A MULTI-AGENT ARCHITECTURE FOR HUMAN-COMPUTER INTERACTION

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Abstract: The main goal of this article is to develop a virtual educational environment model which makes learning easier by using collaboration (and extension, team-research model) as a form of social interplay. The model represents a universe where human agents interact with artificial agents (software agents). Considering the vision of the system, it can be classified among advanced systems for it is client-oriented (student) and provides value added educational services, due to the collaborative learning attribute. The model proposes an original architecture where elements of the socio-cultural theory of collaborative learning are assigned to the artificial intelligence components (the multi-agent system). The expected results are: conceptual models (agents, learning and teaching strategies, student profiles and group profiles, communication between agents, negotiation strategies and coalition formation), software entities, and a methodology to evaluate the performance of eLearning systems.

Key-Words: human-computer interaction (HCI), multi-agent system, multi-agent architectures, collaborative learning, artificial agents.

1 Introduction

The Information Society, on its evolution toward the Knowledge Society, relays on several pillars, the most important being: e-Business, e-Government, eHealth and eLearning. It is interesting to see that the eLearning – electronic teaching or learning by means of information and telecommunication technology – is the fastest term to change its meaning and approaches. One possible definition would be that of a formal and informal teaching process which implies activities, communities and events based on the utilization of all electronic media, such as internet, intranet, extranet, CD-ROM, video, TV, mobile telephony. Thus, eLearning means open distance learning, web based training, technology based learning, online learning. The most important characteristics and facilities provided by the eLearning, which give it a high level of attractively are: the possibility of managing the learning period, interactive feedback, multimedia learning environment, the didactic materials are automatically updated, easy access (all you need is a browser) and, last but least, it implies collaborative learning. When talking about education, the learning borders are surpassed, reference being made to the entire set of educational services and resources [8].

The European Commission has launched for 2004 – 2006 the eLearning Programme, aiming to effectively integrate the Information and Communication Technologies (ICT) in education and training systems in Europe. The eLearning initiative defines the eLearning as “the utilization of internet and new multimedia technologies to the purpose of improving the quality of teaching, by giving free access to resources and services, as well as exchange and distance collaboration. It refers to everybody from students, employees, to teacher and instructors who want to improve their knowledge.” The programme has four directions: promoting digital literature, European virtual campuses, e-Twining between European schools and developing teachers training and transversal actions for promoting eLearning throughout Europe [9].

The eLearning solutions proposed by the Romanian scientific community tend to follow the direction established by the European Union [10, 11]. Must universities and high schools use more or less complicated computer based training systems, based on web applications and services [15]. Developing distance learning programmes has been a catalyst, the institution offering educational services being thus simulated in created courses and seminars on line. The government’s interest in promoting the informational society, with all the implications at educational and research level,
favored the apparitions on the IT market of companies that produce educational software programmes [12, 13, 14]. For example, Siveco Romania [16] created an AEL platform of computer based learning and contents managing. AEL is an integrated teaching learning and managing content system, based on modern educational principles.

2. Human Computer Interaction

From a computer science perspective, the focus is on interaction and specifically on interaction between one or more humans and one or more computational machines. The classical situation that comes to mind is a person using an interactive graphics program on a workstation. But it is clear that varying what is meant by interaction, human, and machine leads to a rich space of possible topics, some of which, while we might not wish to exclude them as part of human-computer interaction, we would, nevertheless, wish to identify as peripheral to its focus.

Take the notion of machine. Instead of workstations, computers may be in the form of embedded computational machines, such as parts of spacecraft cockpits or microwave ovens. Because the techniques for designing these interfaces bear so much relationship to the techniques for designing workstations interfaces, they can be profitably treated together. But if we weaken the computational and interaction aspects more and treat the design of machines that are mechanical and passive, such as the design of a hammer, we are clearly on the margins, and generally the relationships between humans and hammers would not considered part of human-computer interaction. Such relationships clearly would be part of general human factors, which studies the human aspects of all designed devices, but not the mechanisms of these devices.

Human-computer interaction, by contrast, studies both the mechanism side and the human side, but of a narrower class of devices.

Or consider what is meant by the notion human. If we allow the human to be a group of humans or an organization, we may consider interfaces for distributed systems, computer-aided communications between humans, or the nature of the work being cooperatively performed by means of the system. These are all generally regarded as important topics central within the sphere of human-computer interaction studies. If we go further down this path to consider job design from the point of view of the nature of the work and the nature of human satisfaction, then computers will only occasionally occur (when they are useful for these ends or when they interfere with these ends) and human-computer interaction is only one supporting area among others.

There are other disciplinary points of view that would place the focus of HCI differently than does computer science, just as the focus for a definition of the databases area would be different from a computer science vs. a business perspective. HCI in the large is an interdisciplinary area. It is emerging as a specialty concern within several disciplines, each with different emphases: computer science (application design and engineering of human interfaces), psychology (the application of theories of cognitive processes and the empirical analysis of user behavior), sociology and anthropology (interactions between technology, work, and organization), and industrial design (interactive products). From a computer science perspective, other disciplines serve as supporting disciplines, much as physics serves as a supporting discipline for civil engineering, or as mechanical engineering serves as a supporting discipline for robotics. A lesson learned repeatedly by engineering disciplines is that design problems have a context, and that the overly narrow optimization of one part of a design can be rendered invalid by the broader context of the problem. Even from a direct computer science perspective, therefore, it is advantageous to frame the problem of human-computer interaction broadly enough so as to help students (and practitioners) avoid the classic pitfall of design divorced from the context of the problem.

To give a further rough characterization of human-computer interaction as a field, we list some of its special concerns: Human-computer interaction is concerned with the joint performance of tasks by humans and machines; the structure of communication between human and machine; human capabilities to use machines (including the learnability of interfaces); algorithms and programming of the interface itself; engineering concerns that arise in designing and building interfaces; the process of specification, design, and implementation of interfaces; and design trade-offs. Human-computer interaction thus has science, engineering, and design aspects.

Regardless of the definition chosen, HCI is clearly to be included as a part of computer science and as much a part of computer science as it is a part of any other discipline. The algorithms of computer graphics, for example, are just those algorithms that give certain experiences to the perceptual apparatus of the human. The design of
many modern computer applications inescapably requires the design of some component of the system that interacts with a user. Moreover, this component typically represents more than half a system's lines of code. It is intrinsically necessary to understand how to decide on the functionality a system will have, how to bring this out to the user, how to build the system, how to test the design.

Because human-computer interaction studies a human and a machine in communication, it draws from supporting knowledge on both the machine and the human side. On the machine side, techniques in computer graphics, operating systems, programming languages, and development environments are relevant. On the human side, communication theory, graphic and industrial design disciplines, linguistics, social sciences, cognitive psychology, and human performance are relevant. And, of course, engineering and design methods are relevant.

3 The multi-agent architecture

Of all the advanced information technologies we have decided to use, for our model, the following: the agents (personal assistants, avatars, network mediators), multimodal perceptual interfaces, educational captology, behaviorist strategies, negations models, polymorphism through cloning and common ontologies [2, 5, 6, 7, 1].

The model has an evident multi-disciplinary character, being based are five research areas: educational system, sociology, artificial intelligence (multi-agent system), neuronal networks, semantic networks. Specific objectives aim at:

- Development of a model for educational virtual environment to facilitate collaborative learning (by extension, team research model) as means of social interaction. The model implies an universe where human agents interact with artificial agents (software agents). A reflection in the multi-agents space is to be created for the selected model. The interactions between the agents will be created at conceptual level by means of negotiation techniques and group decisions. When appropriate, the agents may be put together into coalition (agent responding in the same manner to a certain situation; e.g. agents that detect similar cognitive profiles for students may form a coalition). Communication among agents is based on the speech act theory in accordance with FIPA-ACL standards (Foundation for Intelligent Physical Agents) [3]. Agents send signals to one another for achieving will established goals: information, warning, help, knowledge distribution or promises (e.g. a document will be looked for). Sending a signal under these circumstances is called a speech act. In the end, all these actions are meant to make another agent believe something or act in a certain manner.

- Projection of the hardware (client and server type components, wireless options), and software infrastructure (multi-agent system) to support the model proposed for the educational environment, choosing a platform which the eLearning system would graft on.

- Development of an experimental model for the multi-agent system. Different agents categories (interface agents, cognitive agents, reactive agents) are projected and integrated in the system. At the same tame, didactic materials (courses, seminars, projects, video-conferences, shows) area loaded for two domains: social statistic and social data processing.

- Development of a methodology in order to evaluate the system’s performance.

- Evaluation and dissemination of the results for further development.

E-Learning general architecture (fig. 1) is an architecture with three levels (user, mediators, provider – educational environment). To each level corresponds heterogen families of human and software agents (fig. 2, 3, 4, 5).

![Figure 1: The three-level architecture of the eLearning system.](image)
didactic assistant (fig. 2). The personal assistant plays the role of a secretary, mediates communication with other human and artificial agents, edits new student activities and sends them to the latter, supervises student activities and the schedules of the activities which take place in the real time. The didactic assistant plays the role of the assistant in the classical leaning system. He assists the professor in creating and distributing the didactic material and activities, manages the professor’s personal database supervising access to it, and, on request, sends the personal assistant message for the students or for other agent teachers. The didactic agent communicates with agents from the social environment (to obtain group profiles) and from didactic environment to obtain documentary information or data for creating didactic activities. The professor has access to the whole educational universe.

The student (human agent) evolves in an agentified medium (fig. 3) with three types of agents. He also has a personal assistant (interface software agent) which monitors all student actions and communicates with all the other agents, with agentified media of other students and with professor agentified media. The students also benefit from two other agents: the tutor assistant and the mediation agent. The tutor assistant evaluates the student’s educational objectives and proposes certain activities. The decisions are based on knowing the student’s cognitive profiles (which takes into consideration the social component). The tutor agent interacts with the student’s personal assistant, with the mediation agent and with the social agentified medium. The mediation agent chooses a mechanism of evaluating the solution given by the student to a test or exercises, analyses the student’s solution, produces feedback. The mediation agent may communicate with other agent’s personal assistant. The system is designed to stress on shared activities between the students, which imply knowledge exchange, creating common projects, task negotiations, sharing resources, mutual effort in understanding a subject, group problem solving.

The social agentified medium (fig. 4) is made up of an agent and a group profiles (social behavior profiles) database. The social agent has for main purpose creating models for groups of students which socialize in the virtual education environment. It seeks groups that may collaborate under good circumstances, that is their level of knowledge and personalities are alike. In collaborational learning model every groups is considered to be an active entity and the system must recognize it as such. One way of putting together group models would be for the tutor agent (from the student agentified) supplies the individual model. Individual models are compared, those alike are put together and the general model of a group having a certain number of axes (for example, common opinion, agreements, conflicts).

The didactic agentified medium (fig. 5) must assist the students and/or teacher cognitive activities. In this environment evolves a web search agent and
a semiotic agent, which stimulates the student mediations agent, sending stimuli such as icons, texts and numbers. The medium has at its disposal a range of instruments and signs recorded in a database.

![Diagram of Didactic agentified medium](image-url)

Figure 5: Didactic agentified medium

The artificial and the human agents interact. We thus distinguish software agents – software agent interactions, human agent – software agent interactions and human agent – human agent interaction. The system will provide instruments for synchronized and asynchronous learning. In a first stage there will be a supervisor agent (typical for the eLearning platform chosen, such as Agent Message Router for the JAT Lite platform – Java Agent Template Lite [4]) at the web server level, which will make the connection of different agents, further on, more advanced solutions are to be used.

Such as it was conceived, the system falls into the category of advanced system through its client (student) orientation and value added educational services offer, obtained through the possibility of collaborative learning. The model proposes an original architecture by combining the artificial intelligence components (multi-agent system) with collaborative learning socio-cultural theory elements.

4 Conclusions

The proposed model aims to constitute a professional group which will facilitate the adaptation of all actors in an educational scenario (teachers, students) to work in virtual environment. The model permits virtual mobility of the researches (it implies network work, each team developing system models, to be put together in a further stage) and virtual mobility of didactic staff.

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