Self-learning Guide for Bioloid Humanoid Robot Assembly with Elements of Augmented Reality to Support Experiential Learning in Sauro Research Seeding

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Abstract. A self-learning guide for assembly robots BIOLOID PREMIUM in human form is presented, where elements of augmented reality are included in order to facilitate the process of assembly and manipulation of prototypes. This guide was evaluated with students belonging to the research seeding SAURO (research seeding in Automation and Robotics) of the Institución Universitaria Pascual Bravo.

For the design of the guide was necessary the 3D model of the humanoid robot and the creation of augmented reality markers, all with the aim of promoting the interaction of students with technological objects and robotic platforms; for this the software Google sketchup and Build AR Pro were used.

It was achieved that the process of assembling the BIOLOID PREMIUM humanoid robot at the time of execution decree. The students using the guide manifested who had fun learning how to put together the robot, who had flexibility in learning and could manage their own time. Likewise, the use of this guide facilitated the understanding of the parts of the robot and the function that each of them fulfills and even the students declared the control of the self-learning process.

On the other hand, students externalized that their interpretation skills of 3D models and their spatial location got better with the use of the guide with elements of augmented reality.

Keywords: Augmented reality · Engineering education · Self-learning

1 Introduction

According to [1] augmented reality (AR) can be defined as "a technology which overlays virtual objects (augmented components) into the real world" where these virtual objects appear to coexist as objects in the real world. AR, usually enable layering of information over 3D space and creates new experiences of the world. [2] says AR offer opportunities for teaching, learning, research, or creative inquiry.

Also augmented reality offers several advantages in the educational context as: (1) it has encourage kinesthetic learning, (2) it can support students by inspecting the

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3D object or class materials from a variety of different perspectives or angles to enhance their understanding, (3) it increases the student level of engagement and motivation in academic activities, and (4) it allows to provide contextual information [1, 3]. In addition, AR juxtaposes real objects, virtual text, and other symbols, which reduces cognitive load in the limited working memory [1].

[1] says that clearly AR's most significant advantage is its "unique ability to create immersive hybrid learning environments that combine digital and physical objects, thereby facilitating the development of processing skills such as critical thinking, problem solving, and communicating through interdependent collaborative exercises." what allows the development of self-learning process by increases students' motivation and helps them to acquire better investigation skills.

On the other hand AR is used today in every level of schooling, from K-12 to the university level [1, 4]. Several examples like [5–11] can confirm it. The fields of education in which the AR has been used are science education, storytelling, health education, geography education, engineering education, art education, foreign languages education, native language education, architecture education, mathematics education, culture education, computer education, library and information science and history education as well as informal education [4].

The research seeding sauro is working on improving the learning and research skills of its members, proof of this is [12, 13]. At the same time one of the most important topics in the Research seeding is robotics, in which have been developed different jobs like [14]. Along with all this is also the development of soft skills through projects as shown [15] and [16], reason why the need to design guidelines that allowed the experiential learning in the laboratory in an autonomous or self-learning way was saw and given the advantages of the AR, the guide for Bioloid humanoid robot assembly were created.

2 Methodology

The general methodology used is show in Fig. 1.

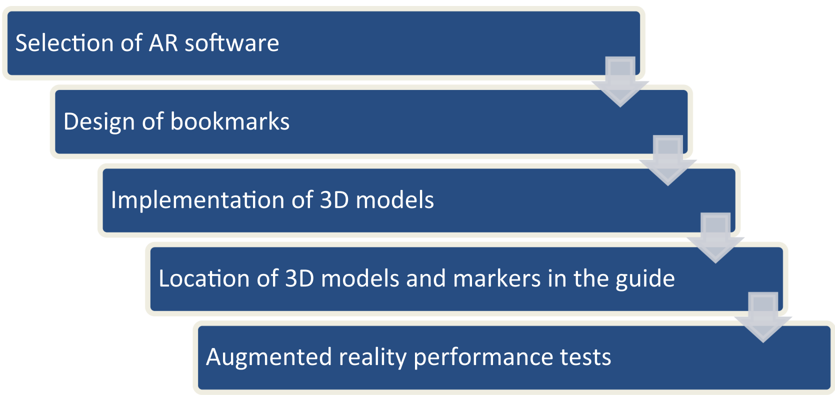

Fig. 1. General methodology for the construction of the Guide for Bioloid Humanoid Robot Assembly.

2.1 Selection of AR Software

For the selection of the AR software several criteria were taken into account, such as: (1) Stability, a system is stable when its level of failure decreases below a certain threshold. In this case, the number of failures obtained in the tests carried out for the software was considered. Faults can be defined such as misidentification of markers, oscillations in the virtual object, and losses of the virtual object at close range of the marker. (2) Multiplatform, ability to install software in more than one operating system. (3) Accessibility to the source code, ability to access or decompose a software in the programming language that was written, for example C++, Basic, Assembler, etc. (4) Low cost, refers to the cost of the license, in this case the lower the cost the better. (5) Programmer experience, knowledge that the user of augmented reality software must have in the specific use of a programming language to be able to implement their applications. (6) Available documentation: refers to the existence and easy access of information regarding software such as tutorials, user manuals and technical characteristics and at last (7) Friendly environment: refers to the ease of use of the programming environment or software development.

Figure 2 shows the comparison of three development environments evaluated in their main characteristics on a scale of 0 to 5. It's observed that the BuildAR software obtained a high qualification in documentation, around friendly, stability, and low cost; however, the ARToolkit obtained higher scores for multiplatform and accessibility to the source code. Despite all the above, the BuidAR Pro exceeds the previous two, since it obtains the highest rating in 4 out of 7 criteria (stability, friendly environment, available documentation, developer experience and low cost), then BuildAR Pro software was chosen for the implementation of the AR.

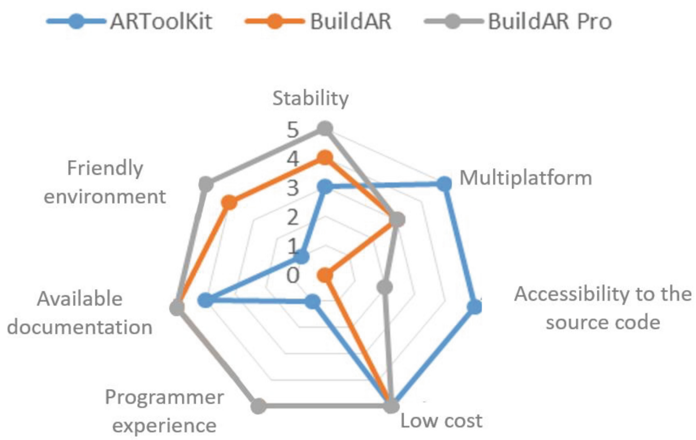

Fig. 2. Comparison of three AR development environments.

2.2 Design of Marks

For the design of the markers, several criteria observed in the literature were taken into account, the majority based on morphological characteristics; They are: (a) The image contained within the box must have a single centroid. (b) The solidity of the image contained within the box must be less than 0.5. (c) The convex area of the image contained within the box must be greater than 35%. (d) The centroid of the image contained within the box should be as close as possible or coincide with the centroid of the marker. (e) It should be avoided to use images with some level of symmetry for the markers since this generates problems in the orientation of the represented objects.

2.3 Implementation of 3D Models

For the implementation of the 3D objects we used the software Google sketchup. A free software that offers libraries of predesigned objects, among them some models of Bioloid robots. The last ones were taken, modified and cut into pieces for the implementation of this project (See Fig. 3).

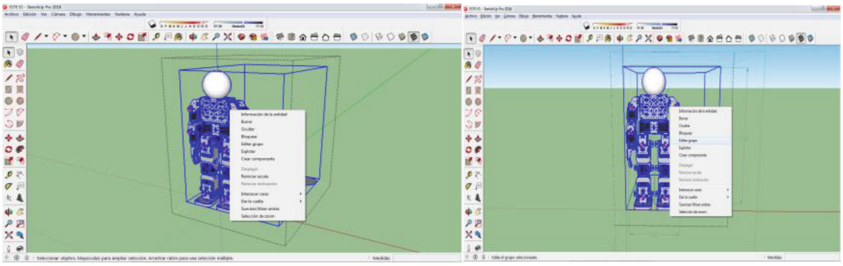

Fig. 3. 3D model of Bioloid Humanoid robot

2.4 Location of 3D Models and Markers in the Guide

For the location of the 3D objects in the manual (Fig. 4), the pages where more complexity was evidenced were chosen so that the 3D models increased in the document would serve as support for the correct assembly of the respective models described in the manual.

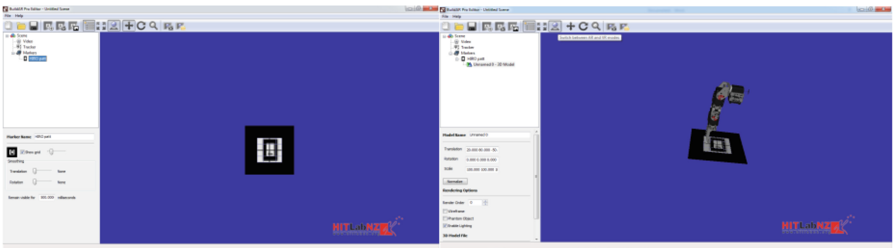

Fig. 4. Markers and 3D model in BuildAR Pro.

2.5 Augmented Reality Performance Tests

Finally, it was validated that all the models increased in the document were consistent with the flat illustrations and that both their location and their orientation with respect to the physical manual were correct and pertinent.

3 Results

The robot was downloaded from the library from Google sketchup, the head is created (see Fig. 3) and cutting in pieces were carried out. The markers with their respective QR code were created and generated to be attached to the robot's assembly guide.

Markers were created and evaluated for both arms (Fig. 5), legs and trunk (Fig. 6). All of them in two different positions, in addition the complete packaging of the robot (Fig. 7) performance test was make.

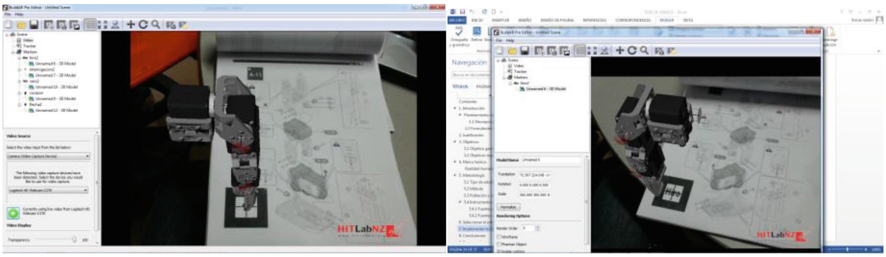

Fig. 5. AR left and right arm in the Guide for Bioloid Humanoid Robot Assembly

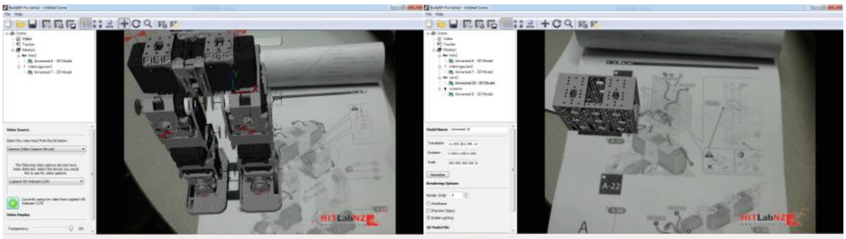

Fig. 6. AR Legs and trunk in the Guide for Bioloid Humanoid Robot Assembly

On the other hand, as a test for the guide, three groups of two students each were taken in order to carry out the assembly of the robot with the help of the guide. Three students had previously made the robot assembly using the traditional manufacturer's guide. In this regard, the following assessments were obtained.

- The interaction of students with technological objects and robotic platforms is promoted.
- The students who had already made the robot's assembly noticed a decrease in the time needed to complete the activity.
- All the students stated that the use of augmented reality was easy and they enjoyed it.
- The students liked the graphic content and the interaction with it.
- The participants said that the understanding of the parts and their functionality in the robot was easy, those who had already done the assembly added that they had better use of their own time given that they depended less on the tutors' help.
- The participants mentioned that the use of the guide with AR allowed them a better understanding of the 3D models.
- The students stated that they felt motivated and that they liked being able to carry out the activity as a team since they were able to share with their classmates.

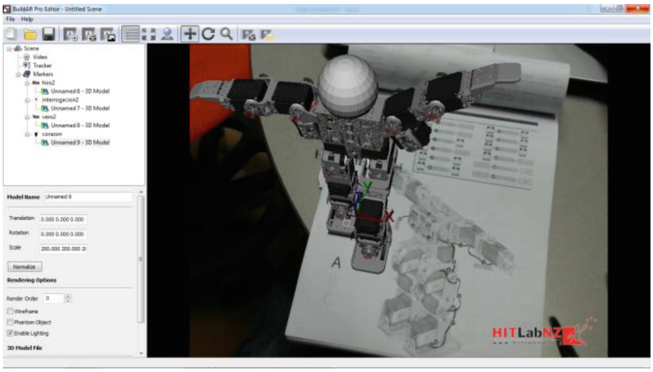

Fig. 7. AR Full Robot using the Guide for Bioloid Humanoid Robot Assembly.

4 Conclusions

The use of AR promoted the interaction of students with technological objects and robotic platforms.

It was achieved that the process of assembling the BIOLOID PREMIUM humanoid robot at the time of execution decree.

The students using the guide manifested who had fun learning how to put together the robot, who had flexibility in learning and could manage their own time. Likewise, the use of this guide facilitated the understanding of the parts of the robot and the function that each of them fulfills and even the students declared the control of the self-learning process.

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