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A framework for developing embodied intelligent agents with affective behavior

PhD Thesis Proposal

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1. Introduction

Systems endowed with affective computing are a promising and growing trend as exhibited by the current coordinated effort to come to understand the issues involved made by the EU-funded network of excellence HUMAINE [1]. Such technology is being studied in order to lead to more natural and intuitive interactions between humans and machines. This leads to new effects and user experiences.

It is increasingly recognized that emotions have great influence on many of human activities, including decision-making, planning, communication, general behaviour and learning, and therefore, emotional factors are central to improving the naturalness between machines and their users. Humans react emotionally to aspects of their environment that matter to them, and these emotions will influence their way of acting, their way of thinking and their decisions. As humans, users expect interaction partners to pick up on signs of emotion and react to them in an appropriate way. Currently, machines do not take into account the emotional dimension and this is a source of frustration.

The obvious application of emotion-oriented computing is part of the general drive to let machines interface with humans as richly as humans interface with each other. Since emotion is pervasive to human behaviour, emotion-oriented computing is fundamental ot the future of human-computer interaction.

Multi-modal interaction is critical for artificial expressive behaviour, as humans often pick up on subconscious queues, such as eye movements, gesture and so-called 'idle movements', thus, virtual character representation and animation becomes more and more important in the field, in order to be able to transmit the rich range of signals that humans use to transmit emotion-related information in interaction among themselves.

2. State of the Art

Existing programming environments provide relevant component technologies but do not allow the user to integrate components. In our research, we will be using the Behaviour and Emotion Markup Languages developed through the HUMAINE network of excellence specifically for affective computer system interoperability.

2.1. Affective Computing

Affective computing is the study and development of systems and devices that can recognize, interpret, process and simulate human affects. It is an interdisciplinary field spanning computer science, psychology and cognitive science. There are several motivations for this research, relative to its intended application. One approach is the simulation of emotions in conversational agents in order to enrich and facilitate interactivity between human and machine. In e-earning applications, affective computing can be used to adjust the presentation style of a virtual tutor when a learner is bored, interested, frustrated or pleased [2]. Psychological health services can also benefit from affective computing as well: patients would be able to act in a virtual world populated by interacting artificial agents and be observed and diagnosed by a professional or learn how to correct their own behaviour. Affective computing is also being applied to the development of communicative technologies for use by people with autism [3].

Our understanding of human emotion is best within the cognitive modality and most existing models of emotion generation implement cognitive appraisal, which is considered to be best suited for affective modeling in learning and gaming applications.

Several emotion representation and generation models have been developed and have made significant contributions since Picard's 'Affective Computing' book established the field in 1997 [4], however some of these act as a separate mechanism that modifies the agent's behaviour and knowledge, instead of motivating it [5], while others are too complex for the capabilities of the agent and impossible to scale down [6]. The importance of emotions evolving according to environment factors, other agents and human interaction has also been stressed in the literature [7]. In this context, the proposed

research intends to develop a flexible, scalable and evolving model of emotion representation.

2.2. Serious Games

Another field that has recently gained momentum is the field of serious games. More and more companies and state agencies are using serious games to train and educate employees or the general public, respectively. A serious game is a game designed for a primary purpose other than entertainment, such as education or training. Although they can be entertaining, serious games are designed in order to solve a problem and may deliberately trade fun and entertainment in order to make a serious point.

There are many advantages to using serious games in education. First of all, computer game developers are accustomed to developing games that simulate functional entities quickly and cheaply by using existing infrastructure. Secondly, game developers are experienced at making games fun and engaging, automatically injecting entertainment and playability into their applications, features that serious games, while meant to train or educate the user could also benefit from.

Affective gaming has received much attention lately, as the gaming community recognizes the importance of emotion in the development of engaging games. Affect plays a key role in the user experience, both in entertainment and in 'serious' games developed for education, training, assessment, therapy or rehabilitation. A significant effort is being devoted to generate 'affective behaviours' in the game characters, player and AI-controlled avatars, in order to enhance their realism and believability [8].

Games Emotion has become increasingly established, as the following examples illustrate: in the SIMS, characters' actions are influenced by an emotive state, which results from their personality and events occurring during the game [9]; in Fahrenheit, players are able to influence the emotional state of characters indirectly [10]. There is also an increased interest in affective storytelling, creating stories interactively.

2.3. Agents in E-Learning

Education has always seemed a natural application domain for emotion-oriented technologies, because emotional issues play a large part in learning and human memory. There are a few applications worth mentioning: in the Cosmo System, the agent used emotional means to achieve teaching goals. ITSPOKE [17] tried to register the student's emotional states and use them to tailor spoken tutorial dialogues appropriately. FearNot used emotion-driven virtual characters in order to teach lessons about bullying [11].

The growing need for communication, visualization and organization technologies in the field of e-learning environments has led to the application of virtual reality and the use of collaborative virtual environments [12]. Virtual reality, together with emotion-capable artificial cognitive agents can highly broaden the types of interaction between students

and virtual tutors. As in conventional learning tasks, the computer can monitor students, responding to questions and offering advice in a friendly manner, while keeping the lesson's pace comfortable to the student [13].

Artificial agents are able to fulfill several valuable roles in a (virtual) e-learning environment: act as a virtual tutor and explain lessons, give help, advice and feedback to students; act as a student's learning peer and/or participate in simulations, especially useful in team training scenarios; an artificial agent may also be used (known or unknown to the student) in order to monitor progress and personalize the student's learning experience. An artificial agent present in a virtual environment should dispose of the following capabilities: demonstrate and explain tasks, monitor students and provide assistance when it is needed, provide feedback to the student, ability to explain the reasoning behind its actions and adapt (a plan) to unexpected events and be able to fill the roles of extras [12, 14].

A virtual tutor needs to have a way of storing and manipulating domain specific knowledge in a useful way in order to be able to explain to, and correct students, and justify its actions. In practice, the best way to build such a system is by using a rule-based system together with a justification-based truth maintenance system.

3. Ph.D. Thesis

3.1. Research Approach and Contribution

The required characteristics of intelligent agents in virtual environments are responsiveness, a high level of autonomy, proactivity and anticipation. The research tries to answer these challenges through the use of cognitive multi-agent systems endowed with emotional intelligence.

We believe that in order to create believable emotional states in artificial agents, we need to model the way in which emotions affect human cognitive structures, processes and functions, such as directing attention, managing memory, motivating behaviour (hope, fear), and allowing for fast decision-making in incomplete knowledge situations, providing, thus, the artificial system with the complex behaviour that emotions yield in humans.

3.2. Thesis Title and Goals

The title of my PhD thesis is:

"A framework for developing embodied intelligent agents with affective behavior"

The main research goal of the thesis is to develop a model of emotion generation for artificial agents able to display affect in interaction with the user in a virtual environment.

The agents should be responsive, at cognitive and affective level, to unexpected events and user actions in an environment in which agents are represented as virtual characters. In order to achieve this goal, we will investigate current models of affective computing and symbolic rule-based cognitive architectures in order to establish the requirements, specifications of the system to be developed and the possible improvements it should make.

To increase believability and life-likeness of the characters, the agents have to behave in an effective way towards their goals while expressing an appropriate emotional behaviour. Thus we will experiment with using emotions in order to manage the driving agent's memory and rule base, and improving agent performance. Our approach will be based on a BDI agent architecture (making use of planning and agenda type inference methods and the RETE algorithm) enhanced with affective behaviour. Towards this aim, an emotional model for agent behaviour will be developed that meshes well with, and improves performance of the prior BDI based knowledge and inference architecture.

The agents also need to express their emotional behaviour by adequate animations, providing a new layer of interaction with the user. The thesis will also develop a flexible virtual character oriented graphics module. Emotional behaviour will be defined using EML (Emotion Markup Language) and BML (Behaviour Markup Language) to convert emotions to behaviour. One first choice to investigate towards embodying our our emotional agents will be the use of SmartBody [15], an open source modular framework for realizing embodied characters.

The targeted application is the development of a serious game for education (e-learning) which will validate the BDI-based intelligence system and the developed emotional model proposed in the thesis.

3.3. Intermediate Results

The intermediate results of my thesis will be presented in two research reports, that will present the progress in the development of my Ph.D. thesis. The title and short descriptions of the reports follow:

Research Report No.1: **Affective Computing for Artificial Agents**
This research report will present the current state of the art in affective computing. While also covering aspects of emotion recognition, it will focus on emotion synthesis techniques, both at the internal level (existing models of emotion generation) and at the external level, namely affective behaviour of embodied agents by facial expression, posture, gazes, etc. An overview of BML and EML will also be included.

Research Report No. 2: **A Model of Affective Behaviour**
The second research report will contain the first version of our proposed model of emotion generation and an associated avatar that will display a limited range of emotions

using a framework for realizing embodied characters.

3.4. Acknowledgements

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References

[1] HUMAINE Network of Excellence [interactive: http://emotion-research.net, available on 9.10.2010].

[2] AutoTutor Tutoring System [interactive: http://www.autotutor.org, available on 9.10.2010].

[3] Massachusetts Institute of Technology Affective Computing Projects [interactive: http://affect.media.mit.edu/projects.php, available on 9.10.2010]

[4] Picard, R.W., Affective Computing, MIT Press, 2000, ISBN 978-0262661157.

[5] Eric Chown, Randolph M. Jones, Amy E. Henninger, An architecture for emotional decision-making agents, Proceedings of the first international joint conference on Autonomous agents and multiagent systems: part 1, July 15-19, 2002, Bologna, Italy.

[6] A. Ortony, G. Clore, and A. Collins, The cognitive structure of emotions. Cambridge: Cambridge University Press, 1988.

[7] Magy Seif El-Nasr , Thomas R. Ioerger , John Yen, PETEEI: a PET with evolving emotional intelligence, Proceedings of the third annual conference on Autonomous Agents, p.9-15, April 1999, Seattle, Washington, United States

[8] E. Hudlicka, Affective Computing for Game Design, Proceedings of the 4th Intl. North American Conference on Intelligent Games and Simulation (GAMEON-NA), McGill University, Montreal, Canada, 2008, pp. 5-12.

[9] The Sims Video Game [interactive: http://thesims.ea.com, available on 9.10.2009]

[10] Fahrenheit Video Game [interactive: http://en.wikipedia.org/wiki/Fahrenheit_(video_game), available at 9.10.2009].

[11] Cowie, R., Emotion Oriented Computing: State of the Art and Key Challenges, Humaine Network of Excellence [available at http://emotion-research.net/projects/humaine/aboutHUMAINE/HUMAINE%20white%20paper.pdf,

9.10.2010]

[12] Rickel, J., & Johnson, W.L., Animated Agents for Procedural Training in Virtual Reality: Perception, Cognition, and Motor Control. Applied Artificial Intelligence 13:343-382, 1999.

[13] Mihaela, D., Godja, C., Anghel, C., Salomie, I., Coffey, T., http://arxiv.org/abs/cs/0605033 2006CoRR abs/cs/0605033 db/journals/corr/corr0605.html#abs-cs-0605033 (informal publication)

[14] Advanced Distance Education [interactive: http://www.isi.edu/isd/ADE/ade.html, available on 9.10.2010].

[15] Marcus Thiebaux, Stacy Marsella, Andrew N. Marshall, and Marcelo Kallmann. 2008. SmartBody: behavior realization for embodied conversational agents. In *Proceedings of the 7th international joint conference on Autonomous agents and multiagent systems - Volume 1* (AAMAS '08), Vol. 1. International Foundation for Autonomous Agents and Multiagent Systems, Richland, SC, 151-158.

[16] SmartBody research project [interactive: http://www.smartbody-anim.org/, available on 9.10.2010].

[17] ITSPOKE: An Intelligent Tutoring Spoken Dialogue System [interactive: http://www.cs.pitt.edu/~litman/itspoke.html, available on 9.10.2009].