Conversational Agents for Advanced Learning: Applications and Research

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Abstract
Learning/training is an important application domain for intelligent agents technologies supporting believable dialogues and realistic virtual environments. In this paper, we first review, in section 2, some of the current applications and research in technology-enhanced learning. In section 3 we discuss the impact of conversational agents on the design of more effective individual and group/community learning environments and processes. Three fundamental emerging approaches to integrate conversational agents in learning environments, at the individual as well as at the group/community/organizational level, are identified: (1) Conversational Agents as advanced help and learning process facilitation tools, (2) Conversational Agents as personal coaches equipped with pedagogical models as well as specific domain knowledge, and (3) Conversational Agents as role-playing actors in simulated experiential learning environments.
In the following sections of the paper we provide specific examples of such conversational agents, focussing particularly on the two last, most advanced categories. Section 4 provides a brief overview of K-InCA, a personal coach agent, supporting learning of knowledge management concepts, practices, and behaviours. Section 5 illustrates the application of Conversational Agents as role-playing actors in simulated experiential learning environments. Starting with a brief description of the EIS Simulation to provide a concrete context for experimentation with Conversational Agents in simulation environments, and then illustrates two planned extensions of the simulation: (1) C-VIBE (role of conversational agents to enhance and extend the learning experience to the domain of virtual teams coordination and decision making) and (2) extension to learning interpersonal and social skills in micro-domains (simulating organizational interactions / dialogues and meetings).
In the conclusions we outline a number of different research questions to be addressed to conduct further research on the impact of Conversational Agents on learning.

Keywords: Conversational agents, e-learning, experiential learning, agent systems, simulation

1. Introduction

Learning and training institutions in the private and public sectors are growingly facing three important challenges. Firstly, the disciplines being taught evolve at an increasing speed. Secondly, their audience (the learners) has become wider, more heterogeneous and more geographically distributed. Thirdly, the subjects being taught often present fuzzy boundaries so that interdisciplinary knowledge is required on the side of the teachers as well as the ability to teach both soft and hard skills. Consequently technology enhanced systems are expected to (1) accelerate the learning process, (2) facilitate access, (3) personalise the learning process, and (4) supply a richer/ broader learning environment. Such systems must have the potential to offer the stimulus, support and environment necessary to guide the user in a continuous and active learning process that evolves with the discipline and with the users. Learning tools must also be flexible enough to allow the user to experiment with what is being learned in several situations and in collaboration with other users so that interdisciplinary aspects can be explored.
In the last five years, computer and telecommunication technologies have been extensively used to address some aspects of these challenges and in particular the growing audience and its geographical distribution. These tools normally offer the possibility to deliver multimedia content to a wide, geographically distributed audience, typically through an intranet or Internet Web site. They however, concentrate on access to information/content and are normally associated to a learning style, which we could call "content transfer", ignoring that learning is in fact a more complex and active process.
This paper proposes an alternative approach, based on the integration of conversational agents in educational and learning systems, allowing to address the above challenges and to support the whole learning process at the appropriate level of complexity. Agent based systems have the potential of creating realistic and appropriately situated virtual learning environments, of establishing believable dialogues with the user, of adapting to the different user learning needs, and of acting as facilitator within a community thereby supporting organisational, as well as individual, learning and knowledge

sharing. These systems would reflect appropriately the needs formulated above: adaptiveness and adaptability with respect to the users, but also with respect to the subjects being taught.

2. Simulations and collaborative learning: classic and enhanced tools

Two important fields of research and development related to technology-enhanced learning are *simulations* and *collaborative learning*. This section reviews some of the non-agent based simulations and collaborative learning tools[1], as well as certain of the more advanced, agent / AI / VR enhanced learning systems.

2.1 Classic simulations and collaborative learning tools

Some of the available products offer simulation software in the framework of personal and electronic learning tools addressing specific learning theories. Cognitive Arts [Cognitive Arts], for instance, offers custom built learning programmes based on the *learning by doing* approach including *goal based scenarios*, which are simulated work environments, where the learner can experience the skills being learned and receive mentoring and coaching from human subject matter experts. Other companies e.g. Learn2.com [Learn2.com], SkillSoft [SkillSoft], and Ninth House Network [Ninth House Network] offer interactive systems for hard and soft skill training, sometimes integrating audio-visual simulations, story telling, and case studies.

Many systems focus on collaborative learning. For instance, Virtual-U [Virtual-U][2] focuses on situated learning and social practice [Lave and Wenger 1991] providing an environment based on the metaphor of a university campus (a space for communication, individual work space, a space for accessing courses, a gradebook, etc.); a similar environment is provided by MFK-Speakeasy which however focuses more on lay communities rather than specific learning communities.

Within the Classroom 2000 project, at Georgia Tech [Abowd et al. 1999], a system has been developed capable of capturing classroom experiences (audio, video, presenter's slides, presenter's whiteboard markings, and students' notes) and connecting them to a persistent collaboration space (similar to Virtual-U and SpeakEasy), so that the collaboration space is immediately related (*anchored*) to the classroom experience. A similar attention to the integration of the physical and computational environment can be found in the Envisionment and Discovery Collaboratory (EDC) framework [Arias et. Al.]. However, the emphasis of this system is on eliciting tacit communication and supporting active informed participation through social debate and discussion.

Whilst the latter two systems strive to integrate computer-based interactions with the activities performed during physical co-presence, other systems assume that physical co-presence may never occur. In this case providing the learners with an appropriate perception of the other members of the community and of the evolution of the learning/work task being performed becomes an essential component of the computational learning system. Community awareness mechanisms have been devised which range from video conferencing mechanisms (see for example [Smith, Sipusic and Pannoni 1999]) to metaphor based 3D environments [Fjuk and Krange 1999].

2.2 Enhanced tools

Whilst the systems described above offer rich multimedia tools, the learning process can be improved by a more immersive and realistic user's experience as well as by some active guidance supplied by the system.

A highly realistic environment, for example, is implemented in the "Mission Rehearsal Exercise" [EurekaAlert 2001] simulation that takes soldier-trainees on a virtual reality mission in a troubled town in Bosnia. Within the framework of EC supported research the ASIMIL (Aero user-friendly SIMulation-based distance Learning - IST-1999-11286) project aims at the development of intelligent agents that offer virtual reality simulated environments for training in aeronautics. Artificial intelligence and simulation techniques are also used in the emergency management training system A-TEAM [A-TEAM]. A specific focus on learner profiling can be found in systems such as KOD (Knowledge On Demand. IST-1999-12503) an agent system capable of providing personal learning paths (knowledge routes), on the basis of users' characteristics (background, interests, skills, etc.). Realistic verbal and non-verbal communication with the user is the heart of the agent Steve - Soar

[1] For a good review of early Intelligent Computer Aided Instruction tools see [Rickel 1989]

[2] For a more theoretical discussion of the use of Virtual-U, see also [Dirckinck-Holmfeld and Sorensen 1999]

Training Expert for Virtual Environments [Rickel and Johnson 2000]. Steve is an animated multimodal conversational agent that can collaborate with students in virtual worlds. Steve's objective is to help students to learn to perform physical, procedural tasks.

3. Emerging approaches for the integration of conversational agents in learning environments

In most of the systems currently available, interactive features are used to deliver simulations or to give access to contents within a computational environment which is essentially passive and whose objective is to offer an efficient infrastructure supporting individual and collective learning. However, systems offering more than infrastructure and capable to actively monitor and support learning, must integrate cognitive models of the user with elaborate virtual reality, dialogue, and tracking in order to operate first at the motivational level, and then gradually involve the learner in an appropriately situated and interactive learning process. In such learning processes an individual should first better understand and develop interest in the concepts and practices being taught, and then successfully integrate and adopt them, individually as well as in his/her organisational or social context. The idea underlying the use of conversational agents in learning contexts is to try to accelerate the individual and organisational adoption of relevant concepts and practices.

Analysing the current state of technological enhanced learning, three emerging approaches can be envisaged that integrate conversational agents in learning environments at the individual as well as at the group/community/organisational level:

- Conversational Agents as advanced help and learning process facilitation tools
- Conversational Agents as personal coaches equipped with specific domain knowledge
- Conversational Agents as role-playing actors in simulated experiential learning environments

Conversational Agents as advanced help and learning process facilitation tools are agents, associated to a specific tool or learning environment, capable of supplying advanced help facilities for the tool or environment. These agents are based on a very good, structured knowledge of the tool or environment and they normally can proactively propose help, which is related to the specific tool's object or action being targeted by the user. Examples of such agents are the Microsoft help agents associated to Office products and advanced help tools associated to learning environment such as company databases or Web sites. Although, this type of advanced help systems may be very useful, they are often perceived by the user as annoying and basically not very smart. Their limitations are due to the inability to place user's actions in the wider context of the reasons underlying the use of the tool itself. Single user's actions, rather than sequences, are normally analysed. Knowledge of the user is lacking and the agents cannot adapt to the user's specific and evolving needs and motivations. Although some of these systems embed some dialogue skills, because of the lack of knowledge about the user, the agent's dialogues are aseptic and often not believable. No learning theory is embedded in these agents which are essentially based on the idea of transferring some content from the tool's user-manual to the user's head.

Conversational Agents as personal coaches equipped with specific domain knowledge are characterised by their ability to represent and continuously update the cognitive and social state of the users, and to communicate through a realistic, interactive interface. Their objective is to monitor and guide the user through a theory-specific learning process, providing suggestions, and facilitating learning and interaction (between the system and the user and amongst individual users). In our current projects and research plans, we are modelling, designing and developing prototypes of Intelligent Conversational Agents (InCAs) operating in different application domains such as making people learn to manage and share knowledge in organisations better and faster (K- InCA), generate and extract value from virtual communities (C- InCA), or become more learning-oriented (L- InCA). These systems, and the K-InCA system in particular, are briefly reviewed in the next section.

Conversational Agents as role-playing actors in simulated experiential learning environments, are agents capable of playing believable roles in simulation scenarios. These agents embed knowledge of the environment/scenario where the learning takes place. Such knowledge includes tasks, behaviours, objects, relationships, etc. that belong / take place in the scenario. Agents of this type can in a sense reproduce, and integrate into, the learning environment. In order to sustain believable dialogues these agents embed dialogue skills and adapt these skills to the user's cognitive and social state. These states

are monitored and updated by the agent in the course of the simulation. Our research in this field is described in section 5.

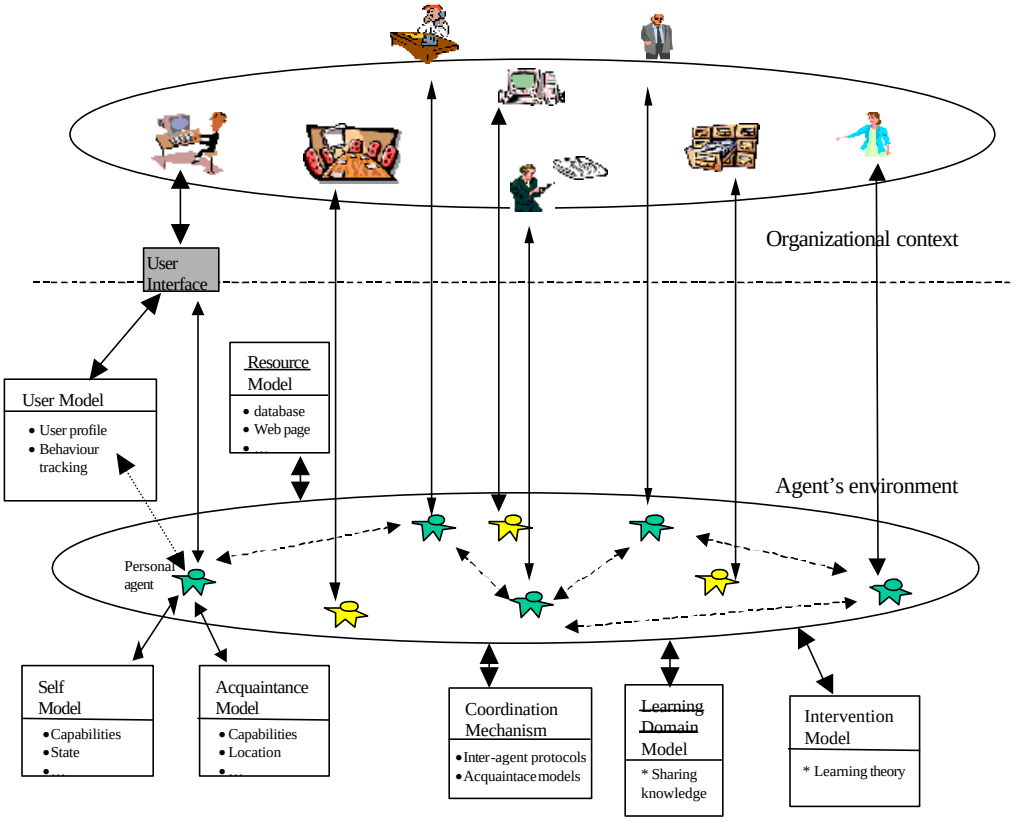

Figure 1 – K-InCA architecture

4. K-InCA: Conversational Agents as personal coaches with domain knowledge

K-Inca[3] is an artificial agent system designed to help people to adopt knowledge management practices [Angehrn et. al 2001; Roda, Angehrn, Nabeth 2001]. K-InCA agents continuously observe the actions of the user in order to build and maintain a "behavioural profile" reflecting the level of adoption of the "desired" behaviours. Using this profile, and relying on a model borrowed from change management theories, the agent supports the user change from his old behaviours to the new ones by providing customised guidance (such as suggesting some resources), mentoring (such as proposing some exercises to complete) and incentive (such as questioning provocatively the user's beliefs [Angehrn 1993]).

K-InCA agents guide the learners through a set of adoption stages (awareness, interest, trial and adoption), and provide them with information and stimuli customised to their profiles and levels of adoption choosing an interaction style adapted to the attitude towards innovation of the user.

K-InCA agents can be thought of as customisable agents, supporting the adoption of behaviours within a given domain. As shown in figure 1, both the domain model and the intervention model (the learning theory) are "plugged-in" the system and they can be modified. The domain model describes the behaviours that should be adopted by the user in the form of a hierarchy of more and more specific behaviours. Action descriptors are associated to the leaf behaviours of the hierarchical structure. K-InCA agents use these descriptors to recognise the behaviours that can be attributed to a user who has performed a given action. In our first implementation, K-InCA agents are designed to support knowledge management behaviours. In the future these behaviours may be replaced by other behaviours such as best practices in learning (L-InCA) or in interaction within a community (C-InCA).

[3] The project K-InCA is funded by Xerox Corporation

5. C-Vibe: Conversational Agents as role-playing actors in simulated experiential learning environments

Our Conversational Agents as role-playing actors in simulated experiential learning environments are extensions of an existing simulation environment, the EIS simulation, which offers a concrete context for experimentation. The kernel of the learning experience is the current version of the EIS Simulation [Angehrn, Nabeth 1997; Manzoni, Angehrn 1997] in which managers and students are allowed, like in a flight simulator, to have a first-hand experience as a member of a change agent team intervening in a company and to test the effectiveness of their implementation strategies and initiatives [Angehrn, Doz, and Atherton 1993]. The EIS simulation is currently used in leading schools and universities to train managers in the theory and practice of managing change and organisational transformation facing the natural resistance to innovation and change latent in organisations. In the simulation environment, users are able to initiate actions to achieve their goal which consists in convincing, over a given time period, the (simulated) senior management team of a (simulated) company to adopt a major innovation. Throughout this experience, the users will be able to implement different organisational initiatives and see dynamically the impact of their actions, thus learning (by doing) in a highly realistic way, how to manage effectively change in an organisational context.

In Change VIBE (C-VIBE) [Angehrn 2001], the kernel of the EIS Simulation will be extended with a 3D interface consisting primarily of (1) a Virtual Board Room, and (2) a Change Agent Avatar. A user (or team of users) will start the simulation (their change management project) by connecting to the Virtual Board Room, where they will meet a Change Agent Avatar (a bot) which will introduce them to the mission and to the features of the Virtual Board Room from which they will manage the change project, and which will be available to them during the whole simulation. The distributed, multi-user version of C-VIBE will allow distributed teams of users to connect simultaneously to the Virtual Board Room (instead of being co-located). Each user will be represented by an avatar and will be able to 'move' freely in the Virtual Board Room, accessing all the information and controls provided, including interaction with other users (for coordination, information sharing and decision-making) as well as with the Change Agent Avatar.

The EIS simulation covers well the 'macro' dimensions of introducing and implementing change management projects (when to do/not to do, what, with whom, at which point of time), however there are important 'micro' domains which could be supported by conversational agents mastering social skills at the level of direct interactions/conversations with other social agents (computer-controlled or human-controlled). These micro dimensions will be integrated in the EIS simulation through a set of simulations of organisational interactions / dialogues and meetings. For example, in the current implementation of the EIS simulation users are allowed to gather information by selecting an information gathering mechanism, and allocating the time for the gathering procedure. In future implementations the user may, for instance, be guided through a simulation encouraging efficient information gathering through dialogues. Effectiveness/Productive dialogues depend from how one behaves during such a dialogue (inquiry skills) as well as from the characteristics of the information source (in social contexts different people more or less enjoy/have a natural tendency towards sharing what they know, people might have some reasons to omit, retain/hide or even falsify information, people might simply be more or less motivated, busy or have their mind somewhere else at that particular moment, etc.). Other examples of micro level simulations may encourage efficient introduction of innovation through dialogue or in group settings. These include all the dialogues aimed at changing the opinions, ideas, and ultimately the behaviour of others.

5. Conclusions

Conversational agents for advanced learning may accelerate the learning process by tailoring the learning experience to the individual user's need, motivations, learning style, personal abilities, and learning goals. They can enrich the learning experience by offering more active and believable learning environments and implementing learning theories that are not limited to content transfer but encourage the active participation of the user in the learning process. These characteristics make conversation agents ideal tools to meet the challenges of nowadays learning needs.

Several research questions remain open, these cover issues of very different nature. They include:

- Defining the minimal depth level of cognitive and social models of the user necessary to create believable conversational agents capable of supporting the learning experience in various applications.

- Defining and evaluating interface agents with diverse characteristics, e.g. anthropomorphism, emotional traits, etc.
- Identifying the most effective agent representation for the given user in the various learning applications, these may go from fully explicit anthropomorphic models to transparent interfaces.
- Entering upon the problem of the conflicting needs of user privacy and user modelling and how to secure the access to user related information.
- Defining methodologies enabling the assessment of the learning tools' effectiveness.

Whilst the above and many other questions remain open, the work of many research labs and private companies, spanning from virtual reality to cognitive modelling, from on-line community facilitation to agent systems, from believable dialogues to ontology definition, etc. will contribute to the understanding and implementation of effective conversational agents for advanced learning.

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