A GAME BASED E-LEARNING SYSTEM TO TEACH ARTIFICIAL INTELLIGENCE IN THE COMPUTER SCIENCES DEGREE

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ABSTRACT

Our students taking the Artificial Intelligence and Knowledge Engineering courses often encounter a large number of problems to solve which are not directly related to the subject to be learned. To solve this problem, we have developed a game based e-learning system. The elected game, that has been implemented as an e-learning system, allows to develop Artificial Intelligence Decision Making Systems of very diverse complexity level. The e-learning system discharges the students of doing work not directly related with the Artificial Intelligence and Knowledge Engineering problems. This way, students can try their development and self-evaluate their progression level. The results obtained after using this e-learning system with the students (during the Artificial Intelligence and Knowledge Engineering course) show a substantial improvement in students' learning outcomes.

KEYWORDS

E-learning, Collaborative Learning, Problem-based Learning, Game-based Learning, Artificial Intelligence Learning

1. INTRODUCTION

Computer science students are usually very willing to study subjects related to software development but when they deal with subjects with more abstract content, such as Artificial Intelligence and Knowledge Engineering, they often struggle. This means that the students usually require a greater number of hours for their learning, so the application of distance education systems in these subjects is clearly indicated, since they provide the student with a greater temporal availability of information.

However, given the type of subject to which we refer and the type of skills to be acquired, it is not enough for this distance learning to use a classic tool that is limited to improving access to content or providing exchange information forums. Recently the concept of community within the courses has been taking force. These communities enhance the collaborative learning. In this way, the students themselves actively participate in the training by providing information and valuing the work of their peers (Fajardo et al. 2015).

The present work describes the initial assessment, the development, and the final results from the innovation project carried out in the context of the Artificial Intelligence and Knowledge Engineering courses, within the Computer Engineering degree. The implemented platform enables students to develop and test their work, in individual and cooperative ways, on intelligent systems for decision making. The advantages of using a game as the platform are, among others, a higher motivation from students and a limited domain that does not need external experts.

After using the e-learning systems (developed to address the practical contents of the courses), the results from evaluations clearly justify the work carried out.

This paper is organized as follows. Firstly, in Section 2 we provide some background about both Artificial Intelligence and Knowledge Engineering which are the subjects for which the e-learning system have been developed. This section also introduces the characteristics of the game elected to develop the system. In section 3, we briefly explain the game based e-learning system, its operation and the benefits that it brings to students. Section 4 presents the academic results before and after the students use the developed system. Finally, Section 5 points out some conclusions and further developments.

2. BACKGROUND

Artificial Intelligence aims to reproduce human behavior through computational systems. In this way, it tries to obtain systems that are able to respond to consultations or situations as if they were a human being.

Artificial Intelligence reached great achievements with the development of Expert Systems (Ignizio, 1991). Knowledge Engineering is the area of Artificial Intelligence that works on the development of Expert Systems or Systems Based on Knowledge (Frost, 1986). Knowledge Engineering focuses its efforts on the development of high performance systems specializing in certain professional domains and researches methods and techniques to develop man-machine systems with expert problem solvers.

Feigenbaum presented the following two fundamentals ideas in the International Joint Conference on Artificial Intelligence of 1977 (Feigenbaum, 1977):

- The power of an expert system derives from the knowledge it possesses, not from the particular formalisms and inference schemes it employs.
- Expert knowledge provides the key to high productivity, while knowledge representations and inference schemes provide the necessary mechanisms for their use.

Traditionally, for the coursework of the Knowledge Engineering course, students develop prototypes of systems capable of performing decision-making using context information. These assignments have the following problems:

- There are no human experts who students could apply techniques of acquisition of knowledge for the later modeling of a system.
- It is necessary to choose an area of knowledge in which to make decisions. As they are real areas of knowledge, they are not bounded. For this reason, a lot of time is spent in the work of information retrieval and little in the development of Artificial Intelligence techniques.
- Students spend a lot of time developing visual interfaces. This interface is not the fundamental part of his work for this course but it is a necessary part to assess the proper functioning of his work.
- Usually, the motivation of the students reflects on their interest for the elected topic to develop the prototype, and not all the topics proposed by students are equally valid for the development of the practices.

To tackle these problems, we have decided to change the work to develop and in this change one of the priorities is to do more attractive the work to develop to pass the course.

2.1 Games, Artificial Intelligence and Engineering

Traditionally, game playing has been an area of research in Artificial Intelligence. Games such as checkers and chess have been used to prove the power of Artificial Intelligence methods since the beginning (Schaeffer, 2008). There are references of this research since the 50s (Copeland, 2000). To highlight the achievements of these works we can mention the defeat of Garry Kaspárov by IBM's Deep Blue computer in 1997 (McCorduck, 2004).

From the early days to the present, Artificial Intelligence in games has evolved notability. Today is unthinkable to develop a game that does not have any Artificial Intelligence in it. The use of Artificial Intelligence in videogames is making a better user experience. Now, the quality of Artificial Intelligence is a high-ranking feature for game fans in making their purchase decisions and an area with incredible potential to increase players' immersion and fun (Nayerek, 2004).

The use of Artificial Intelligent in the software development gets results that are far from repetitive models and patterns. For this reason, Artificial Intelligence techniques are used every day in any area that aims to simulate human behavior, from video games to computer animation. Scenes of movies as famous as The Lord of the Rings or Avatar include Artificial Intelligence in their development.

In addition to the previous information we can say that games have been used in the education of engineering students and professionals for decades (Hauge et al., 2012). Similarly, a variety of games have been developed and proved successful for the mediation of skills in complex systems (Windhoff, 2001).

After these reasons, using games as a tool to teach Artificial Intelligence and Knowledge Engineering is clearly justified. But we also think that games are highly attractive to students, both from the perspective of the game itself, and from the perspective of doing the work to get specific milestones.

In this way, we have changed the work to pass the subject's coursework. Now the student should develop a prototype of intelligent player of a tactical game. This idea is based on the fact that games have traditionally been of fundamental importance in the research of Artificial Intelligence. The development of a game is reduced to a set of decisions making in a bounded environment, depending on the information provided throughout the game. The complexity level of the universes where the games run can be very different. Games can also reproduce environment and situations with a high level of realism and, in addition, it is a well-known fact the addiction that games can generate on their players.

For these reasons, we have designed and developed a parametric game based e-learning system to use for the coursework of the aforementioned courses. In this system, the game is the main component. This e-learning system enables the interaction between humans and automatic gamers (prototypes of decision making systems) developed by the students.

2.2 The Elected Game

To implement the coursework over a game, we have to guarantee that it fulfills a set of fundamental characteristics. The chosen game must be attractive (addictive if it is possible), complex enough to ensure that the student may develop such sophisticated systems as their personal capacity will allow, and parametric to ensure that the game features change for different years.

To meet our needs, we have chosen a tactical game in which a set of robots fight a battle on a particular terrain. At each moment of the game, players must make decisions based on the terrain, the state of the robot and its location on the map.

We can see that the use of the chosen game as an environment for the realization of the subject's practices guarantees the solution to the problems previously discussed because now:

- Instructor and students themselves become experts, so students can apply knowledge acquisition techniques for later develop making decision systems.
- Now the scope is clearly bounded, so students can spend much more time applying artificial intelligence techniques.
- As the e-learning system has an interface, the students do not need to develop it. Again, the students have more time to spend developing the artificial intelligence techniques for their own decision-making system.
- Usually a game is an interesting topic to develop thus achieving greater student motivation. As the game has been specifically chosen for this coursework, it is appropriate to teach decision making systems to the students, and it has the same complexity level to all of them.

3. THE GAME BASED E-LEARNING SYSTEM

For all the above, the main goal has been to develop and introduce a specific e-learning system to be used for the coursework of the Knowledge Engineering course. The system takes the form of an on-line game with a graphical interface that allows to the students to test their pieces of coursework in an individual and cooperative form. This way, coursework changes from developing an intelligent decision-making system in an unspecified domain to developing an intelligent player capable of make decisions in the on-line game. For this, the students develop a multiagent system (Wooldridge, 2009) that is later uploaded by a web interface to our e-learning system.

The game has been developed over a web system. In this form, the students can test the performance of their coursework in an interactive way at any time and place, with the only restriction of needing a network connection. This fact makes it easier for the students to develop their work for the subject, adjusting to their own rhythm of study, without temporal or physical limitations, even allowing the students to dedicate additional time to the coursework.

Another additional goal of the e-learning system is that students can test the performance of their intelligent players against players developed by other colleagues, in a healthy competition among peers that allows them to deepen in the goals of the subject.

The game platform developed is fully parametric, enabling the instructor to change some features of the game to obtain substantially different problems to solve. We can assign different coursework to students each

academic year. These parameters are set at the beginning of the academic year, before the beginning of the course. After this, the students must study the settings of the game being used and adjust their developments to those characteristics. This software feature assures that coursework is not copied from one call to another, and forces the students to understand the presented problem and its context.

When the game start, the system runs the players' software and shows the game progress in the screen (Figure 1). The students can see how their robots (their Artificial Intelligent System) make decisions.

In a detailed form, the operation within the system is described next.

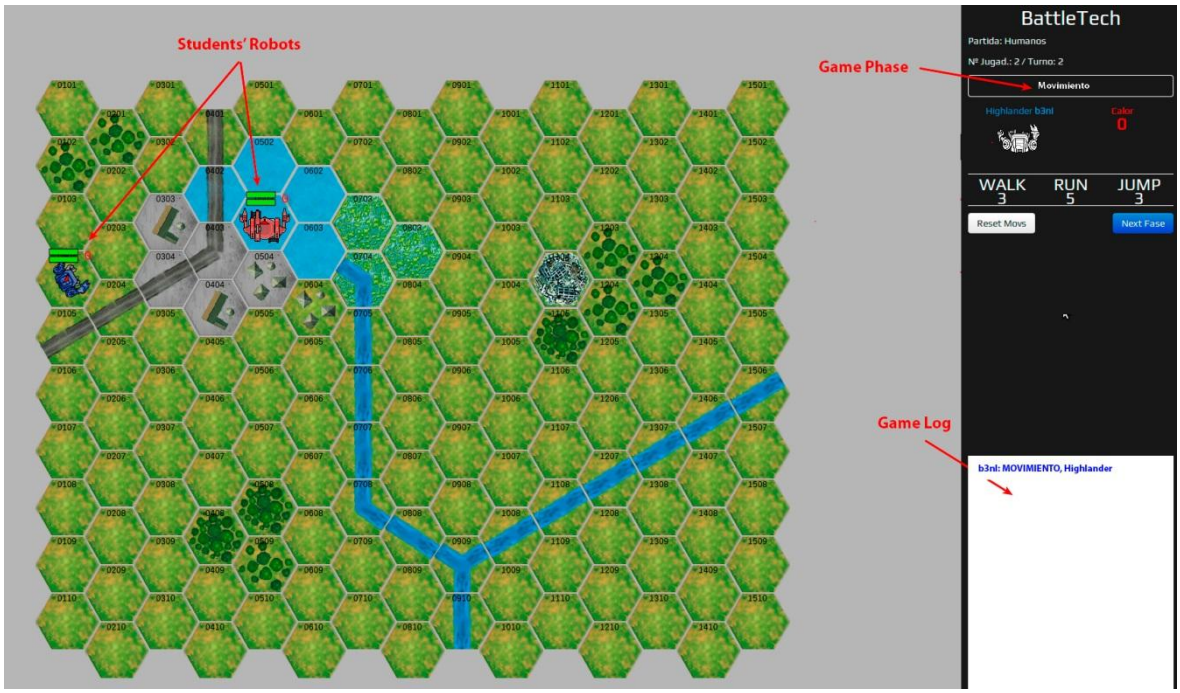

Figure 1. Screenshot showing the game board with trees, lakes and elevations, and two players' robots

- The student logs in the e-learning system. After this, the e-learning system shows the active games. The student can select to play an active round, to create a new game or to manage his Artificial Intelligence System (Figure 2)
- If a student selects to manage her Artificial Intelligence Systems, she can upload new Systems (the Artificial Intelligence Systems are developed by students using Python), update existing Systems, see errors of the last run or delete Systems.
- If a student decides to select the new game option, an interface gives her the necessary tools to generate a new game. The new game will be configured as a battle with the intervention of two or more players, and can be a closed game (only the players selected during the game creation can play) or an open game (the e-learning system permits that any user can later join the battle).

Usually in the first stages, students define battles of two players where a player is his Artificial Intelligence System and the other player is himself (It is possible to play in an interactive form using an interface). In this form, when the user plays against his System, she can evaluate the quality of her own work.

Figure 2. Game selection

When the students have theirs Artificial Intelligence Systems in advanced stages of development, they often begin to generate games with lots of players (open or closed) using the Artificial Intelligent Systems stored in the e-learning system.

This way, students have two self-evaluation levels:

- A first level, when they compete again themselves (student vs. her Artificial Intelligent System)
- A second level, when they compete against other students (student's Artificial Intelligent System vs. other students' Artificial Intelligent Systems).

The feedback achieved when the student competes against herself is the most important, because when a student gets a System that can beat her, she has really achieved an Artificial Intelligent Systems that plays as herself (or even better!).

It may seem that the feedback achieved in the second level (vs. others) only gets the student and her Artificial Intelligent System (if she uploads it) to play better.

But this second level of evaluation makes the student part of a cooperative system, since the improvements made in her software (software that she later uploads to the e-learning system for testing) are contributions that help to the improvement of their peers' systems.

Obviously, there is a large part of the system designed to control battles. These modules must ask the players (software or human) for the movements and other actions for combat, verify their legality with respect to the configuration established for the game, manage the results of all the actions of the players and show all the information through the system interface.

4. ACADEMIC RESULTS

The e-learning system has been fully deployed in the teaching of the Knowledge Engineering course. Since the students started using the system, they have achieved a deeper understanding of the contents of the course and have more easily reached the competences of the subject. This is mainly due to the new platform encouraging a greater temporal dedication to the learning of the specific content of the subject and to the practice of the associated skills, removing other tasks not directly related to the course. This has resulted in an increase in the success rate of students in the course.

These assessments are demonstrated through a notable improvement in the students' marks, achieving an increase in the success rate of the students compared to the levels of the previous years. The students themselves value very positively the realization of the coursework using the gaming platform, and recommend it to be used in subsequent years.

As we can see, the percentage of students evaluated that passes the coursework of the subject is, after the implementation of the e-learning system, clearly higher than in a previous course (Figure 3).

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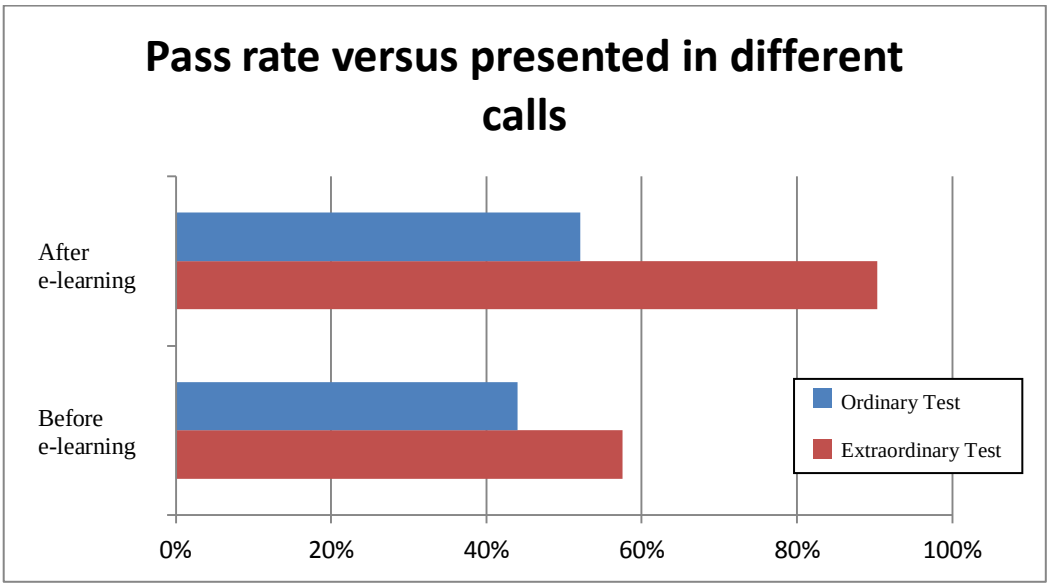

Figure 3. Rate of success in the practices of the subject (students approved on students presented).

5. CONCLUSION

This work shows the teaching innovation made in the course Knowledge Engineering of the degree in Computer Engineering.

The coursework for this course focus on building an intelligent system for decision making. However, several aspects made the academic progress of the students not appropriate to the goals of the subject. Among the main problems were the diversity of work domains, the lack of motivation of the students in the specific problem, or the need to develop additional software components that had nothing to do with the subject, but were necessary to achieve the objectives.

After identifying such problems, we have developed a game-based e-leaning system, on which students must develop intelligent players. Additionally, the e-learning system prevents students from having to develop additional tools for their coursework and facilitates that they focus their work efforts on the objectives of the course in an individual and cooperative form.

The interest shown by the students has increased significantly since a game is used to develop and evaluate the practices of the subject.

The use of new methodologies to teach computer science, as well as to do it from a didactic and practical perspective, is in accordance with the principles expressed by the National Agency for the Evaluation and Accreditation (ANECA) for the Degree in Computer Science (ANECA, 2005), agreed by all the Spanish universities that teach said studies.

The results of use the e-learning system during the last courses of the subject have been very positive, both for the students and the teachers.

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