Multi-Agent-Based Simulation as Interdisciplinary Tool

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Abstract

This paper presents some case studies with undergraduate and graduate students that they were introduced in agents and multi-agent-based simulation areas, basing in experiments with these computational techniques. The main goal was to develop skills in interdisciplinary phenomena.

Keywords: *Multi-agent-based simulation, Interdisciplinary.*

I. Introduction

Multiagent Systems (MAS) area studies the behavior of a set of autonomous agents, possibly with different features, evolving in a common environment. These may interact with each other, in order to perform their tasks in a cooperative way, sharing information, avoiding conflicts and coordinating the implementation of activities [1]. Additionally, the use of simulation as an aid in human decision-making tends to be very effective because your job allows examination of specific details with great precision [12]. The integration of agent technologies and simulation is called Multi-Agent-Based Simulation (MABS), which is especially useful in areas where interdisciplinary is present [8].

According Fazenda (1994)[6], interdisciplinary is a line of research of modern times, which emerged in France in the 60s, in order to tune the teaching to large issues, as social, political, economic and scientific, and these issues which could not be solved by a single discipline or knowledge area. Interdisciplinary gained traction in educational institutions, whether at primary, secondary or higher, especially in their speech. However, studies have revealed that interdisciplinary is still little known and practiced [2].

The MABS area has great research activity in graduate school, including counting in several programs with specific subjects. However, the use of this technique with undergraduate students, in computer science courses, is still restricted. In under graduation, the subjects related to Artificial Intelligence (AI) are varied, such as Neural Networks, Genetic Algorithms, Fuzzy Logic, among others. Thus, deep studies with agents and multi-agent-based simulation can not be done.

This paper presents case studies with graduate and undergraduate students, who were introduced to agents and MABS areas and conducted simulation experiments in two environments: first, in an environment quite simple to use, working with a formation of structured rules in Portuguese, called SIMULA [7]; after, in a more complex and complete environment (related to possible resources), called NetLogo [10]. The main purpose of these case studies was to determine whether the use of MABS can be used as a tool for interdisciplinary studies, and if students had consciousness during their activities.

The paper is divided into four sections. Section 2 presents the concepts of agents, simulation and MABS. Section 3 presents the case studies and Section 4 shows the conclusions and further works.

II. Multi-Agent-Based Simulation

The simulation methods are used with great success as an aid in making-decision, especially in the medium and long term planning and in situations involving high costs and risks. Simulation models are very effective and versatile in the study of many different problems. Their use allows examination of specific details with great precision [11].

In this way, computer-based simulation is one of the most powerful tools available today to design, plan, control and evaluate new alternatives and/or changes in strategies in real-world systems. Its use means building computer programs (software) that 'represent' the real world and 'imitate' its operation [8,11]. The simulation can be divided in three steps [12]:

- Modeling Step: build the model of the phenomenon to be studied;
- Experiment Step: apply variations on the model constructed by changing parameters influencing the resolution process;
- Validation Step: compare experimental data with the model and reality, allowing the analysis of the results obtained.

The combination of both, multiagent systems and simulation, generates a new research area called Multi-Agent-Based Simulation (MABS), that deals with problems that involve multiple domains [7]. An example of a MABS application domain is medicine and how the diseases are disseminated. Typically, it involves researchers from various scientific areas, such as social psychology, computer science, social biology, sociology and economics. The interdisciplinary character of MABS is an important challenge faced by all researchers, while demanding a difficult interlacement of different theories, methodologies, terminologies and points of view.

MABS has provided architectures and platforms for the implementation and simulation of relatively autonomous agents and it has contributed to the establishment of the agent-based computer simulation paradigm. The agent-based approach enhances the potentialities of computer simulation as a tool for theorizing about social scientific issues. In particular, the notion of an extended computational agent, implementing cognitive capabilities, is giving encouragement to the construction and exploration of artificial societies, since it facilitates the modeling of artificial societies of autonomous intelligent agents.

According to Drogoul and Ferber (1992) [5], MABS goals are:

1. Testing hypotheses about the emergence of social structures from the behaviors and interactions of each individual. This is done by testing the minimal conditions given at the micro-level that are necessary to observe these structures at the macro-level;

2. Building theories that contribute to the development of a general understanding of ethological, sociological and psycho-sociological systems, by relating behaviors to structural and organizational properties; and

3. Integrating different partial theories coming from various disciplines, as sociology, ethnology or cognitive psychology, into a general framework, by providing tools that allow the integration of different studies.

III. CASE STUDIES

The case studies were conducted with students of the Universidade Federal do Rio Grande (Brasil) with undergraduate students (4th year of Computer Engineering) and graduate students (Master in Computational Modeling).

In the under graduation discipline, there are many AI subjects to study, as Neural Networks, Fuzzy Logic, Bayesian Inference, Genetic Algorithms and Agent. In the agents' part, the students studied agents, involving communication, organization, decision making and simulation. In the graduate discipline, the students studied simulation and simulation models (micro, macro, and dynamic multiagent based).

For the two disciplines, two works were required based on multi-agent simulation: one using SIMULA environment and other using NetLogo environment.

The proposed outline for the work was as follows:

1. Choose a problem to be modeled;

2. Specify the agents and rules of the problem;

3. Specify the problem environment;

4. Implement the problem in SIMULA and NetLogo;

5. Prepare a report showing the evolution of the agents during execution (one for each environment).

The idea was that the description of the work to be as generic as possible, giving students the opportunity to choose their problems in different areas of knowledge.

Steps 1, 2, 3 and 4 in the work description are directly related to the steps required to model a phenomenon from the MAS [8]. Requesting a report with the evolution of agents (step 5) was the way shown to students how primitive behaviors of each agent can influence the overall behavior, even if not implemented directly.

The proposed works are directly related to the goal of "test" hypotheses about the behavior emergence cited by Drogoul and Ferber (1992) [5], since the students would not build theories for understanding phenomena.

A. Examples of Implemented Works

The works were carried out individually or in pairs. Knowledge areas to model the problems by students were very diverse, as biology, economics, physiology and games. There was no requirement that the second work (in NetLogo) to be the same problem that developed in the SIMULA. However, many students chose to develop work the same in both environments, because there is no need to learn a new problem domain for the second implementation.

SIMULA Environment

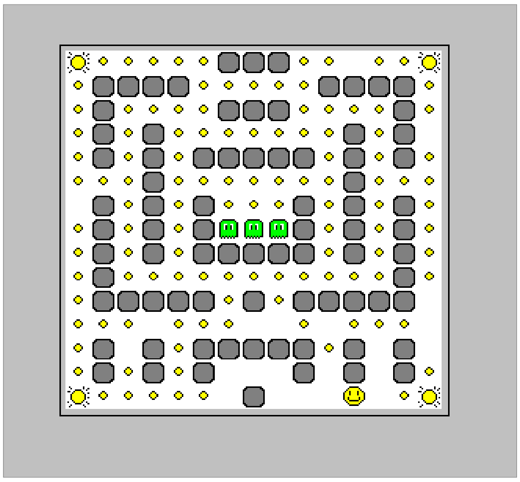

Fig.1: Example of simulation in SIMULA: Pacman

Figures 1 and 2 show some of the work done by students in the environment SIMULA.

Figure 1 shows how students implemented the popular game Pacman. Students defined the agents Pac, Ball, Ghost and Wall, and movement rules, where Pac (face "smiles" in Figure 1) looks for the balls (small yellow circles) and Ghosts (green) seek the Pac. The agent Wall is a static object that was used to assemble the environment labyrinth (gray squares). The goal of the simulation is that the Pac "eat" all the balls and it is not eliminated by the Ghosts.

Figure 2 presents the implementation of Immunologic System when attacked by a virus. Students defined the agents GoodCell, InfectedCells, Virus and Antibody. The simulation starts with a large amount of GoodCells (circles with black outline in Figure 2), a low amount of virus (in green) and a very low amount of antibodies (blue). Viruses, when they find GoodCells, attack and these cells become InfectedCells (circles outlined in red). However, the virus priority is to run out of an Antibody. Antibodies, when they realize that the InfectedCells number grow, reproduce and try to kill the virus. Antibodies try to recover the InfectedCells to restore the stability of the system, i.e. stop the virus.

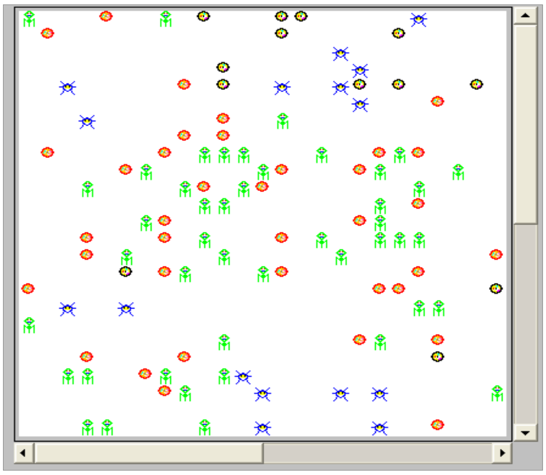

Fig. 2: Example of simulation in SIMULA: Immunologic System

Besides the two presented examples, some very interesting works have been implemented, such as: Simulation of the spread of Dengue disease, which was presented as mosquitoes breed, showing the stages of egg and larva, and attack and infect people; Simulation of a state of war between two armies, where different strategies have been created, and depending on the configuration of each army, one may be better than the other; Simulation of Detective Game, where the killer may be disguised among the people, and not be discovered.

NetLogo Environment

Figures 3 and 4 show some of the work done by students in the NetLogo environment.

Figure 3 shows how students implemented the H1N5 virus (bird flu) spreads. The initial contamination in wild birds previously contaminated that transmit the virus through feces contact or the soil or water in which these feces were posted. Because of its high concentration in a short space, this flu spreads very rapidly among poultry, reaching to humans. People acquire the virus similarly by manipulating bird flu infected by coming into contact with your blood or feces. Transmission between humans is rarer but still concern.

Students defined the agents Farmer, Sylvester Ave, Domestic Ave and Person. The simulation begins with the desired number of all agents (in blue boxes on the left side of Figure 3), whereas the environment allows the creation of custom graphical interface in an easier way.

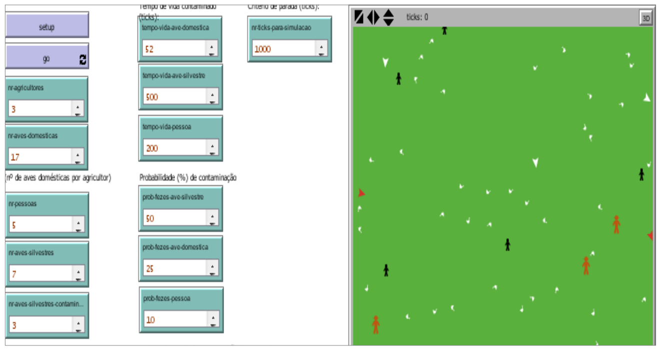

Fig. 3: Example of simulation in NetLogo: Operation Contamination Virus H1N5

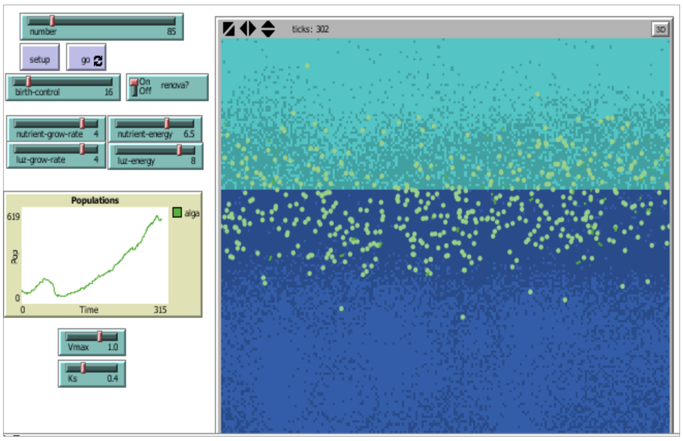

Fig. 4: Example of simulation in NetLogo: Ecosystem Microalgae / Light / Nutrient

Figure 4 shows how students implemented an ecosystem containing microalgae, light and nutrients. Microalgae move randomly, as well as light and nutrients are renewed in the same manner. When a microalgae find light or nutrient, it absorbs energy to survive. The effects of light and nutrients can be be set with different values via the interface, creating a hostile or nicer environment for microalgae. Students defined three agents: Microalgae, light and nutrients. The environment is also divided into two parts: the deep sea (in dark blue), where light can not penetrate completely and for this is colder and microalgae expend more energy to stay alive, and the sea surface (in light blue), where light penetrates thoroughly and it has more nutrients. This work presents graphics with the evolution of the population in simulation time. This is another advantage of the use of NetLogo.

Besides these two presented examples, students also implemented other works, such as: Simulation of frog life cycle, egg, maggot, tadpole and frog; Simulation of a state of war between the four countries, where different strategies were created, based on strength and weapons available; Simulation of security engineering, where there is time to evacuate a place.

IV. Conclusions

MABS is an extremely interdisciplinary area and can be applied to various fields. The use of a agent-bases simulation tool makes the process of learning easier in this area. There are several tools available, as Cormas [3], SWARM [4] and Madkit [9].

The choice to SIMULA and NetLogo are due to the fact that they are extremely simple to use.

In the case of SIMULA, the tool has several restrictions such as number of agents, environment size (grid) and definition of movement rules (pre-defined routines). This tool works just with reactive agents and it does not support the communication. Its great advantage is the implementation in Java, allowing use on different operating systems.

In the case of NetLogo, a major constraint is the language used to implement, the LOGO. However, the tool is extremely comprehensive, allowing large numbers of agents (thousands), drives, communication and use of cognitive and reactive agents. The creation of graphical user interface is facilitated, allowing initialization of variables, definition of graphs, etc. Furthermore, a tool is very stable.

For activities for undergraduate and graduate proposals, the students were introduced in agent area, starting with SIMULA, that is simpler and it attend all requirements for multi-agent-based simulation. Next, they were introduced to NetLogo, a more complex environment (related to the amount of possible facilities). This methodology helped in the students training in agent area, broadly corresponding to the proposed objectives. Undergraduate students were given more time to develop the proposed activities. However, both students did good works, very productive, because they could choose the themes, and they developed high level works.

To carry out the work, the students were encouraged to study and think "how" chosen problems functioned, in order to model and subsequently, implemented the simulations. Interesting to note that all choices were problems of “non-exact” areas, such as physiology, biology and games, proving that the interdisciplinary was put into practice. Thus, in a didactic point of view, the results of the proposed work were completely positive because the students learned a new computational technique and applied it effectively.

As future work, expected to carry out new experiments, making an analysis of how these problems can be resolved without the use of MABS, and if this technique facilitates the process as a whole.

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