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Mixed Reality Platform for Operation of Robots in Academy and Industry Environment

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Abstract **-** In this paper, the research and execution of a mixed reality platform created with the purpose of benefiting operators, the industry and academy are described. Though the implementation of remote operation by a worker, providing a support tool for collaborative robot operators, allowing improve of tasks, protecting the integrity of operators, and reduce operating costs. The operator has the function of solving communication and link problems between the user and the UR-3 robot through a virtual environment, by collecting information that is linked from the cloud, creating an IOT (Internet of things) environment. With this, it is possible have control of the manipulator arm in the virtual and augmented reality environment.

Keywords**:** Mix Reality, Virtual Reality, Augmented Reality, Robot, Industry, virtual environment, IoT, operator, Safety.

1. Introduction

The bases for the development of a mixed reality platform are established to work effectively in the industry through a theoretical and practical approach. The theoretical approach focuses on obtaining the behavior and investigating the complexity of the processes and application of new technologies in the industry. The practical approach proposes a platform architecture that facilitates the operational process between the user and the device to be controlled safely and effectively.

It is vital to introduce the concepts necessary to understand the topic. We will begin by explaining the difference between Virtual Reality (VR), Augmented Reality (AR), and mixed reality (MR) (see Table 1).

VR is an interactive, participatory environment that can sustain multiple remote users sharing a virtual space. It is characterized by the illusion of participation in a synthetic environment rather than external observation of such an environment. It relies on three-dimensional, stereoscopic, head-tracked displays, hand/body tracking, and binaural sound. VR is also an immersive, multisensory experience. It is also referred to as virtual environments, virtual worlds, or microworlds that have the potential to provide additional power to its users through increased perceptual fidelity. It can also improve the performance of users by lowering the cognitive load in the completion of a task. VR can improve the quality of life for workers in hazardous or uncomfortable environments and may eventually have an impact on the whole society. [1]

Augmented Reality (AR) is physical reality in which participants also see virtual elements [2] AR technology input can be audio or visual. AR enhances perception of the user's world. Though AR is often considered a type of virtual reality, it is a technology with unique characteristics and a different purpose. Virtual Reality typically replaces the real world with a simulated one, immersing users in a reproduced or alternative reality. Augmented reality enhances the current environment, creating a mixed reality instead of replacing that reality. Previous typologies of AR have tended to focus on technical aspects of the approaches [3].

The first definition of MR is presented by the reality–virtuality continuum, which is a scale modeling real-world representation of classes based on computing techniques. Mixed Reality is a class of simulators that combines both virtual and real objects to create a hybrid of the virtual and real worlds[4]. The main goal of MR is the creation of a big space by merging real and virtual environments wherein real and virtual objects coexist and interact in real-time for user scenarios[5].

Table 1: Differences between virtual and augmented reality devices, characteristics, and features of each of them [6].

Characteristics	Differences
User Experience:	AR blends virtual content with the real world, enhancing the user's perception of reality in the physical world.
	VR completely immerses users in a simulated environment, totally disconnecting them from the physical world.
Interaction With the Environment:	AR enables users to interact with virtual and physical objects in their immediate surroundings.
	VR restricts interaction to only the virtual environment by requiring specialized controllers or hand-tracking devices to interact.
Level of Immersion:	AR provides a partially-immersive experience, allowing users to perceive virtual and real-world elements simultaneously.
	VR offers a fully-immersive experience, placing users in a virtual environment with minimal external stimuli.
Hardware Requirements:	AR experiences can be accessed through smartphones, tablets or specialized AR glasses.
	VR experiences can often only be accessed through a dedicated VR headset with controllers and other sense-tracking devices.

The usefulness of the UR-3 collaborative robotic arms will also be used both in industry and in fields such as training and education, placing emphasis in the functions that are necessary to operate them.

Explaining the role that these new technologies play in Industry 4.0 and how interaction is possible thanks to technological advances between devices and the users, allowing remote operation. System integration based on common cloud providers and development are combined to create tailored solutions that are both fast and scalable in various fields.

By integrating the scientific fields of Mixed Reality, and IoT, it becomes possible to allow virtual objects to perform actions on real ones [7]. As is the case of this platform combines the use of different technologies such as robotics, mixed reality, and databases.

2. Platform development

The graphical interface and programming between the HoloLens 2 mixed reality glasses and the real-time Firebase database was created on the Unity platform. The main function of the platform is to allow users the possibility of teleoperate devices that are in different places based on the TCP/IP protocols of the growing interconnection of industry 4.0. The operator will be able to connect the HoloLens glasses from anywhere as long as they have a solid internet connection. It is important for the database to process requests data in real time since the delay between the configuration movements of the lenses and the connection with the real UR-3 arm must be as efficient as possible to avoid errors in the movement commands of the joints. Figure 1 shows platform operation diagram.

The following diagram (Fig. 1) represents bidirectional communication. The system connects to the cloud through the TCP/IP protocol and stores the data in the Firebase database. Once the information is in the cloud, it can be collected ed through the "Get" protocol. The information and sends the data to the lenses and through "Put" the information is sent to the database that updates the positions of the twins and places the updated data in the cloud to be used by the robot.

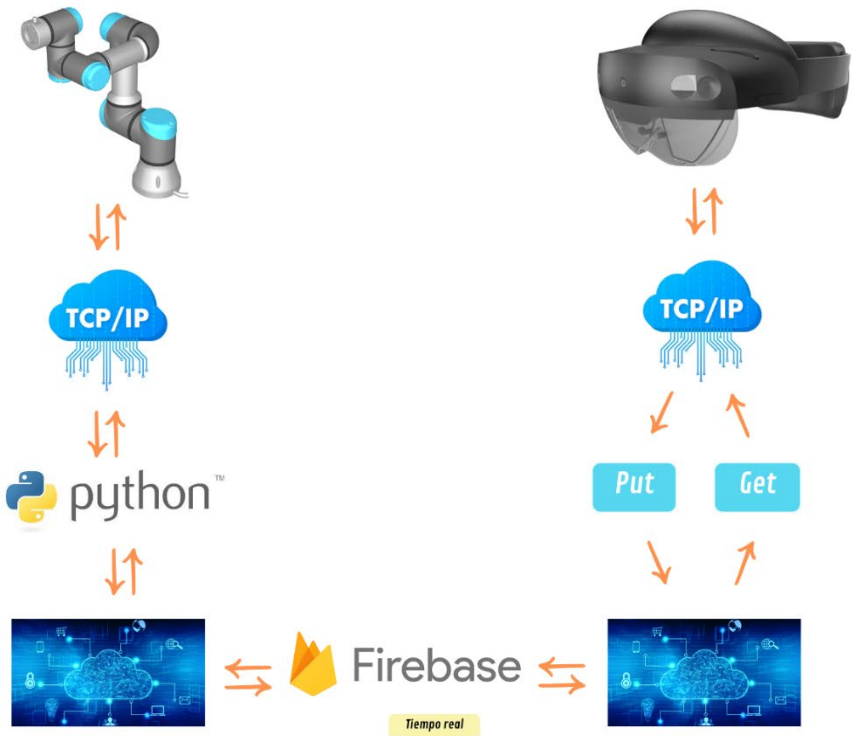


Fig. 1: Representative diagram of bidirectional communication of the MR platform.

2.1. Augmented reality glasses

In HoloLens, holograms blend with your physical environment to appear as if they are part of your world. Even when holograms are around you, you can still see your surroundings, move freely, and interact with other people and objects. We call this experience "mixed reality." [9]

The holographic frame places the holograms where the eyes are most sensitive to details, and the display lenses leave peripheral vision unprotected. With spatial sound, you can identify a hologram even if it is behind you. Additionally, because HoloLens learns and understands its environment, it can place holograms in and around real objects, as well as your apps and games. Hence, a character in a game could sit on the couch, or space robots could come out of your walls [9].

For this application, the glasses connect to Firebase to acquire data previously collected from the real robot, allowing the operator to observe the behavior of the UR-3 arm in the designated area and to program it from the 3-D model implemented in the glasses. Creating a virtual twin of the real model to take advantage of the benefits of augmented reality, enabling the operator to remain comfortable and safe away from robotic devices.

The 3-D object created to resemble the real one respects the distance values required by the manufacturer for scaling. This is crucial when calculating the direct kinematics in the Denavit-Hartenberg table to prevent significant differences in the data that could cause errors in the operation of the robot in the area.

2.2. UR-3 Collaborative Robotic Arm

The UR-3 is a collaborative robot aimed at interconnection and teamwork among others. units, has a compact format ideal for small workspaces. Due to its dimensions, it can be used on worktables or installed directly on machinery, making it ideal for light assembly and screwing applications, and it is also widely used at an educational level for training.

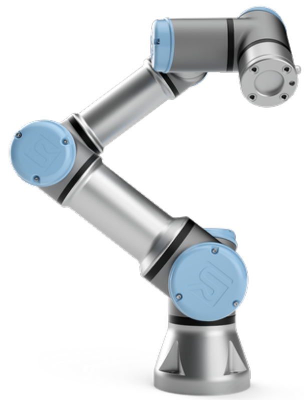


Fig. 2 UR-3 collaborative robot [8].

2.2. Platform Menu

The platform has a menu where the operator has the possibility to choose between 3 options:

The first option allows the operator to freely manipulate the robotic arm, helping them become familiar with the rotation movements that each join, reducing costs and training them before implementing the operation.

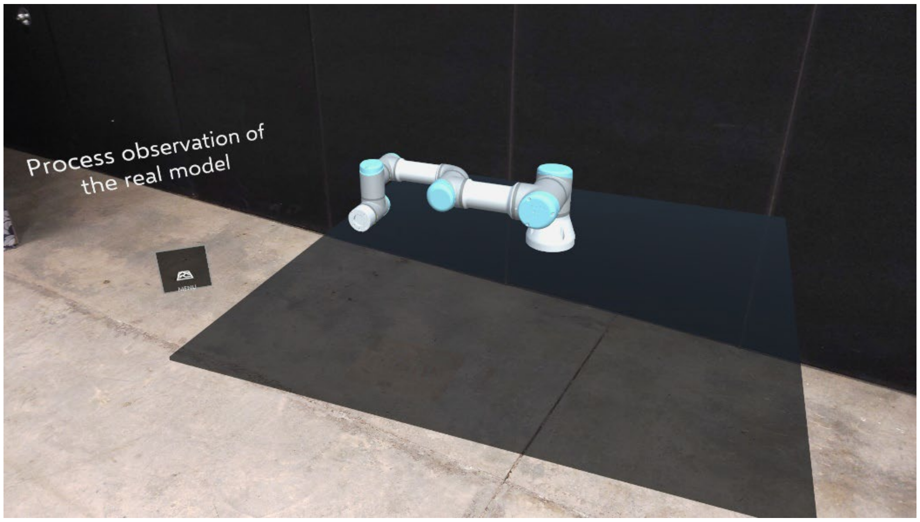
In the second option of the menu, the operator acts as observer of the behavior of the direct model of the environment. In this option is not possible to manipulate the joints of the robotic arm, but it is possible to zoom in and scale the model to be able to observe the model in augmented reality while continuing to perform different tasks.

The third option enables the user to manipulate the robotic arm through the virtual twin created identical to the real one. This operation involves moving each joint and acquiring real-time data, which is then sent to the database. Through a script, communication is established between the data from the virtual twin to the database, allowing the data to be directly introduced to the real robotic arm to initiate the operation. This enables remote manipulation of the device without exposing the operator to any damage, leading to significant improvements in operator safety and cost reduction for companies.

When the program is started, the first thing that is displayed is the navigation menu (see Fig. 3). The panel presents three options: “Follow process”, “Practice” and “Programing”. To enter, choose one of the options presented on the screen.

Fig, 3 Navigation menu.

In the “Follow Process” option (see Fig. 4), it can be seen the movements execution by the UR-3 robot. However, this option does not allow manipulation of the joints, since it is designed just for observing the process carried out by the robotic arm. Nonetheless, users can move and spatially adjust the model."



Fig, 4 Option “Follow Process”.

In the second option "Practice" (see Fig. 5), user can interact with the model, moving each joint independently with their hands to practically understanding of axes of rotation that each of the joints can execute.

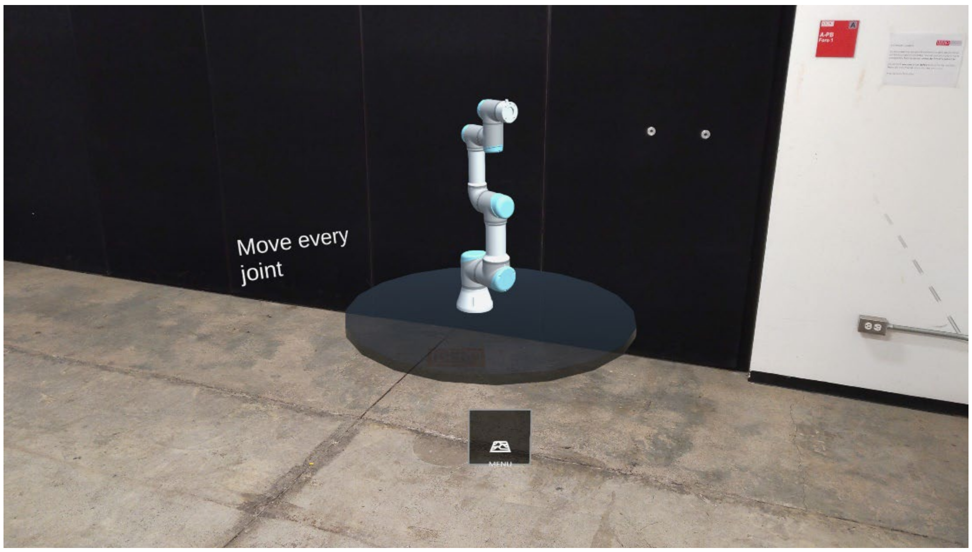


Fig. 5 “Practice”

In the third option, "Program" (see Fig. 6), it is possible to execute actions that the UR-3 arm will perform in the real world. It has two buttons, the first allows users to run a pre-programmed sequence, while the second allows them to send the arm to the “Home Position”. Additionally, through sliders it is possible to rotate each joint independently. All this information is sent in real-time from the database of the UR-3 robot movements to replicate the movement of the virtual model in the glasses.

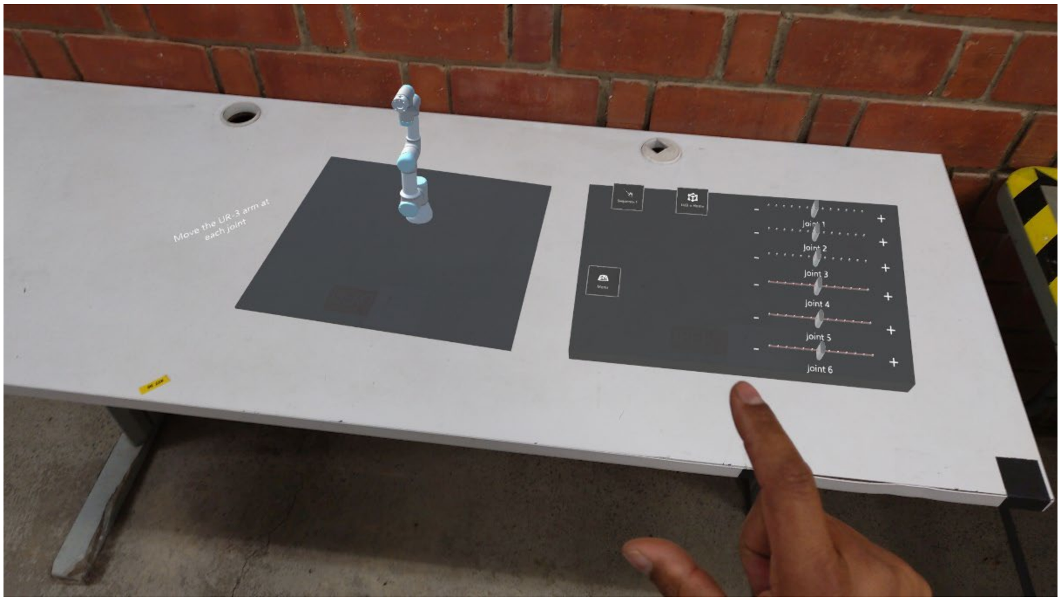


Fig. 6 “Program”

In all three cases, it is possible to spatially scale the models in size and adjust their position. Also, all three options include a “Menu” button that redirects to the main menu.

4. Conclusion

In conclusion, the development of this mixed reality platform and intercommunication with robotic devices, facilitated by industry 4.0 technology, represents a significative advance in the safety and efficiency of the automation of industrial processes and academy.

In this project, a mixed reality platform was developed for operating robots in industry and academy. Successful bidirectional interconnection between the UR-3 robotic arm and the virtual twin programmed in the glasses was achieved, representing a important progress in the use of new immersive reality technologies.

And at the same time, it highlights the potential of this type of platform across a wide field of study to implement improvements and advances in emerging technologies. This not only applies to industry but also opens the door to areas such as medicine, education and another research branches.

Acknowledgements

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