World Academy of Science, Engineering and Technology
International Journal of Educational and Pedagogical Sciences
Vol:1, No:3, 2007

Design of an Intelligent Tutor using a Multiagent Approach

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Abstract— Research in distributed artificial intelligence and multiagent systems consider how a set of distributed entities can interact and coordinate their actions in order to solve a given problem. In this paper an overview of this concept and its evolution is presented particularly its application in the design of intelligent tutoring systems. An intelligent tutor based on the concept of agent and centered specifically on the design of a pedagogue agent is illustrated. Our work has two goals: the first one concerns the architecture aspect and the design of a tutor using multiagent approach. The second one deals particularly with the design of a part of a tutor system: the pedagogue agent.

***Keywords*— Intelligent tutoring systems, Multiagent systems, Pedagogue agent, Planning.**

I. Introduction

THE goal of Intelligent Computer Aided Instruction (ICAI) is to build programs for teaching and presenting a lesson as a set of parts adapted to every student [11]. In the development of a software for education, commonly called intelligent tutor, artificial intelligence proposes the following:

-- Mastery of the learning domain.
-- Individualization of learning.
-- Flexibility of the man-machine interaction.

However, the evolution of artificial intelligence application domains to recover complex and heterogeneous domains as the supervision of industrial processes has showed the limits of the classical artificial intelligence that centralizes expertise into a unique stand alone system [10]. In the 70s, researches on concurrence and distribution have contributed to the birth of a new discipline: Distributed Artificial Intelligence (DAI).

In this paper, the second section presents the DAI approach in general and the Multiagent Systems (MAS) in particular. The third section exposes the advantages that DAI offers in the design of intelligent tutors. In the last section, we illustrate the proposed tutor system with a particular emphasis on the pedagogue agent.

Manuscript received November 28, 2004.

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II. Distributed for Artificial Intelligence and Multiagent Systems

A. *Distributed Artificial Intelligence*

Distributed Artificial Intelligence (DAI) tries to remedy at some problems of classical artificial intelligence, such as inability to deal with multiple expertise and the possibility of incoherence in large knowledge bases, by distributing expertise and control among a group of agents able to work togother, interact, and solve the eventual conflicts in order to sole a given problem. This can be achieved through complex agents process such as cooperation, coordination, or even negotiation. So, while classical artificial intelligence tries to model the intelligent behavior of a single agent, DAI is interested by the cooperation and coordination of a group of intelligent agents.

A DAI system can be viewed as a society of autonomous agents that work (using occasionally complex modes of cooperation, coordination, or negotiation) to acheive a global goal such as problem solving, making diagnosis, or plan construction, etc. [8].

DAI applications cover many domains such as diagnosis, teaching, planning, etc. Research in DAI covers especially three axes [5]: distributed problem solving, parallel architecture and multi agent systems. The latest domain is concerned with the cooperation of independent and concurrent entities known as agents.

B. *Multiagent Systems*

In multiagent systems, two main agent categories can be distinguished: reactive or biological agents [7], and social or cognitive agents [12]. The first category concerns the study of non intelligent agents with a simple behavior of type stimuli-response. Intelligence emerges from the interaction of the group of reactive agents. In this paper, on the contrary of reactive agents, we are only interested with cognitive agents that present an intelligent behavior. Research in MAS tries to cooperate a set of agents having an intelligent behavior and coordinate their goals and action plans to solve a problem. In order to make this cooperation effective, an agent have to reason about the knowledge and abilities of other agents [7].

An agent can be defined as a physical or abstract entity able to act on itself or on its environment [6]. It has only a partial representation of this environment and can communicate with other agents. It achieves an individual goal and its behavior is the result of its observations, knowledge and interactions with the other agents.

So, MAS are concerned by the intelligence and autonomy of the agent which must have a protocol of communication that enables interaction with other agents in order to obtain a good cooperation and coordination of actions. There are two modes of communication:

-- Message sending: systems using this mode of communication present a total distribution of knowledge, results and methods used to solve problems.

-- Information sharing: agents in this case are not directly connected but communicate using shared data structure where the solution of the problem is constructed. The best example of this mode of communication is the blackboard architecture.

III. Intelligent Tutors and Dai

When we speak about technology in education, two concepts are suggested. The first one is the technology in education where the application is to give a help in the learning process. The second one is the technology of education that applies the scientific principles to the education in order to obtain an efficient learning [2]. These two concepts have a common goal: find the best learning way and give solution to education problems. For this reason, many techniques evolved in this way: micro world, hypermedia, AI.

The principle of ICAI and AI is that the computer cannot be considered only as an object that helps a learner to solve a problem. It must be able to reason on data and understand the problem given by the student in order to help him in the learning process [1].

The classical model of a tutor tries to simulate an activity of a single intelligent man but multi functions. As a human being teacher, this system executes sequentially tasks associated with each function. In Distributed Intelligent Tutor (DIT) [9], we distinguish a set of generic tasks such as: planning a lesson, generating an exercise, solving an exercise, and explaining a solution, that are distributed among specialist agents that can work in parallel. These agents are heterogeneous: each one has a representation language of data and inference mechanisms adapted to his function.

A. DIT Advantages

Two arguments plaid in favor of DAI [4] to solve problems:

-- The problem is itself distributed.

-- Parallel processing is needed.

The design of an intelligent tutor needs the contribution of a team of experts [14]. It needs at least the collaboration of a specialist of domain and an expert in pedagogy. Each of these expertise can be divided in many others expertise. The use of DAI approach in the design of an intelligent tutor is done as a function of different activities of tutor: diagnostic, control of learning session, etc. We generally associated an agent at each activity. The interactions are implicitly contained in plans and reduced to a scheduling of parallel tasks. For example explanation is not viewed as a punctual message but as an interactive process independent of resolution [3].

The second argument that plaids for the use of a DAI approach in the design of an intelligent tutor is particularly important because the response time of an ICAI system must be sufficiently short in order to maintain learner attention.

We can easily show others advantages of DIT as modularity, efficiency, heterogeneity, reliability, reusability, etc.

IV. The Proposed Tutor

Our tutor is composed of five agents: the pedagogue, the generator of exercises, the solver, the explainer and the corrector.

Agents of the tutor cooperate in a “command” mode. In this mode of cooperation a superior agent A decompose the problem into sub-problems that are distributed between other agents. These agents solve problems and send partial solution to A [13].

So the pedagogue agent, supervisor of all the set of agents in the system, ensures the collaboration between different agents of the system. The system uses a communication by sending message mode. Each agent can identify two kinds of messages: request messages named “stimulus” and data messages. These two kinds of messages allow an asynchronous communication. The first kind of message serves as an identifier for the required processing while the second one may contain the necessary parameters for the well execution of the required task or the result of an eventual processing.

A. The Pedagogue Agent

The pedagogue agent is the main part of the system. It communicates with the other agents in a “command” mode. It ensures the following functions:

-- Management of the interface with the user.

-- Management of a course session which is defined as the running of the different tasks within the other agents such as: presentation of a teaching concept, generation of exercises, proposition of explanation, correction of the learner solution, and management of the learner model.

A course session is presented by three tasks:

-- Open session.

-- Interpretation of the plans of the session.

-- Close the session.

From the pedagogic point of view, there isn’t a unique method of teaching. There are many pedagogical methods, buts none of them proposes a computational method of teaching. To solve this problem, pedagogical planning must have opportunist character and admit error.

So, we adopted a plan-based pedagogical agent architecture that offers the following advantages:

-- The notion of planning (use of plans) offers a good conceptual frame for representing pedagogic activities.

-- Using plans allow the knowledge of the pedagogue agent to be explicit. So, it can explain its own behavior to the learner or to the teacher who supervises the session. For these reasons, we choose a declarative planner.

-- Pedagogue agent interprets plans independently from the teaching domain and so it can be easily used in different tutors.

The pedagogue agent uses a plan library. There are two classes of plans: course plans and pedagogical plans. Course plans represent the decomposition of the course (teaching content). Pedagogical plans represent the steps to follow for teaching a concept. They are independent from the teaching domain.

B. The Dynamic Aspect

The dynamic aspect of planning is shown in these two points:

-- The first one is in relation with the choice of a pedagogical plan. In fact, even the choice of the first plan is done according to the profile of a learner, it can be changed if it shows a failure, even a partial failure, to achieve the goal. For example, if we consider the plan P5 (define a concept without examples), this plan can fail with a learner who has not enough information about this concept. So, the pedagogue agent takes the initiative and changes this plan with the plan P1 (add examples at each definition).

-- The second point is in relation with the choice of the pedagogical mode. In the system we have defined different pedagogical modes. Consider, for example, two of them: the guided learning mode and the learning modes. The first mode is used for a beginner learner and represents teaching by knowledge transmission. The second mode is used for a trainer learner, who wants to enhance his information, and represents teaching by apprenticeship. The pedagogue agent can modify temporary the guided learning mode in free learning mode if he notices that the learner makes a high rate of errors.

The choice of the above two classes of plans is justified. In fact recent researches in pedagogy show that teachers plan their lesson in a cyclic and hierarchical manner. In the first time, a teacher divides his lesson into different elementary contents (selection of a teaching content). In the second time, he imagines an activity for each content and proposes the running sequence of each activity (how to teach). An example of a plan for teaching an array structure is illustrated in Fig. 1.

In the phase of a plan interpretation, the pedagogue agent executes two kinds of plans: the course plans and the pedagogical plans. A plan models a scenario to achieve a task or to achieve a goal. For the course plans, these goals represent different teaching units. The pedagogical plans represent different manners to teach a unit of a lesson depending on the criteria considered for the learner evaluation. We can for example classify these plans according to three criteria:

-- Method of a lesson presentation: a detailed method with examples or a simplified method with only definitions (detailed, simplified).

-- Style of knowledge presentation: we can present knowledge as an example followed by a definition or a definition followed by an example (ex-def, def-ex).

-- Style of explanation: concrete explanation can be given on an example or only the comments can be sufficient(concrete, non-concre

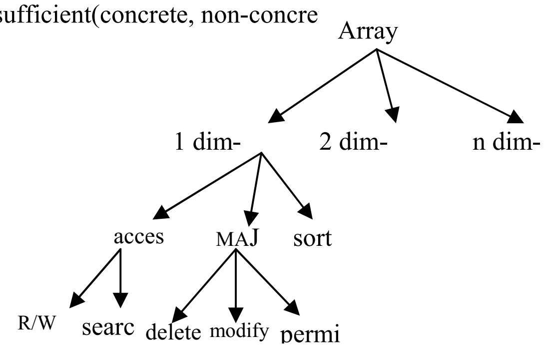

Fig.1. Example of a lesson plan

Taking into account the two mentioned values for each criteria, we obtain a set of plans in Fig.2.

P1: teach (lesson, detailed, ex-def, concrete).
P2: teach (lesson, detailed, ex-def, non-concrete).
P3: teach (lesson, detailed, def-ex, concrete).
P4: teach (lesson, detailed, def-ex, non-concrete).
P5: teach (lesson, detailed, empty, concrete).
P6: teach (lesson, detailed, empty, non-concrete).

Fig.2. Example of pedagogical plans

V. Conclusion

In this paper we have presented the benefits of the multiagent approach and the advantages it offers for designing and implementing a DIT. The architecture of the purposed tutor shows the structure of an agent and the cooperation of the heterogeneous agents.

The purposed DIT is centered on a pedagogue agent that is based on plans. This choice of design offers two sources of flexibility:

-- The first one reposes on the variation of pedagogical strategies.

-- The second one is justified by the choice of the teaching subjects and the learning mode.

Despite the difficulties we can encounter in the design of intelligent tutors, it is possible to develop intelligent tutors that can propose a variety of courses and thus allow any motivated person to acquire deep knowledge in a specific domain.

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