

## A New Virtual Reality Interface for Underwater Intervention Missions

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**Abstract:** Nowadays, most underwater intervention missions are developed through the well-known work-class ROVs (Remote Operated Vehicles), equipped with teleoperated arms under human supervision. Thus, despite the appearance on the market of the first prototypes of the so-called I-AUV (Autonomous Underwater Vehicles for Intervention), the most mature technology associated with ROVs continues to be trusted. In order to fill the gap between ROVs and incipient I-AUVs technology, new research is under progress in our laboratory. In particular, new HRI (Human Robot Interaction) capabilities are being tested inside a three-year Spanish coordinated project focused on cooperative underwater intervention missions. In this work new results are presented concerning a new user interface which includes immersion capabilities through Virtual Reality (VR) technology. It is worth noting that a new HRI module has been demonstrated, through a pilot study, in which the users had to solve some specific tasks, with minimum guidance and instructions, following simple Problem Based Learning (PBL) scheme. Finally, it is noticeable that, although this is only a work in progress, the obtained results are promising concerning friendly and intuitive characteristics of the developed HRI module. Thus, some critical aspects, like complexity fall, training time and cognitive fatigue of the ROV pilot, seem more affordable now.

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**Keywords:** HRI; Virtual Reality; Marine Robotics; Underwater Intervention, Problem Based Learning.

### 1. INTRODUCTION

While commercially available Autonomous Underwater Vehicles (AUVs) are routinely used in survey missions, a new set of applications exist which clearly demand intervention capabilities given their complexity (Ridao et al., 2015). The maintenance of permanent underwater observatories, submerged oil wells, cabled sensor networks, pipes and the deployment and recovery of benthic stations are but a few of them. Nowadays, these tasks are addressed using manned submersibles or work-class Remote Operated Vehicles (ROVs) equipped with teleoperated arms. Current Intervention-AUVs (I-AUVs) prototypes are big and complex systems exhibiting only a limited set of functionalities including docking and fixed based manipulation on a subsea panel, as well as search and recovery of simple objects.

There has been a lot of work invested in these problems, like the SAUVIM project (Yuh et al., 1998), which demonstrated the possibility of autonomous underwater floating manipulation and opened way for a technology that has become commercial nowadays. But the first systems had a very complex control interface, sometimes requiring several human experts as controllers and training these experts was also a challenging task. Sheridan (1992) studied the limitations of this master/slave architecture and the overload it produces on the human controller. Projects like TRIDENT made further advances (Sanz et al., 2010) aiming to make the technology cheaper, more robust, flexible and easier to use. These advances were in big part thanks to the inclusion of context in the HRI interfaces. These ideas were incorporated

in the simulator UWSim (Prats et al., 2012), which allowed to train human control and supervision avoiding risks during intervention operations in real scenarios. Nowadays, state-of-the-art projects like *OceanOne* (Khatib et al., 2016) use a humanoid robot as an avatar of the human controller, with complex manipulators and sensors, constraints and even haptic feedback (Brantner and Khatib, 2018).

On the other hand, new sophisticated applications, like transporting and manipulating bulky objects, or assembling complex structures in underwater could require several I-AUVs working cooperatively. This is the aim of the TWINBOT project (TWIN roBOTs for cooperative underwater intervention missions). This is a three-year (2018-2020) project founded by the Spanish Ministry, where three different partners are working together (i.e. Universities of Girona, Illes Balears and Jaume-I of Castellón). The present paper represents work in progress in the context of this coordinated project, developed at Jaume-I University.

With the aim to approximate the real problem of autonomous cooperative grasping and transportation of an object by means of two underwater vehicles (I-AUVs) we decided to implement a first HRI module in which these vehicles will be teleoperated by a human pilot (i.e. the intervention expert equivalent to a ROV pilot). So, we focused on the development of a new interface to reduce, as much as possible, the complexity for the human operator, given the necessity to control two different robots at the same time. It is noticeable that replicating usual available interfaces (with keyboards, joysticks, mouse, several screens, etc.) was not a realistic approximation, knowing the human being limits in

its control capabilities (Miller, 1956). In this paper we explain the first steps done to create a simple to use HRI module for underwater robotics based on Virtual Reality (VR), and at the same time, a natural process for learning how to control the robot. First of all, in Section 2, we talk about HRI and VR and previous work done in this field. Next, in Section 3, we explain the experimental setup and in Section 4 the first results obtained with the system. Finally, in Section 5 we discuss the results obtained and the future plans to further improvements.

## 2. HRI

### 2.1 Virtual Reality

By definition, VR is the most immersive of the "reality" technologies, and usually involves wearing a headset that creates a 360-degree visual simulation, virtually placing the user into an immersive visual experience designed to make it feel like he or she is actually there.

VR is related to Sutherland's vision of the Ultimate Display (Sutherland, 1965) but limited to vision. In 1989 Jaron Lanier coined the term Virtual Reality (Rheingold, 1991) trying to aggregate the different concepts and technologies. During the following years the scientific community developed technology and algorithms to fulfil his vision. Two of the main problems were the price of the hardware and its capabilities. The inflexion point was in 2012, when a Kickstarter project called *Oculus Rift* provided an affordable high-quality Head-Mounted Display (HMD), oriented to gaming but which allowed the creation of multiple applications (like García et al. (2015) or Kot and Novák (2014, 2018)).

A vast amount of products trying to implement aspects of the vision of the Ultimate Display are appearing at affordable prices (like *Oculus Rift S1*, the latest version of the HMD) and graphic card makers like NVIDIA and AMD which have included features in their graphics boards supporting current and upcoming HMDs.

VR and its evaluation has been an object of study from the beginning of its development (Marsh, 1999). For example, Anthes et al. (2016) offer a look at the field mainly from a hardware perspective.

The next step from VR is Augmented Reality (AR) (Azuma, 1997), in which we combine the virtual world with the real one. In robotics, while VR reality can be used for training, mission planning and giving instructions to the robot, AR allows to improve the control in real time of the robot, as the feedback is immediate.

### 2.2 Teleoperation

Teleoperation can appear when some work has to be done in dangerous conditions, but also when autonomous operation performance is not comparable to the teleoperated one. The solution is having the human operator at a distance, safe from danger but in control of the process. One of the methods used nowadays is a robot with sensors and manipulators that provides information to the human being and obeys his/her

instructions transmitted using a GUI (Preece et al., 1994) (Sheridan and Verplank, 1978). But multiple studies, like Chen et al. (2007), show that human factors like stress, situational awareness and workload can cause problems to the human operators and errors when taking decisions. In any case, as the systems can be very complex, becoming a teleoperator can be a difficult process.

There are systems which try to use Artificial Intelligence (AI) solutions, in which the robot is partially autonomous from the human operator instructions and can reduce the impact of his/her decisions (Sanz et al., 2010), or systems in which there is anticipation of the user actions (Brantner and Khatib, 2018) (Huang and Mutlu, 2016), but we consider that most problems can be solved or at least mitigated using better interfaces, like in Almeida et al. (2017).

### 2.3 HRI in progress

Teleoperation is a challenging task because the operator is remotely located and has to operate the robots through video images (usually), which tend to have a restricted field of vision, provide limited depth information, and can be further degraded by bandwidth limitations (to the extreme that the communication can be broken). As a result, the operator's situation awareness of the remote environment can be compromised and the mission effectiveness can suffer. In theory, the use of VR creates a complete field of vision and 3D images, providing depth information. Underwater teleoperation is also challenging in terms of operator's workload because he/she often has to switch among different camera views, take into account time limitations for each task and/or manoeuvre the robots with a time delay due to technological limitations. Also, in underwater operations, it is likely that the operator will have to control the robots from a moving ship, which will make the tasks even more difficult.

In Table 1 we can see the interface characteristics developed in different representative projects from older and more basic (top) to modern and complex (bottom).

**Table 1. Interface main characteristics**

Project	New characteristics
SAUVIM (Yuh et al., 1998)	Multiple displays, keyboards, joysticks, several expert users for robot.
TRIDENT (Sanz et al., 2010)	GUI, one human controller, contextual GUIs
MERBOTS (García et al., 2015)	VR cockpit with track and estimation of human poses, one human controller (not expert).
Venus (Haydar et al., 2008)	3D models from sensors data, AR interface
OCEAN (Brantner and Khatib, 2018)	Bimanual haptic devices, stereoscopic vision, GUI, a world display, constrains: overrides human actions.
DexROV (Gancet et al., 2016)	Real time simulation environment, haptic devices (arm and hand exoskeletons), cognitive engine to translate user instructions.

Although the ultimate aim this part of the TWINBOT project is creating an AR environment in which the data provided by the different robots is integrated into one control system, as a first step we are creating an immersive VR interface.

In particular, the main objective of this part of the project is the integration of the different guidance controls that exist for the intervention robots into a single VR interface, including immersion capabilities (Gandhi and Patel, 2018). This new interface should be enough intuitive and friendly to simplify, as much as possible, the pilot's work, reducing expended time and inherent complexity of this kind of systems for operating and running the intervention mission in a suitable manner.

At the same time we wish to explore possible ways to teach a non-expert to control a ROV in the easiest and more natural way possible. As we will see in Section 4.3, we organized the tests of the interface as a learning experience based on the idea of Problem Based Learning (Boud and Feletti, 2013), in which the users learn the material as they need it to solve the type of problems presented in our scenario (see Figures 2-6).



Fig. 1. User connected to the system.

### 3. EXPERIMENTAL SETUP

We employed the *HTC Vive* system to create a realistic 3D immersion in a friendly manner (in Figure 1 we can see a user connected to the system). Its main specifications are: 110 degrees field of view, 90 frames per second, 2160x1200 resolution, and 32 sensors in the glasses for spatial localization and 24 in each controller. We used a desktop computer with an NVidia 960GTX, with 8GB of DDR3 RAM, and an Intel Core I7-4790 3.60 GHz.

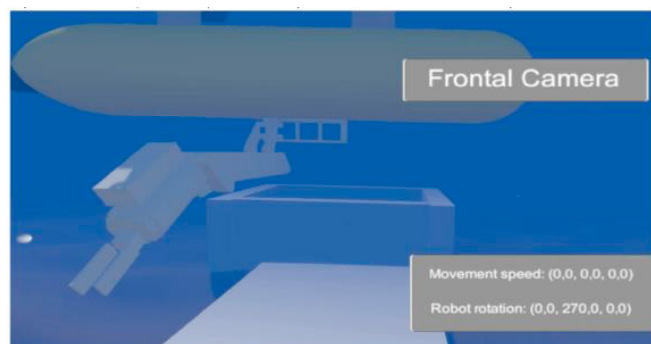


Fig. 2. Environment simulation and interface.

As software we used the Unity gaming engine, by Unity Technologies, (Unity, n.d.) to develop the VR system. Unity

has integrated (as a plug-in) several drivers for different VR equipment, and a well-developed physics engine.

Following the TWINBOT project, the pool simulated is that built as part of the CIRTESU project (<http://www.irs.uji.es/cirtesu/cirtesu.html>), and the underwater vehicle simulated is a GIRONA500 (<https://cirs.udg.edu/auvs-technology/auvs/girona-500-auv/>), the one used in the TWINBOT project, and the arm, an ECA-CSIP Arm5e (Fernandez et al., 2013).

The GIRONA500 is an AUV with three hulls in the form of torpedoes. The two upper hulls contain the flotation foam and the electronics housing and they are positively buoyant, while the lower one contains batteries and payload. The dimensions of the vehicle are 1 x 1 x 1.5 meters (height x width x length) and a weight of less than 200 Kg., making it easy to move.

Its main characteristic is its capacity to reconfigure for different tasks. On its standard configuration, the vehicle is equipped with typical navigation sensors (DVL, AHRS, pressure gauge and USBL) and a basic survey equipment (profiler sonar, side scan sonar, video camera and sound velocity sensor). In addition, almost half the volume of the lower hull is reserved for mission-specific payload such as an imaging system or an arm for manipulation tasks.

The propulsion system is also configurable. The basic configuration has 4 thrusters, 2 vertical to actuate the heave and pitch and 2 horizontal for the yaw and surge. However, it can be reconfigured to operate with only 3 thrusters and with up to 8 thrusters to control all the degrees of freedom.

## 4. RESULTS

### 4.1 VR functionalities

With the aim to improve the assistance of the user through the teleoperation process within an intervention, new VR functionalities have been implemented. As a proof of concept a realistic scenario has been implemented dealing with recovering an aircraft's black box on the bottom of a pool. In Figure 3 we can see the intervention area, with the black box model included inside the simulation as a graspable object.



Fig. 3. Black box model in the simulation (we can see the shadow of the robot and a previous version of the interface).

So, in this manner a new functionality is now helping the user teleoperates a target through available VR, guaranteeing to see if he has placed the arm and the robot correctly at any time.



#### 4.2 VR Interface

After several initial tests among the developers (Sanz et al., 2019), which motivated some modifications in the interface (like including the name of the camera in use in Figure 2 that does not appear in Figure 3) we created a stable version. This VR interface can be divided in two parts: control of the robots and visual information feedback.

The controls have been divided into two groups, those in charge of managing the vehicle and those in charge of managing the arm. We employ two independent control modes between which the user can change with the side button of the controller, this will also change the camera between the vehicle and the arm.

When robot control is selected, the right controller manages the forward and backward movement and the rotation of the vehicle, while the left one controls the up, down and lateral movements (left in Figure 4).

In the arm mode, the right controller will manage the upper part of the arm (shoulder and slew) and the left one will control the lower part (elbow and jaw) both of them have a trigger that will control the gripper (to open and close it).



Fig. 4. Robot control (left) and arm control (right).

In the screen (Figure 2, 5 and 6) we will be shown the active camera image (robot and arm) and some extra information, always displayed. There were several section:

- The FPS and Lag section shows the information of images per second and delay between time of sending and processing of the signal. Preliminary tests made us remove this information to the computer monitor.
- The camera name section shows the name of the actual active camera and work mode.
- The third one shows information about the vehicle movement speed and rotation (Figures 2 and 3, down).

The visual information feedback also includes a change in colour in the black box when the robot is near enough to grasp it (Figures 5 and 6). This functionality is supported by a communication process among several classes which activates and deactivates the highlighters of the objects when they can be picked up. We employ a tag called *Takeable* in the *Unity engine* to make it able to be grasped by the robotic gripper.

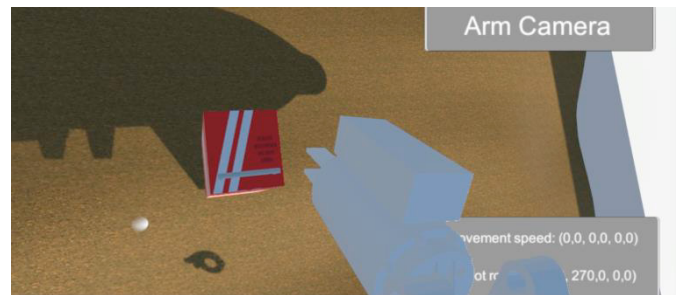


Fig. 5. The robot has approached the black box.

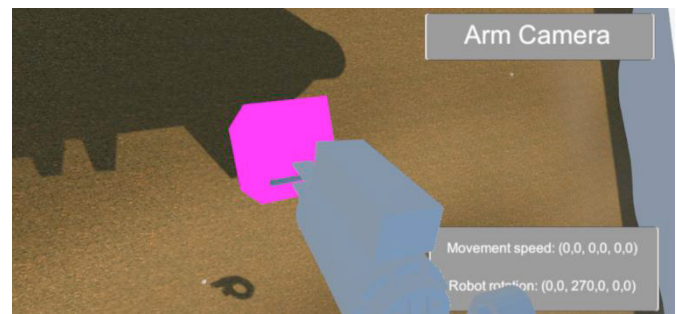


Fig. 6. The robot can grasp the box, as indicated by the change in colour of the box.

#### 4.3 Learning Experience and Usability Tests

The usability of the VR interface developed was tested on four environments (problems) with different difficulty levels. They were organized as a learning experience, in which they had to learn the robot model, how to move an underwater vehicle and the basics of grasping with a physically limited arm. From less to more difficulty the problems were:

1. In the first test the point of view (camera) is in third person and the user needs to take the black box and bring it to the white container. The user only knew about the camera/control change button and that the elements are moved with the touchpad.
2. In the second test the problem to solve is the same but there are two cameras, one on the robot arm and the other one is outside the robot.
3. In the third test, one camera is placed on the body of the robot and the other in the arm, like in reality.
4. In the last test, we maintain the points of view of the third test but there is an obstacle (selected randomly among a Vertical Wall, a Cylinder and a short Horizontal Wall) between the black box and the robot.

As one of our aims was testing how easy and natural was learning to use the interface, the users had minimal (verbal) information about the system. In the first test, the points of view were positioned outside the robot and they were independent of it. The objective was to confirm the thesis that images and manipulation were enough to allow them to create a mental model of the vehicle and the arm.

The first VR interface was tested with a user group of 25 members, which were a heterogeneous group of students, researchers and teachers of the Jaume-I University. Previously to their tries with the interface they were asked

about their experience with VR and video games to generate a value (0-1) which indicated his affinity towards the test. The characteristics of the users (age, sex, and affinity), the number of attempts and the time they took in each of the tests is shown in Appendix A.

The average time and typical deviation for each task can be seen in Figure 7 and, as expected, shows a relationship between number of tries and time taken to complete the tasks: more time is associated to more trials to complete successfully a task. It is interesting to note that the time of the expert, in green, is a lot better than the average, but the difference with the best users' results is a lot less.

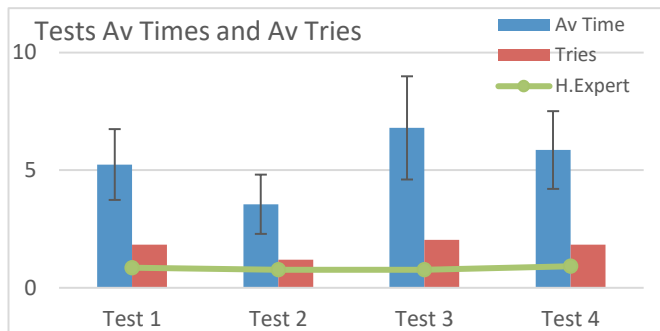


Fig. 7. Average time (minutes), typical deviation, tries for each test and time of the expert user (green line).

When taking into account age or sex, there were not significant differences in the times or number of tries. As expected, the only important characteristic seemed to be the affinity (previous experience with VR and video games).

At the end of the tests the users did a small questionnaire:

- Are the controls easy to learn?
- Is the environment realistic?
- Do you think that the interface has real usage?
- Would you add something to the interface?

And the users provided information about their feelings in relation with the simulation. Their opinions were diverse but all considered that a tutorial would simplify the learning.

Figure 8 shows how easy the users think that learning all the controls in the simulation and make a good use of them was for them, how realistic the environment was and if the simulation can be useful in a real intervention.

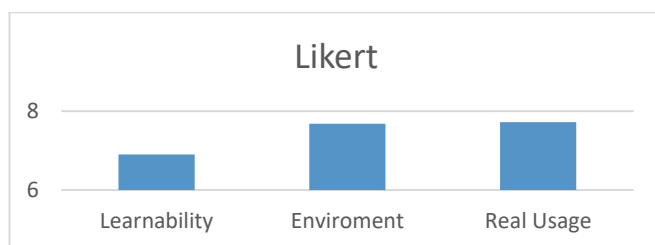


Fig. 8. Satisfaction of the users with the system.

For the learning time a score of 6.9 out of 10 was obtained which, taking into account that the basis of the test was, that

the users had no information and that they should discover the controls beyond they use the simulation, this supposes a higher note than expected in the first instance.

As for the environment the note was a 7.68 out of 10, the most highlighted comment is that we could try to simulate water streams with enough force to hinder the handling of the robot, which might be interesting in a future extension of the project, but in general the mark is over our expectations.

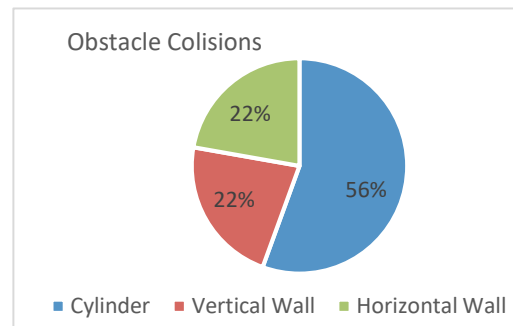


Fig. 9. Rates of collisions in Test 4 with the different obstacles (Cylinder, Vertical Wall and Horizontal Wall).

Finally, the user was asked about the real usefulness that they believed the interface would have in a real intervention and they gave a score of 7.72 out of 10, giving comments like, "if used as a training tool, it might be a good idea to try to adjust the 1Hz refresh rate to simulate a wireless intervention, and that could be added to the information shown in the glasses some aspects such as depth". This was taken into consideration in planning future modifications to the system.

Some of them expressed to have problems imagining the robot, specifically the robot arm, which made it more difficult to control. They declared that watching the robot from the exterior in the two first tests was not enough to get a good mental model of the robot and the arm. This is supported by the type of collisions, as the Cylinder, a supposed easier obstacle (smaller), caused more collisions than the bigger and more evident ones, the walls (rates in Figure 9). Aiming to solve this problem, we have already created a simple explanatory document of the robot, the arm and the controls, in the form of a short manual for the second version of the system, to complement the oral explanations that were given in the first version and we plan to add several VR videos moving cameras around the robot to clarify its form.

#### 4.5 Efficiency

According to ISO-92411 (ISO, 2018), product Efficiency can be defined as "resources spent by user in order to ensure accurate and complete achievement of the goals".

With regards to software products and information systems, the key measured resource normally is time spent by the user in order to achieve the goals.

Thus, Efficiency can be calculated as user Effectiveness divided by the time spent by the user.

Let  $N$  - be the total number of scenarios/goals (4 in our case)

$R$  – It is the number of respondents/users (25 in our case)

$n_{ij}$  – It is the result of coming through scenario  $i$  by respondent  $j$ ;  $n_{ij}=1$  if the scenario has been completed successfully and user goal has been achieved, and  $n_{ij}=0$ , if the scenario is unsuccessful and user failed to achieve the goal (in our case all our users completed the scenario eventually).

$t_{ij}$  – It is the time spent by respondent  $j$  to come through scenario  $i$ . In case of unsuccessful scenario completion, measured till the moment of scenario quittance by the respondent as a result giving up the goal or logging off the system.

Then, overall time-based user Efficiency of a product  $\bar{P}_t$  will be calculated according to (1):

$$\bar{P}_t = \frac{\sum_{j=1}^R \sum_{i=1}^N \frac{n_{ij}}{t_{ij}}}{RN} \quad (1)$$

The Efficiency of the VR system is thus 0.010578.

If we use the time expend by the users in their first (unsuccessful) try of the different scenarios, we can calculate overall relative time-based Efficiency using (2):

$$\bar{P} = \frac{\sum_{j=1}^R \sum_{i=1}^N n_{ij} t_{ij}}{\sum_{j=1}^R \sum_{i=1}^N t_{ij}} * 100\% \quad (2)$$

We obtained a 22.15% (taking into account the last try of each user we will have obtained a 100%, which does not provide us with useful information). Of course the time-based user Efficiency was different (and worse) taking into account the times of these first tries: 0.005990.

The main creator of the simulation and interface acted as our expert to calculate Expert Efficiency. He is able to come through scenario with the maximum possible user speed and a-priori successful completion.

Let  $t_{oi}$  – be the ideal time an expert needs to complete scenario  $i$ .

Then, the time-based expert Efficiency will be (3):

$$\bar{P}_{te} = \frac{\sum_{i=1}^N \frac{1}{t_{oi}}}{N} \quad (3)$$

The physical meaning of the time-based expert Efficiency is the highest theoretically possible speed of work with the product. The value obtained was 1.219.

### 5.3 Comparative with previous work

Given the lucky circumstances that some (three) of the users had been also part of the usability study presented in García et al. (2015), we interviewed them in deep:

Subject 1 clearly prefers HTC Vive, as he/she felt dizzy when using the Oculus technology. He/she had to restart the test several times before completing because he/she felt sick.

Subject 2 considers that while the HTC Vive system is nicer, the Oculus one is easier to use because it provided more information. He/she did prefer the joystick and he/she did not see the need to have two different control instruments (they

could not be used at the same time and learning to use them was challenging). Changing the point of view was a problem.

Subject 3 preferred the Oculus system as he/she considered the quality of the simulator (UWSim) to be better. He/she did not have problems using the joystick to control the robot and felt that using two hands was unnecessary. Maybe it could be useful in more complex tasks.

## 6. CONCLUSIONS AND FUTURE WORK

We have seen how an immersive VR interface of a simulated underwater vehicle (GIRONA500) in a water tank has been created and tested, as part of the TWINBOT project. As expected, it has shown that users prefer this type of interface to others, harder to learn and use.

Thanks to the usability tests, some ideas from the users are being taken into consideration, such as the inclusion of some extra data in the information that is shown to the user in the glasses, information like the actual vehicle depth, the pressure and the forces applied to the ROV. Currently, the HRI module continues under development.

The users also suggested to make the simulation more realistic, not simply with better graphics, but changing the refresh rate of the simulation to 1Hz in order to represent a real wireless connection with the robot through which you are not able to send full HD pictures, with a 60Hz rate, like the actual wireless interventions has to train the pilot in that situation. Also, it was suggested to represent the problems of underwater wireless communication, such as low image refresh and quality of the real systems. We are adding sound (e.g. impacts with obstacles and the working engines), as part of the simulation, for increasing realism and working as feedback. Of course, after finishing the new version of the VR interface we will make another round of tests.

The main developments, we wish to approach, are:

1. To connect the interface to a server simulator, as a first step for connecting with a real robot. We plan to develop a level (i.e. Dogmatic Games, n.d.) to make a translation between the controller and ROS instructions, for enabling the interface be available for using in different experiments and applying it to the TWINBOT project.
2. To transform our VR interface into an AR one, with information provided by the robot sensors.
3. To integrate another robot in the simulation (later on, a real robot), with the aim that cooperate together, for solving problems, with the user controlling only one of them at a given time.
4. To control two robots, with the same interface. Although, a priori, it would be interest to have an interface able to allow two or more users, guiding their own robots, previous experiences have shown how the umbilical cables tangle themselves in that case.
5. To further develop the learning process we have implemented an interface guideline (<https://drive.google.com/open?id=1upnAiUqe72Cikb>)



[OLRm4tuISfQWTsXazs](#)) and several VR videos ([youtu.be/sLfUisdYlzM](#), [youtu.be/LwgQM54GhM0](#), [youtu.be/Fzp7\\_ud9NXA](#), [youtu.be/heeDfSPIOzq](#)) to make easier the hardware understanding. A more complex sequence of open tasks is being developed, and there are plans to use it for teaching (e.g. Master degree in underwater robotics).

Of course they are not the only possibilities. For example, it would be interesting to increase the dimension of the project by adding AI to reduce the need of the user intervention, as some *hybrid* systems already do (Dicianno et al., 2009).

We could also integrate different tools to interact with the simulation, which could help the users to control the robot (Peshkova et al., 2017). For example using the microphone incorporated in the HTC Vive, which could allow the user to change the point of view, could increase the usability of the interface and reduce the learning curve.

#### ACKNOWLEDGEMENTS

This work has been partly funded by Spanish Ministry of Economy, Industry and Competitiveness under DPI2017-86372-C3 grant (TWINBOT), by Valencian Government under IDIFEDER/2018/013 grant (CIRTESU) and by UJI under UJI-B2018-34 grant (NEPTUNO).

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24	313	2	97	1	256	1	453	4	1	9
54	343	3	167	1	780	3	344	1	0.2	7.5
46	352	1	196	1	744	4	240	1	0.4	8.25
22	192	2	75	1	163	1	141	2	1	9.5
44	430	2	198	1	711	3	811	3	0.2	9
46	197	3	115	1	250	1	167	1	0.4	7
22	144	1	155	1	167	1	153	1	1	9
22	197	3	80	1	167	1	249	2	1	7.75
23	163	1	135	1	150	1	176	1	1	8
24	158	1	161	1	190	1	135	1	0.8	8
44	238	1	174	1	745	5	311	1	0.2	7.75
33	207	1	298	2	300	1	335	1	0.4	7
31	207	3	80	2	324	3	159	2	1	7
48	186	1	238	1	462	1	711	4	0.4	8.5

Appendix A. Table of experimental results

**Table 1. Age of the user (Age), time in seconds for each test (T1, T2, T3 and T4), number of tries (t) until successful completion, affinity (A) and pleasantness (P). Female users appear in grey and the last row are the human expert results.**

Age	T1	t	T2	T	T3	T	T4	T	A	P
23	352	1	199	1	1182	7	183	1	0.5	7
43	265	1	385	1	395	2	296	2	0.2	8
27	430	1	650	3	201	1	318	1	0.7	9
22	543	3	138	1	156	1	236	1	1	9
28	463	1	286	1	274	1	421	1	0.4	8.5
45	647	3	360	1	558	2	352	1	0.1	7.5
28	250	2	89	1	432	3	367	2	0.5	8
30	965	3	337	1	451	2	724	3	0	8
24	125	1	122	1	139	1	393	4	0.5	9
29	381	4	491	2	676	2	919	4	0.1	8
38	115	1	103	1	325	2	193	1	1	8.5