Agent-Based Elearning Environment

ABOUBEKEUR HAMDI-CHERIF (1), CHAFIA KARA-MOHAMMED (alias HAMDI-CHERIF(2))

Computer Science Department
Qassim University
PO Box 6688 – 51452 Buraydah
SAUDI ARABIA

(1),(2) Permanent Address : Université Ferhat Abbas Setif (UFAS)
Faculty of Engineering
Computer Science Department
19000 Setif
ALGERIA

Abstract—We describe an attempt of bridging the gap between web-based learning and agents capable of learning from experience. The emphasis is made on the interaction between two core fields, namely agents and Unified Modeling Language (UML) as a standard for Object Oriented Design. The tangible results remain the integration of agents for elearning based on machine learning methods such as entropy-based Decision Tree Learning, AdaBoost and First Order Inductive Learning (FOIL). As a special case of soft computing methods, fuzzy agents are used for profile personalization. Prospectively, much effort is still required to meet the actual challenges so as to scale up to real-life problems of any significant complexity.

Keywords—Advanced learning technology (ALT), e-learning infostructure, distance education, web-based instruction, multiagents, machine learning, learning from experience.

I. INTRODUCTION

Broadly speaking, elearning is synonymous with electronic learning, delivered via a broad array of technologies such as television, video tape, intelligent stand-alone tutoring systems, computer-based training, and the Internet. The structure of a typical elearning course is based on readings and exercises from simple quizzes to projects, on-line discussion, forum participation, live chat (audio and video), time commitment, and video-conferencing, amongst others. Specifically, distance education takes place when teacher(s) and student(s) are separated by physical distance and technology such as voice, video, data, and print, often in concert with face-to-face communication and used to bridge the instructional gap.

On the basis of previous experiences [1], [2], [3], [4], [5], we show how emerging technologies can be applied, in theory and in practice, to elearning settings. Each individual learns in a different way and behaves differently when learning. Actual systems are poorly adaptable to individual behavior of the end-user. That is why we propose to use the multiagent approach for its high flexibility and autonomy. This last concept can be summed up as the system’s adaptability to different and unpredictable situations and generating human-like decisions with no recourse to external help [6]. For so doing, we rely on soft computing methods such as fuzzy systems [7], on the one hand, and on machine learning methods, specifically entropy-based Decision Tree Learning (DTL), AdaBoost, and First Order Inductive Learning (FOIL), on the other hand [8]. The targeted result is a complete multiagent system to be built under constraints, partially known at the outset and progressively specified during the analysis phase and constantly refined during all design stages.

The paper presents the following structure. In the Section 2, we describe some of the most important elearning experiences undertaken in academia and industry. In Section 3, we describe a novel intellectual environment...
involving interaction between elearning and multiagents. Section 4 deals with architecture constructs. Section 5, reports the agents-free applications that we developed, complemented by the agents-based applications described in Section 6. A conclusion reports the main positive aspects of the proposed approach and hints to possible future extensions.

II. ELEARNING REVISITED

Numerous systems and web-sites are dedicated to elearning. We will only refer to some of the prominent experiences.

A. Academic Settings

(i) The KSU-UFAS experience
The UFAS-KSU project is a joint project between Université Ferhat Abbas Setif, Algeria (UFAS), and King Saud University (KSU), and recently Qassim University, Saudi Arabia, [4], [5], [6], [7], [8]. The aim in this project is the extensive use of Unified Modeling Language (UML) for the development scalable distance education platforms.

(ii) The MIT Open Course Ware (OCW)
Going forward, the OCW team is updating existing courses and adding new content and services to the site. At the time being (2008), 200 new and updated courses are scheduled each year. OCW remains one of the educational sites that have the highest number of visits with around 2 millions per month, in 2007. For more details, see [http://ocw.mit.edu/].

(iii) The Fathom experience
Columbia University's for-profit elearning venture called Fathom, adopted a strategy of marketing eclectic courses to the public. Fathom's member institutions present their knowledge across every area of interest - from business to global affairs, from arts to technology. [w.columbia.edu; www.fathom.com/].

(iv) The All-learn experience
[www.alllearn.org/]. At its beginning, the company offered on-line courses to the alumni of these universities only. The directories feature over 12,000 websites with 19 different subject areas. Now 50 courses in a dozen disciplines are available.

B. Learned Societies
The Institute of Electrical and Electronic Engineers (IEEE) [www.ieee.org] and the Association for Computing Machinery (ACM) [http://pd.acm.org] offer hundreds of courses and elearning facilities through their corresponding websites.

C. Elearning solutions from IT Companies.
U.S. News and brandon-hall.com have teamed up to compile a directory of nearly 600 vendors that offer software, courses, tracking systems, and other electronic corporate training tools [www.usnews.com/usnews/biztech/elearning/].

- IBM™’s elearning solution: the so-called IBM MindSpan™ Solution [www-3.ibm.com/mindspan]
- Sun™’s elearning solution: the so-called WebCT™ [www.sun.com].
- Blackboard™’s elearning solution: Blackboard 5™ [www.blackboard.com].
- Sun™ Center of Excellence. Sun™ and BlackboardTM teamed up in 1999 to establish the so-called Center of Excellence open in March 2002. [http://dotedu.wisconsin.edu].
- Macromedia elearning Suite™ from Macromedia™ [www.macromedia.com/software/elearningsuite/]
- KnowledgePresenter™, one of Australiа’s elearning companies’ products. [www.knowledgepresenter.com]
- GamaLearn, one of the few Arab companies established in Dubai, UAE, offers elearning solutions [www.GamaLearn.com].

2.4 Educational multiagents projects
Some educational systems include, but not limited to, the following.
- **I-Help** [10], a web-based application that allows students to locate human peers and artificial resources available in the environment to get help during learning activities, [11].
- **Pedagogical agents** Some interesting results have been achieved by regarding the student motivations [12].
- **Tutor agents** [15] are usually related to student modeling and didactic decision-making.
- **Multiagents for distance education** [16]. Multiagents are used to teach plane geometry for secondary education.

III. ABED - A NOVEL ENVIRONMENT

A. Refined Objectives
Our aim is to enhance the previous contributions by adding a UML layer to the approach. UML has indeed grown to an industrial standard of software design because of its many advantages such as abstraction, inheritance, polymorphism, encapsulation, message sending, associations and aggregation [17], [www.uml-zone.com]. The way how UML is used in elearning design has been reported in previous works [4], [5], [6], [7], [8]. Therefore it will not be described here.

B. Motivations: towards emergence of a novel technology
We describe our Agent-Based intellectual Environment for eDucation (**ABED**) [8]. The chosen agent-oriented methodology brings several advantages to the development of educational applications. Indeed, this methodology deals well with applications involving different entities with unique personalities such as elearners with various learning habits, instructors, course designers with different cultural backgrounds, while integrating different components of software, ranging from ready-made programs to customized development tools.

C. ABED Adopted Strategy
In order to meet the requirements of the proposed environment, we follow the following strategy.

<table>
<thead>
<tr>
<th>ABED Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. STRATEGY SET OUT</strong></td>
</tr>
<tr>
<td>Follow specifications set out by Learning Object Metadata (LOM) and Sharable Content Object Reference Model (SCORM) standards.</td>
</tr>
<tr>
<td><strong>2. AGENT-FREE STRATEGY</strong></td>
</tr>
<tr>
<td>2.1 Study the process involved in design / development of non object-oriented agent-free systems.</td>
</tr>
<tr>
<td>2.2 Repeat the previous step for object-oriented (via UML) of agent-free systems.</td>
</tr>
<tr>
<td><strong>3. AGENT-BASED STRATEGY</strong></td>
</tr>
<tr>
<td>3.1 Study the process involved in design / development of non object-oriented agent-based systems.</td>
</tr>
<tr>
<td>3.2 Repeat the previous step for object-oriented (via UML) of agent-based systems.</td>
</tr>
<tr>
<td><strong>4. AGENT-ON-DEMAND STRATEGY</strong></td>
</tr>
<tr>
<td>Study the process involved in “parametrized” systems based on agents on demand.</td>
</tr>
</tbody>
</table>

D. Overall Operation in ABED
In our proposed strategy, the first step is to follow specifications set out by standards such as Learning Object Metadata (LOM) [http://ltsc.ieee.org/wg12/index.html] and Sharable Content Object Reference Model (SCORM) [www.adlnet.org/]. After complying with adopted LOM and SCORM standards, the second step in the **ABED** strategy is to study the process involved in design / development of non object-oriented agent-free systems, culminating with the use of object-oriented (via UML) of agent-free systems. Agents are introduced in the third and fourth steps. Because of the specificity of the present article, we will concentrate on these last two steps. All agents have a similar general behavior, described in four main steps:
- **Initialization**
  The same environment is shared by multiagents, by objects representing the
solution constructed by the student, by objects describing the problem solved and simple objects representing candidate behavior. Initially agents choose no action.

- First interaction
  Agents perceive the environment. If an agent perceives in the environment the presence of elements represented, it becomes active. Since the agent is active, it is able to choose one set or more of candidate actions.

- Next interactions
  Agents keep updating their states according to changes perceived in the environment. Action occurs in turns and active agents can choose eventually other relevant set of actions.

- Stabilization
  When no significant changes are perceived in agent's states and actions, diagnosis is considered to be over. The state of an agent is conditioned by the presence of the elements perceived in the environment.

E. Possible Applications of ABED
Applications concern the following issues.
1. To meet student needs and offer guidelines for better learning skills.
2. To offer novel methods for improving interaction and feedback between students and instructors.
3. To improve design, planning and organization of courses and overcome computer limitations found in traditional elearning settings.
4. To identify instructional development and the key phases of the process including design, development, evaluation, and revision of courseware.
5. To set guidelines for agent-oriented evaluation of course delivery by specifying the types of evaluation.
6. To allow elearning institution management.
7. To point to common research questions such as agent-based learning vs. traditional elearning, the importance of multiagents, and cost vs. benefits.

IV. ARCHITECTURE CONSIDERATIONS

A. Chosen Design Specifications

The idea is to generate actions from percepts in a given environment. We consider the following specific tasks destined to both asynchronous and synchronous modes.

- Specific tasks are concerned with the following:
  * To help in the definition of learning material with the actors involved (students, instructors, ad hoc specialists, staff), their ways of accessing to the system and their communication tools.
  * To define the type of tests and detailed content of courses concerned.
  * To manage changes (add/remove/update) in courses and actors properties.
  * To manage students' registration and pedagogical evolution.
  - Design / develop / adapt associated tools and interfaces necessary for the task.
  - Initially consider only a small, but upgradeable, range of activities to be undertaken by agents. Upgrade activities from non object-oriented agent-free to object-oriented agent-based systems.

B. Overall Tasks and Operation
The basic structure of our architecture is composed of the following modules.

- Eadministration: a module that provides tools for elearners, instructors, staff, and others.
- Ecourseware: managing courses taking, course elaboration and presentation, synchronously or asynchronously.
- Forum: near-anonymity use for the enhancement of learning process such as course content, delivery method, system operation, among others.
- Newsgroup for offline communication and accessible to all relevant actors.

All subsystems are meant to be independent from course contents. This implies that contents structure has to be normalized so that it can be handled by the system's engine and in the same time has to be sufficiently flexible to maintain themes diversity.

V. AGENT-FREE UML-BASED TASKS
At this level of development, the main issue is to model easily-maintainable object-oriented systems using the UML. The main tasks deal with the design, maintenance and reverse engineering of eLearning systems using the UML. As far as agent-free UML-based strategy, there are two main phases:

**Phase 1:** Development of a comprehensive set of UML diagrams for a core Virtual University.

**Phase 2:** Implementation with state-of-the-art tools such as IBM Rational Rose™ or .NET™ Technology, allowing reverse engineering. We discuss both phases.

### A. Applied UML

Specifically, we have developed a set of UML diagrams for a core Virtual University [18]. At the design level, the proposed architecture considers most of the processes involved in a Virtual University. Starting from first principles, we constructed a model by drawing most of the UML Diagrams. We concentrated on Use Case, Class, Sequence, and Collaboration Diagrams. The actual model offers the following facilities:

- Student registration, course management, course attendance, with automatic check-up.
- Various forms of self-assessment and examination from early courses up to graduation:
  - On-line, off-line, quizzes, full exam.
  - Automatic, semi-automatic, manual grading, according to exam form.
- Other facilities to be added, because system is totally open.

### B. Implementation with state-of-the-art tools

Specifically, we have successfully used a state-of-the-art CASE (Computer Assisted Software Engineering) tool, namely IBM Rational Rose™, coupled with Microsoft™ .NET™ Technology, namely VB.NET™ to implement part of the characteristics described in the Section above [19]. Maintenance issues are resolved through IBM™ Rational Rose™’s capability of handling reverse engineering. Other facilities can easily be added, because system is totally open and supports reverse engineering facility.

### VI. AGENT-BASED DEVELOPMENT

The issue addressed, at this level of design, is agent implementation based on machine learning methods.

#### A. Fuzzy Agent-Based Development

After a thorough study of soft computing methods in eLearning, we use fuzzy logic for implementation of agent-based eLearning system [20]. The result is the development of a system that automatically constructs unknown characteristics of an eLearner. We apply here two major aspects of artificial intelligence i.e. fuzzy logic which expresses the idea of imprecision characterizing human endeavors, and agent approach which describes reactivity, pro-activity and/or autonomy. Blending these two approaches in an eLearning setting is a challenging task. Our system has handled this problem with a great degree of success since it provides eLearners with a fuzzy agent that helps in the construction of their profile automatically, on the basis of user past behavior. Furthermore, we used ad hoc tools for developing two levels with increasing complexity.

(i) **Implementation Strategy**

The first level, a traditional prototype, is implemented using Matlab™ [mathworks.com]. It is based on traditional non-object-oriented method. A second level uses an object-oriented method and is based on Microsoft™ .NET™ Technology, such as C#.NET™.

(ii) **Results**

Any eLearner using our system will be classified and advised on a unique basis. Thus, two different eLearners using the system will have two different behaviors from the system, e.g. two different screens. This contributes to a more personalized eLearning based on intelligent Graphical User Interface (GUI).
B. Agents and Machine Learning
At this level of design, the main issue considered here is the UML-based agent implementation of ad hoc advanced GUI. The specific goal is to devise platforms for cooperation between UML and agents.
We have studied the background of computational learning theory and we have developed general-purpose software implementing well-known algorithms. We concentrated our efforts on entropy-based Decision Trees Learning (DTL) and AdaBoost and First Order Inductive Learning (FOIL). Furthermore, we draw a useful comparison between these different classes of algorithms [21].

VII. CONCLUSION
As result of the interaction between UML and agents, a novel agent-oriented architecture for elearning is proposed. In addition to maintenance and modularity as key traditional concepts, autonomy is assured by multiagents which act for the benefit of the elearner considered here as a specific and unique entity. Through the mediation of our environment, elearners can enhance their ability to learn since they are indirectly helped during their entire search by agents. These tune their behavior according to user's behavior, thus generating a human-like assistance during the elearning process. Future work might include the use of automatic concept formation capable of clustering instances and their associated description into a hierarchy of categories. As the actual results stand, we can assert that our work has made a useful contribution that we believe is relevant to modern educational technology.

VIII. ACKNOWLEDGMENTS
Authors would like to acknowledge financial support of this work from King Abdulaziz City For Science and Technology (KACST), Riyadh, Saudi Arabia, under ID Contract MIM-SAD-11-2.

References

[www.cs.ubc.ca/~conati/publications.html].

"citeseer.ist.psu.edu/webber02twolevel.html"
{Carine.Webber, Sylvie.Pesty}@imag.fr