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The Impact of Effective Communication between Users in 3D Collaborative Virtual Environments: the conversational agent use case

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Abstract *— This paper aims to aid in the development of interactivity in virtual worlds, especially within the context of a virtual museum that serves the purpose of introducing its visitors to computing and basic electricity. We opted for the use of software agents with instructional and interactive purposes, which were personified as intelligent avatars serving as guides to a museum. This paper presents both a virtual 3D museum about the history of computing, developed using the OpenSimulator virtual worlds platform, where its 3D modeling and development tools were used with the help of scripts, as well as the focus of the project, which is the development of software agents. For the sake of achieving the objectives of this work, a research was conducted with a case study in order to verify whether the use of an intelligent agent in a virtual world can facilitate or support in the process of teaching and learning providing knowledge about the historical part of computing. The construction of this environment, integrated with an intelligent agent named AGIMC (the portuguese acronym for Intelligent Agent of the Museum of Computing) used the public web server pandorabots. To verify the feasibility of using the environment, a case study was carried out, which demonstrated that the use of these environments does contribute as a mean to support teaching, but there are also some technological limitations that may hinder its practical use in the educational context. An assessment was carried out with IFRS (Federal Institute of Rio Grande do Sul). The results obtained during the evaluation with the students met our expectations, obtaining good results and indications that the agent did support the student's conception of knowledge in the discipline introduction to computing, despite some difficulties found in its implementation.*

Keywords *— **Virtual Worlds; OpenSimulator; Virtual Museum; Software Agents.***

I. INTRODUCTION

Usually, both computing and related areas have in their curricula an introductory discipline to the area of computing, which seeks to explore the history of computing and its relation to the main uses and applications of computers, presenting students with an overview of the scope of computing in the most diverse segments of society. The best regarded books in the study of introduction to computing also address these topics, as well as aspects of a computer's functioning and its programming languages [6], [5].

In this context, different approaches have been proposed to add to the classes considered "traditional", among them the use of simulations, computer games and virtual environments [4], [11]. Such strategies seek to make the student become an active being in the process of learning, as opposed to the classical view of the content receiver. The constructivist use of 3D immersive virtual environments advocates the construction of knowledge from "x" to "x + 1" by balancing cognitive structures as an interactive learning process, conditioned on the balance between heredity and central nervous system maturation, physical and logical-mathematical experiences and the social transmission of knowledge

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[13]. That environments also enhance the collaboration and interaction process promoting a new educational paradigm, where students act on this knowledge, manipulating content in various ways and, consequently, analyzing, exploring and giving it meaning, [17].

One possibility is the use of Virtual Worlds in support of education, [12] which enable a series of educational and training activities to be carried out. Considering these premises, the development of a virtual museum immersed in a 3D virtual world began, where students can carry out a virtual tour through the history and evolution of computing. There, they may interact with artifacts from different eras, providing them with both general and chronological views of subjects regarding technologies, personalities, concepts and related subareas.

In this sense, it is possible the students to interact with an elementary electricity experiment designed to work on basic concepts of electrical current, voltage and resistance due to the need for its application in computational logic circuits. This experiment was designed to be in line with Piaget's approach to the need for progressive and reversible actions (such as increasing or decreasing the resistor R1 electrical resistance value) to become concrete and formal cognitive operations [13].

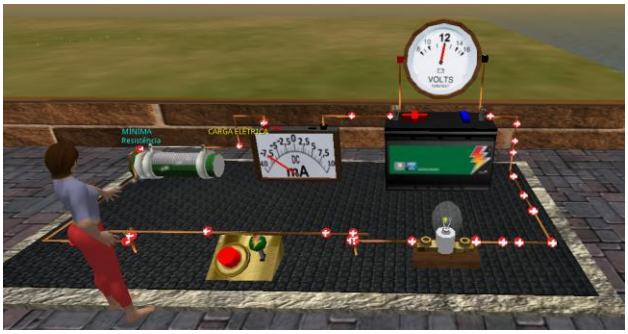

Fig. 1: Elementary electricity experiment

This article aspires to insert intelligent avatars into the aforementioned context. These should interact with students, playing the role of guides to the museum, [4]. They may act in two different modes: as informational agents, who offer help so that the students can have an orientation about the museum and its galleries; and as intelligent conversational agents, or chatterbots, that respond to users' questions, contributing with information and knowledge about the artifacts, potentializing the teaching and learning process of students. Moreover, the agent may also act as a companion through social dialogues, searching for a greater interaction and proximity to students immersed in the environment.

II. CONVERSATIONAL AGENT

For Russell and Norvig [13], an agent is something that perceives and acts in an environment, being able to perceive its environment through sensors and to act on this environment through actuators. Wooldridge [15] conceptualizes an agent as a program that assists the user in performing some task or activity. Smart agents are basically a system capable of making decisions and interacting with the environment or other users based on some data source. Every intelligent agent must have at least four characteristics [16]:

1. Autonomy, having control over its actions;
2. Reactivity, perceiving changes around it;
3. Sociability, interacting with other agents through some kind of communication language;
4. Pro-activity, not only reacting to the environment, but taking initiative when convenient.

The term intelligent agent can be used to refer to any software agent that has some sort of intelligence. Artificial intelligence (AI) has exerted a very strong influence over the field of agents and has already displayed a great evolution [16].

Fig. 2: Communication agent

According to Russell and Norvig [13], before starting the design of an agent, a clear idea regarding the possible set of perceptions, actions, objectives and the environment in which the agent will act will have to be well defined. This set is known as PAGE (Perceptions, Actions, Goals and Environment).

Russell and Norvig [13] propose several agent architectures: reactive agent, reactive agent with an internal state, objective-based agent and optimizing agent. Within these architectures different types of agents can be developed: agents for simulations, commercial agents and conversational agents, as well as educational conversational agents which are the focus of this article.

Guetl [7], the concept of an intelligent pedagogic agent comes from the meanings of the names agent and

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intelligent and pedagogic agent. The agent is a software component that can act by itself in a goal-based environment. In the educational context, the intelligent agent has pedagogical abilities to achieve educational objectives. The agent provides personalized instructions, improving student motivation. Each agent acts and interacts with the environment based on the goals to be achieved.

Intelligent agents are attractive for contributing to learning environments especially for group work involving individual learning and decision making as well as group learning activities. This requires strong intellectual interactions and social skills between individuals, [16]. Work related to this will be discussed in the next section.

III. RELATED WORK

Related to this work are projects such as the "Greybeards Project" in which virtual guides are created for virtual worlds that can help people in their journeys. This project originally started using another platform for the chatterbot's AI. Sun Tzu - The Greybeards Project [14] is now using Daden's Artificial Intelligence technologies inside the game Second Life [14]. This advancement in Artificial Intelligence offers many features for using automated avatars in virtual worlds for training and as virtual guides, such as guided tours, avatar movements, teleportation, chatterbots, instant messaging, Twitter updates and the ability to learn from the environment. It uses web scraping technology, allowing the Virtual Guide to answer users' questions using a web service database such as Wikipedia to provide it with data to respond to these questions [14]. This work is very similar to the work proposed in this article, since agents are used as virtual guides, using artificial intelligence techniques so that the agent answers questions using its database, although now inside the Second Life virtual world context. The proposed agent is a conversational one and it also answers the user's questions about the history of computing, but in a different open source platform, called Opensimulator.

Refund.me is another Virtual Assistant. It serves a flight company as an assistant and also functions as a smart helpdesk. InteliWISE is a service software, which provides buyers with immediate answers to most of their questions, at a more cost effective service. It has the smart combination of search, with a very minimalist look and intuitive page navigation, providing immediate answers. [8]. Thus, this work is differentiated from the work proposed in this article, because it is designed to be a virtual assistant and a web page, not being used in an immersive environment.

IV. PROJECT

This chapter presents the implementation of the conversational intelligent agent called AGIMC, a Portuguese acronym for Intelligent Agent of the Computer Museum. Some characteristics of the agents are necessary so that the active elements can interact with the other elements and with the virtual world. "Fig. 2" shows the elements that bring the viewer, the interface and avatar agent conversational [3].

Fig. 3: Agent conversational

Fig. 4: Architecture effective communication

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Fig.5: Implementation Pandorabots

Regarding the software implementation, Figure 3 Architecture effective communication. It also illustrates the entire necessary computational structure, starting with the MySQL database, which is free and open source, followed by MOODLE, which is the virtual learning environment, where all the theoretical material regarding the content is added. There is also OpenSim, the 3D virtual world creation environment, and SLOODLE, which interconnects them, allowing classroom data such as videos, slides and texts to be displayed dynamically in the virtual world. An AIML database was also created on a public server called pandorabots at Figure 4 for storing software agent categories. All these software are installed and stored on the server with the Linux operating system, all of them free and open source. it the use of scripts it was possible to make the museum's artifacts interactive, making the environment more attractive to the student, increasing his attention during the visit. The museum structure is divided into an entrance hall, four exhibition galleries and two rooms. In the entrance hall is the museum agent, as well as a map of the museum for students to orient themselves and an environment for the visualization of an introductory video about the museum, presenting its structure and its main attractions.

The framework was developed using OpenSim's 3D object modeling and creation tools, as well as the use of scripts for some interactive parts of the artifacts. The student can interact with the artifacts inserted in the scenery of the museum and some galleries that compose the Museum of Computing.

For the NPC creation stage it was necessary to make some modifications to certain lines of code in the "OpenSim.ini" file, as shown in the official OpenSim page. The NPC (Non player character, i.e., a programmable character in virtual worlds) was created. In this way the user will have the feeling that he is interacting with another avatar, which will give him a sense of constant mentoring. Configuration commands should be adjusted. Table 1 presents the necessary changes to the OpenSim.ini file.

Table. 1: Changes needed in OpenSim

1. Allow_osNpcCreate = true; 2. Allow_osNpcMoveTo = true; 3. Allow_osNpcRemove = true; 4. Allow_osNpcSay = true; 5. Allow_osAvatarPlayAnimation = true; 6. Allow_osAvatarStopAnimation = true.

The [XEngine] has been changed in the [GridInfo] section and the following specific lines of NPC functions were added. Table 2 shows the changes:

Table. 2: specific lines of NPC

1. Enabled = true in the [NPC] section; 2. Enabled = true in the [XEngine] section; 3. AllowOSFunctions = true in the [XEngine] section; 4. OSFunctionThreatLevel = VeryHigh in the [XEngine] section.

After this part of the configuration is complete, the OpenSim.ini file has been saved. It should be noted that such changes will change all regions. The following scripts were created in a prim (virtual world object) NPC trigger. When this object is touched by the avatar an NPC will be instantiated. Following inside the object (prim) was created another script called "Appearance". To visualize the appearance it is necessary that the object be touched, displaying a notecard called "appearance". Table 3 shows the code:

Table. 3: Notecard code

```
Default
{
   touch_start(integer num)
   {
      osAgentSaveAppearance(llDetectedKey(0),
"appearance");
   }
}
```

It was necessary to create an appearance for the NPC that was suitable for use inside the Museum. With that he was dressed in a suit and tie to simulate a human avatar inside the museum. In order to communicate with the NPC it is necessary to type in the imprudence viewer chat imprudence the /create command. After this, the user will be dialoguing with the NPC, integrated with the Pandorabots chatterbot and the virtual world server OpenSim. While interpreting AIML, the chatterbot seeks

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to seamlessly match patterns by searching word for word instead of category by category. For this, the Graphmaster algorithm is used [7].

The development followed the model of the ALICE Artificial Intelligence Foundation. To integrate pandorabots with the Opensimulator it was necessary to create an account at http://www.pandorabots.com/botmaster/en/home. The bot is based on the AIML (Artificial Intelligence Markup Language) language, which is the agent's base of knowledge.

The possibility of interconnection by this implementation involves the use of scripts and the ability of NPC communication with the knowledge base, thus allowing the search for information in this database. In this sense, the ability to interconnect an NPC with the agent enhances the interaction capacity between the users and the NPC. The chatterbot knowledge base has been customized for the project specifically where the chatterbot will come into play. Editing the chatterbot knowledge base was done by creating a file built with the AIML markup language.

Next, the AIML knowledge classes were implemented in order to make the bot intelligible to interact with, guide the user and dialogue about social interactions and specific knowledge regarding the introduction to computing. Through it, the system can be hosted in the public server and be available for user access. The system offers the possibility to publish the bot project with specific names and create more documentation. The tool expedites this step of coding the questions and answers made in the elaborated documentation, thus showing an efficient structure for tests with the language.

The AGIMC was fed with approximately 1800 categories in six tables in its knowledge base, in order to enable a very effective dialog on the chatterbot's behalf. The agent's knowledge base can be improved when necessary, expanding its capacity for dialogue and interaction, mainly through the inclusion of categories. The agent has skills such as interaction, autonomy, reactivity and proactivity. At the moment, the agent identifies the user in its range of action, it establishes a communication channel through the chat, thus being interactive with the user, being able to interact and dialog.

V. RESULTS

The application of the experiment was carried out during the end of a semester in the second semester class of the systems analysis and development course with a group of ten students. The students had a tutorial available online on the use of the museum to carry out the experiment. There was an introductory class for students to have contact with the virtual world and familiarize themselves with its use, where the inserted content and learning objects in the museum were approached. Some students already knew some game commands and linked the system to a game. Others not knowing virtual worlds, even after an explanation, had difficulties to assimilate the software.

As this evaluation is considered both qualitative and quantitative, we used the Likert scale to do the analysis, using five levels. This analysis deals with the questionnaires that are used to stimulate the opinions of students, [9]. Regarding the questions, the students participating in the evaluation filled out the questionnaire and it consisted of five statements in which the student could: 1. disagree completely, 2. disagree partially, 3. be indifferent, 4. agree partially or 5. Fully agree. The mode used to analyze the results obtained was to calculate the percentage for each question, assuming that all items approached attitude and opinion.

As a first step the students were directed to the computer lab and invited to download and install the viewer. In order to have access to the virtual world it was necessary to have installed a virtual world viewer, in which case it was suggested to use the Imprudence viewer. The user goes to the agent and interacts with it in the museum. The agent is represented by an intelligent conversational software agent that aims to communicate with the users by improving the interaction during the visitation. The agent has a sensor to establish contact with the user, identifying it within its radius of action. At the end of this visitation, users had to respond to a questionnaire that will be addressed below. Some students left recommendations, while others did not want to mention their considerations. Students who agreed on most of the questions recommended that the environment may assist the student as a complement to their learning. Most students mentioned that they were satisfied with the agent and that they would recommend the use of the environment with the insertion of the agent in other disciplines of their institution's computer courses. The students' feedback about the recommendations and suggestions also mentioned the similarity of a real environment, proving that the representation of a dialogue with the agent was satisfactory. In addition, the experiment conducted with student's shows significant clues that the agent is able to support the student in their conversation. That's because the students confirmed that the testing environment worked properly and the simulation of the dialogue was even more motivating.

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VI. REFLECTIONS

This article aimed to present the development of a software agent, immersed in a 3D virtual world, to act as a conversational guide in a Virtual Computer Museum. In the development of the AGIMC, the integration of a chatterbot simulating a conversational intelligent agent was carried out, in order to provide the student with an environment of knowledge and to assist in the doubts regarding the history and introduction to computing. For this, it was necessary to develop an adequate knowledge base for the topic. The use of tools such as the Pandorabots public server facilitated the product development and the use of the software with intelligent agent interconnection was necessary, in order to verify if the proposed solution was able to achieve the objectives of the work. Given the above, it became possible to verify simulations of dialogue with the agent and to see if the dialogue was motivating to stimulate the students to continue interacting, identifying associations with the real world. According to the evaluation of the results, it was possible to observe that the indexes indicate that at the moment of the evaluation the students felt themselves talking with the agent, thus making the learning more motivating, continuing the dialogue and wanting more interaction on the subject. The use of the topic introduction to computing for the students of a course of Technologist in Analysis and development of systems favored the dialogue, for having interests in knowing more about the area mainly because it is a simulated environment in a virtual world. The inclusion of the intelligent agent facilitated, therefore, the use of the dialog in the computer museum in which the student can recognize the object in 3D and be able to use more of the interaction, besides enabling the use of the software in the classroom in classes of introduction to computing or courses that follow this teaching methodology.

The use of the agent allowed a better interaction with the student, making him feel more motivated towards the dialogue, which was observed during the evaluation. Another characteristic of the AGIMC was the availability, since it was constantly active as a bot allowing the student to clear up their doubts and get an answer to a question at the time that better suits him, i.e., he can access the virtual museum at times outside the room and gain knowledge using the virtual world as a complement to the discipline.

VII. FUTURE WORKS

More research is needed to advance studies on virtual worlds, intelligent agents, immersion. Current researchers are working on the use of neuroeducation using these technologies. An example is the use of wearable equipment (EEG) to track a student's brain while the student performs the activity in the virtual environment, [2]. We will be proposing the reading of biosigns, detecting stimuli during the traditional class process and the comparison with the use in virtual reality. Some studies already indicate this use in education and with surprising results.

The study “Research in Brazil - A report for CAPES”, conducted by the US company Clarivate Analytics, points out that Brazilian scientific production is done almost exclusively within public educational institutions. One of today's challenges for public universities is transform scientific research into products and services available in the form of solutions, promoting job openings and financial results that feed the academic system and enhance the production of scientific research.

In this context, this project will continue with the development of a new gallery, where the intelligent agent, through tools such as Model Plan Canvas and Minimum Viable Product (MVP), will provide the researcher with validation of his application to the market. , as well as the simulation to launch the new product or service with the lowest possible investment, aiming to test the business before making major investments. It is noteworthy that this Virtual World can be adapted to educate from young to mature adults, and can be used in any area of knowledge, reaching audiences that often because of distance or resources, has no access to traditional education, ie in classroom.

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