ward & Mellor, 1985) during the modeling phase. The given problem for the practical training is chosen in such a way, that it cannot be solved by one student on its own. Therefore, each topic is divided in sub-topics which can be assigned by the tutor agent to one of the participants.

- *Provides help for toolbox buttons*: each tutor-agent is able to provide students basic help regarding the usage of the Passenger Client. Within the tutor-agent’s architecture there is implemented a pattern recognition algorithm. Using this algorithm the agent can provide adequate answer to students’ questions like: “How (1) can I draw (2) a control transformation (3)?” where (1)(2) and (3) ~How… draw… control transformation…~ represent a pattern example. After recognizing a pattern the agent will search its knowledge database for a proper answer and will provide this answer to the student. For this example the answer is “You should press the third button of the Case-Tool buttons from the first row, and then go with the mouse in your working area and click where you want to have a control transformation… ”

- *Supports and gives hints on awareness functions*: the tutor agent should be able to provide to participants proper feedback on awareness issues like: “Why can’t we see Jack? (Answer: Jack should press F3 or select send video from Video, or maybe Jack does not have a video-camera)”

- *Controls and gives hints on floor control mechanism or selects floor passing method* (adaptive): the agent can provide answer to questions like: “Why my colleagues cannot hear me? (Answer: you must be the actual floor holder in order that the others can hear you, therefore you should request the rights. There is a button on …)” or it should be able to avoid the deadlock situations like: one student which is the floor holder leaves the session but she/he forgets to pass the floor, therefore the other participants cannot modify the common artifact or they cannot communicate. One of the remaining participants can ask the floor from the agent-tutor. The agent can notice that the actual floor holder is inactive (e.g. he hasn’t made any changes to the common document for more than 10 minutes). Therefore the agent has the ability to take the floor from the inactive participant and to give it to the one that has requested for it.

- *Gives hints for next steps in modeling*: during a session it can occur that the students might reach a deadlock- the students do not know how to continue their work to fulfill their common task. The agent should be able to analyze the current state of the students' work and to provide hint for the next steps. If the agent cannot accomplish this task then it should communicate with other tutor-agents from another Passenger sessions. If the other agents cannot provide a proper answer then the analyze evaluation should be communicated to a human-tutor. The human-tutor if he is available can replace that agent within its session or he can provide the agent the adequate answer.

- *Group Manager* - has the ability to control the coherence of the group. The necessary agents' skills (requirements) for this role are: to monitor the owners of the Passenger Floor Control PFC, to control the entries in the PFC-list and to grant the Floor to the inactive users. Also a requirement of this role is to assure a fair distribution of PFC among participants in a learning session using Passenger. A detailed description of PFC and PFC list can be found in work of Marin *et al.* (2004b). This role tries to solve one of the open problems in the collaborative virtual environments: communication issues among participants.

5. MENTAL MODEL OF TUTOR-AGENT

The success of a life-like character in terms of user appreciation depends on factors like characters' role, competence and communicative skills relative to an application and its ability to present itself as a believable virtual personality. Our model includes the following concepts: personality, emotions and attitudes. For a detailed description of personality and attitudes concepts reader is refered to our previous work (Marin *et al.*, 2005).

As a product of evolution, emotions have a particular purpose: they have helped humans become the most successful species on earth. Emotions bypass the need for deliberative thought by providing biases toward the behaviors with better chances of survival short-circuiting time-wasting rationalization. Other kinds of mammals also exhibit emotional capabilities with very similar reactions to humans.

Psychoevolutionary theory succeeds at explaining the reasons for emotions and provides a basic understanding of their roles as evolutionary tricks to improve survival rates. Psychoevolutionary scientist Robert Plutchik (1980) shares such theories. According to Plutchik, there are eight primary emotions—associated in complementary pairs: anticipation and surprise, joy and sorrow, acceptance and disgust, fear and angerHowever, Plutchik's approach fails to take into account the cognitive process associated with emotions.

Figure 2. Emotions' display: sadness and joy

Our approach investigates the reasons for emotions' appearance: all emotions in embodied creatures are initiated by sensations. The notion of sensation can be defined as an immediate reaction to a creature's current status. By definition, sensations are experienced practically based on changes in the current situation. Two factors may cause sensations: the current perceptions (that is, stimuli from the environment), or cognitive activity (that is, thinking).

Perceptual sensations: are the sensations typically triggered by perceptions. The body detects stimuli from the environment, and the information causes an immediate reaction in the brain. For example, the tutor – agent may experience a sensation of surprise when a student appears suddenly in the middle of a learning session.

Cognitive sensations: represent the sensations triggered by reactions to the mental state (for instance, knowledge of the world or other emotions). Here, basic processing of information in the brain part causes the sensation. For instance, surprise can be caused by a student not being present, when the agent thought it should be there.

Our approach embraces these theories and represents emotions as our agent-prototype's response to students' questions by synthetic speech, facial display and gestures. Verbal and non-verbal behavior is synthesized in agent's mental model and interpreted in a learning-session (Figure 1). The facial display of our tutor –agent is limited to a predefined set of animations like happy, sad, etc (Figure 2). In order to extend the animations for our model we implemented also gestures to express emotions like confused: agent is lifting shoulders or don't recognize the question: put a hand to mouth.

Feelings are a more powerful concept; unlike emotions, they can be expressed about the past or future, and unlike sensations they do not rely directly on current state. Instead, feelings can be associated with arbitrary objects, in the past or future. Feelings are also very broad in that they can be applied to any concept (for instance, attributes or categories of objects). A feeling is a persistent association of an emotion with a class of object.

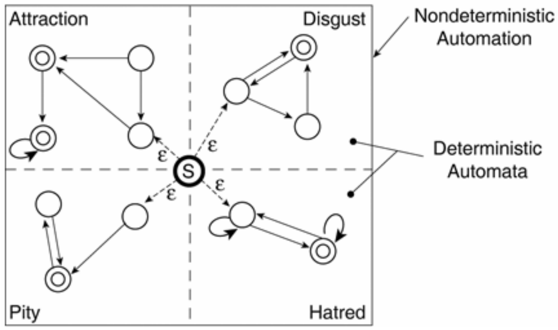

Figure 3 Feelings recognition module

The agent will be subject to four independent feelings: pity, hatred, attraction, and disgust. These are relatively easy to portray in the behaviors (especially in a learning session), and are sufficiently distinct from each other. Each feeling is recognized by a finite-state automaton. The automaton uses the data collected about the participants to decide what the agent's feelings are. For example, attraction is triggered for students which agent *likes* and *trusts*; disgust instead is felt for particularly *not-trusted* and *not-liked* students.

Instead of keeping each finite-state automaton (FSA) separate, these are grouped into one large nondeterministic FSA (NFSA) for convenience. Non-determinism allows the different automata to be merged together very simply, using (epsilon) ε transitions, as shown in Figure 3.

The FSA for the new feeling can be modeled separately, and grouped with the NFSA during the design. The feelings will mainly be used to generate new sensations. However, the feelings can be used by other behaviors as necessary—for example, selecting which student to ask to continue the exercise.

The system is hierarchical in that many components depend on each other. More details concerning the agent's architecture can be found in previous work (Marin *et al*., 2004a; Marin *et al.,* 2005).Technically speaking, all the concepts are modeled using finite-state techniques: feelings are expressed as a nondeterministic automaton, emotions as fuzzy-state machines, sensations as fuzzy automata, attitudes as nested states.

An important role of the system is played by the cognition module which is responsible for generating models of social dialogue for participant trust. Since we are interested in dimensions that have an effect on trust – which can be considered as one of the key factors of an agent's believability – we follow the approach of Svennevig (1999) based on three dimensions of the interpersonal relations in conversations: *familiarity*-highlights the way in which relationships develop through a session, *power* – ability of one participant to control the behavior of others, and *solidarity* – having similar behavior dispositions.

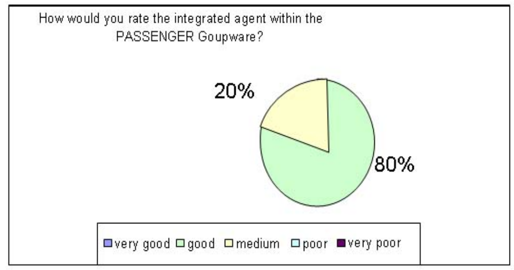

Figure 4.Acceptance of Passenger-Agent-Tutor

6. EVALUATION

The intended evaluation study for this prototype concerns two levels:

- Usefulness level: the usefulness of the agent facilities within Passenger groupware needs to be evaluated by human teachers.

- User friendliness level: this level highlights how the agent was accepted by students.

Several experiments took place in the local area network of our institute. Only the second part of the evaluation study was conducted among 25 first year Master-students.

Each session consisted of three students and one tutor (human or agent). The student experienced the traditional lab with the human tutor and also with the agent feature of the Passenger system. After these experiments, students had to answer to questionnaires files. A sample of questions concerning the second level that were asked to the students is the following:

1. *Do you consider the application attractive? If yes, what did you like about it?*

2. *Do you think that the "agent" features prevented you from understanding the educational process better?*

3. *Do you prefer the agent tutor instead of the human tutor? Please justify your answer.*

Based on these questionnaires several statistics could be made. Some results concerning the agent integration and acceptance are shown in the Figure 4.

Although the number of participants in the evaluation test was rather small for a quantitative evaluation, the trends seem to be unambiguous. We plan to realize the full-evaluation test including an evaluation result for the first level and also to increase the number of student participants

7. CONCLUSIONS

Enhancing social roles to animated pedagogical agents can develop a new social-psychological model for life-like characters similar with a human one. In particular humans can easily adjust their behavior based on their role in a socio-organizational setting, where their actions tend to be driven emotions, attitudes and personality.

This paper goal was to show how to integrate agent technology to support collaborative learning in distributed environments. The aim of this research is to provide the first steps to define a method for creating a believable tutor agent which can partially replace human-teachers and assist the students in the process of learning.

The outcome of such research is relevant both for basic research into the nature of social minds as well as for design and development of systems in application areas that requires agent to show and use aspects of human intelligence like: ability to learn, recognize or express emotions.

REFERENCES

Aroyo, L. & Kommers, P. (1999). Preface - Intelligent Agents for Educational Computer-Aided Systems. *Journal of Interactive Learning Research*, 10 (3/4), 235-242.

Bates J. (1994) The role of emotion in believable agents. *Communications of the ACM,* 37(7), 122-125.

Biolluz, A. & D'Halluin, C., (2001). Usage on an mediated environment for the cooperative learning. *Les cahiers d'études du CUEEP*, 43.

Blumberg P.M. (1996) *Old Tricks, New Dogs: Ethology and Interactive Creatures*, PhD Thesis, MIT.

Conati, C. (2002). Probabilistic assessment of user's emotions in educational games, *Applied Artificial Intelligence*, vol.16, 555-575.

Denis, B. (2003). Which tutors' roles are intervening in creation of distance-education devices? *Distances et saviors*, 1(1), 19-46.

De Rosis, F., De Carolis, B., and Pizzulito, B. (1999). Software documentation with animated agents, *Proceedings 5th ERCIM Workshop on User Interfaces For All*.

Hunger, A., Werner, S., & Schwarz, F. (1999) Measures to improve the globalization in higher education. *Proceedings of ICCE 99*, Chiba, Japan, II, 803-804.

Kay, J. (2001). *Learner Control. User modeling and User Adapted Interaction.* Netherlands: Kluwer Academic Publishers,11, 111-127.

Kitamura, Y., Tsujimoto, H., Yamada, T. and Yamamoto T., (2002). Multiple character – agents interface: an information integration platform where multiple agents and human users collaborate, *Proceedings of AAMAS-02*, New York.

Lees, B. & Ye, Y. (2001). Preface of the Proceedings of ASCW01 – Workshop of Agent-Supported Cooperative Work. *5th International Conference on Autonomous Agents*.

Lester, J.C., Converse, S.A., Kahler, S.E., Barlow, S.T., Stone, B.A., and Bhogal, R.S. (1997). The Persona effect: Affective impact of animated pedagogical agents, In *Proceedings of CHI-97*, 359-366.

Marin, B., Hunger, A., Werner, A., Meila, S., & Schuetz, C. (2004a). A Generic Framework for an Interface Tutor Agent within a Virtual Collaborative Learning Environment. *Proceedings of 4th IEEE Int. Conf. on Advanced Learning Technologies*, 31-35.

Marin, B., Hunger, A., Werner, A., Meila, S., & Schuetz, C. (2004b). A synchronous groupware tool to conduct a spatially distributed collaborative learning process. *Proceedings of the 5th IEEE International Conference on Information Technology Based Higher Education and Training*, 269-274.

Marin, B., Hunger, A., Werner, A., Meila, S., & Schuetz, C. (2005). Roles of an Intelligent Tutor-Agent within a Virtual Society. *Proceedings of IEEE International Symposium on Applications and the Internet (SAINT 2005).*

Plutchik, R. (1980) *A General Psychoevolutionary Theory of Emotion, Emotion: Theory, Research, and Experience* 1:3–33, New York: Academic.

Schmidt, C. (1999). A remote laboratory using virtual reality on the web. *Simulation*, 73 (1),13-21.

Svennevig J. (1999) *Getting Acquainted in Conversation*, John Benjamins, Philadelphia.

Thalmann, D., Noser, H., and Huang, Z. (1997) "Autonomous virtual actors based on virtual sensors", *Creating Personalities for Synthetic Actors,* ed Trappl, R., Petta, P., Springer, Berlin New York, 25-42.

Ward, P.T. & Mellor, S.J. (1985). Structured development for real time systems. Prentice-Hall Internet.