

Multimodal Human-Robot Interface for Supervision and Programming of Cooperative Behaviours of Robotics Agents in Hazardous Environments: Validation in Radioactive and Underwater Scenarios for Objects Transport

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Abstract

Tele-robotic interventions in harsh environments, such as radioactive or disasters as well as underwater scenarios, require well trained operators in order to carry out the operation safely. The complexity of the intervention rapidly increases with the number of robots which take part to the operation. In several situations it is more convenient to leave the control of multiple robots to a single operator than having multiple operators, who could conflict in case of misunderstanding or due to their different tele-operation capabilities.

The Human-Robot Interface developed at CERN allows to control a heterogeneous set of robots in an homogeneous way, allowing the operator, among other features, to activate multi-agent collaborative functionalities, which can be programmed and adapted in runtime. The operator is given the capability to enter in the control loop between the HRI and the robot and customize the control commands according to the scenario. Two different types of functionalities are available for the operator: HRI-side functionalities can be programmed in runtime using a script editor integrated in the interface and are executed in an outer control loop between the HRI and the robot; robot-side functionalities (e.g. visual servoing for grasping) can be activated or deactivated but not modified in runtime, and are executed in an inner control loop fully on the robot. The main difference between the two approaches relies on the importance of the functionality in the control loop. In fact, as the HRI is designed to communicate with the robots through unreliable channels, HRI-side scripts should be used only when the specific behaviour is not critical, to enhance safety, even when the connection to the robot might be lost.

The HRI has been validated through a unique experiment, performed both in simulation for underwater cooperative applications and in a real ground robot scenario at the LHC mockup. A pool of agents was required for grasping a pipe and transport it. An additional robot was used to provide an external point of view to the operator. The intervention has been planned in advance using the *HRI Intervention planning tool*.

1. Introduction

1.1. CERNTAURO Project

The CERNTAURO project [1] aims to create a set of different robots for inspection, reconnaissance and teleoperation in harsh environments and more specifically in the CERN accelerator complex [2], which are easy to use and can be given to a facility expert who is not, necessarily, an expert robot operator. The project covers a wide series of tech-

nologies, from custom robots development, robot control, network communication, safety, human-robot interaction, virtual reality, and artificial intelligence, to new but a few.

The CERNTAURO project's goal is to create a complete framework which is totally modular in order to be adaptable to the necessities, and in order to be upgraded with time as far as new features

need to be integrated.



Figure 1: A high level scheme of the CERNTAURO framework.

1.2. TWINBOT Project

TWINBOT project aims to achieve a step forward in the underwater intervention state of the art. A set of two I-AUV's will be able to solve strategic missions devoted to cooperative survey and cooperative manipulation (transport and assembly) in a complex scenario. So, the Spanish coordinated Twinbot project faces the problem of underwater cooperative intervention which, in a first stage, will be able to pick up, recover and transport objects such as pipes, using two intervention vehicles, wireless communications, a supervisory control human-robot interface, and an auxiliary robot for giving the user and the robot team external views for enhancing the intervention. The system uses as knowledge base previous results from the FP7 TRIDENT [3] and MERBOTS [4] projects.

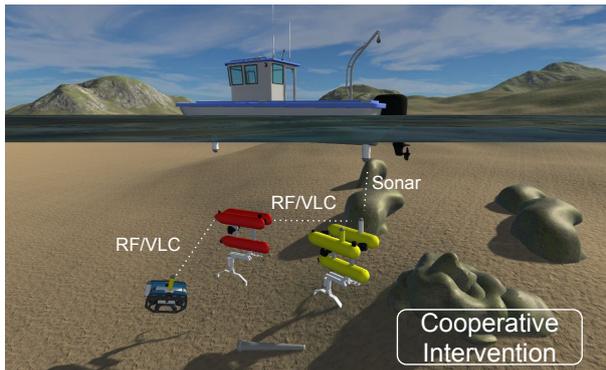


Figure 2: The TWINBOT Envisioned Concept

1.3. Synergies between CERNTAURO and TWINBOT projects

The CERNTAURO and TWINBOT projects present several synergies that allowed the development of a common Human-Robot Interface.

- Supervised Multimodal Human-Robot-Interface to teleoperate and launch semi-autonomous cooperative interventions.

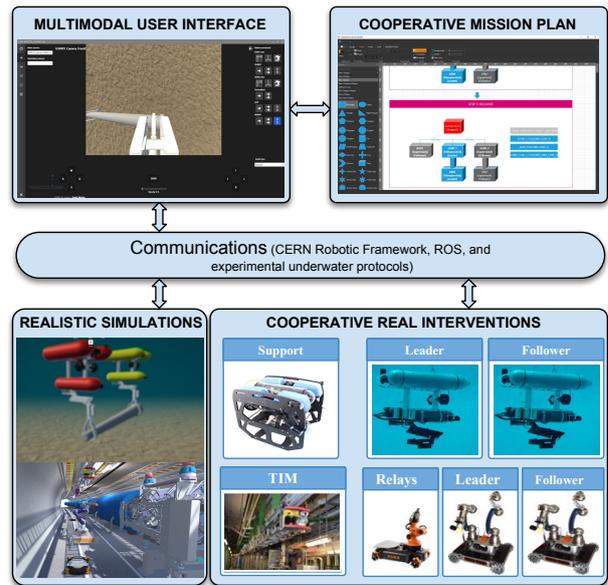


Figure 3: Synergies between the CERNTAURO and the TWINBOTS projects

- Necessity to perform interventions with grasping and transporting capabilities, including pipes for cooperative transportation.
- Vision behaviours for tracking, 3D reconstruction, and grasping determination, using visual-servoing techniques.
- Necessity to apply fine-grained underwater and indoor localization techniques for robot teams.

Figure 4 highlights the common tools available on the HRI used during a grasping and transport task of an object.

2. Overall system Description of the User Interface

The user interface developed for this project present a series of features in order to facilitate the use of robots for teleoperation, with the goal of providing a highly usable and highly learnable interface which can be used by untrained operators. The HRI adapts itself to the robot configuration, in case of multi-agent operation as well. Multimodality is one of the main features: with the distinction between *interaction with the robot* and *interaction with the interface*, the operator has available a set of different interaction devices, which can be chosen in any moment during the operation in order to make it more comfortable.

3D environmental reconstruction and Virtual Reality are available to the operator to get a more clear view of what is going on in the environment surrounding the remote robot. 3D reconstruction can be used as well for collecting precisely positioned data about the environment, such as radiation, temperature, oxygen level and others.

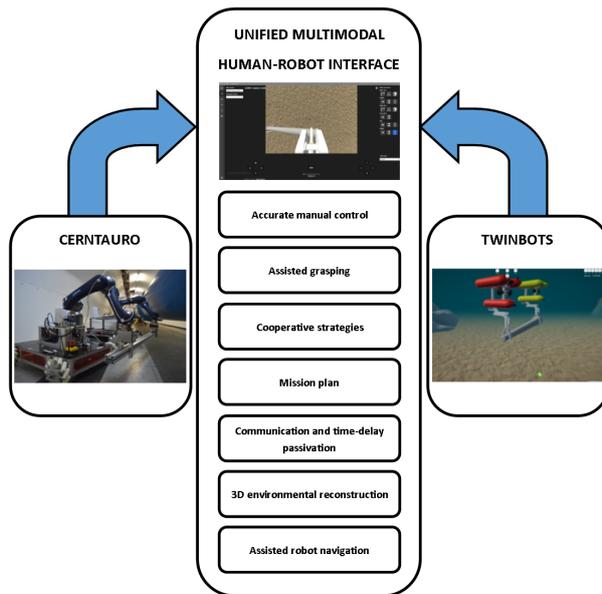


Figure 4: Synergies between the CERNTAURO and the TWINBOTS projects during a grasping and transport task of a heavy object.

3. Conclusions

In the present paper the preliminary results of a novel multimodal user interface for cooperative robotic interventions has been presented. The former version of the system has demonstrated to be very effective in more than 80 real robotic interventions at CERN accelerators, allowing the operator to remotely control the mobile manipulators in an effective and safe manner. Also, the current paper shows how the user interface has been provided with a new scripting and cooperative mission plan functionality, which allows the user to plan the intervention in advance, implement additional cooperative scripting behaviours if necessary, and activating them during operation. In fact, the system is provided with a simulation training server that lets the user operate the robots using the user interface, before facing the real intervention. Further work will focus on the experimentation of more advanced cooperative behaviours, improving the team localization and the study of reliable vision-based behaviours for metallic pieces.

4. Acknowledgements

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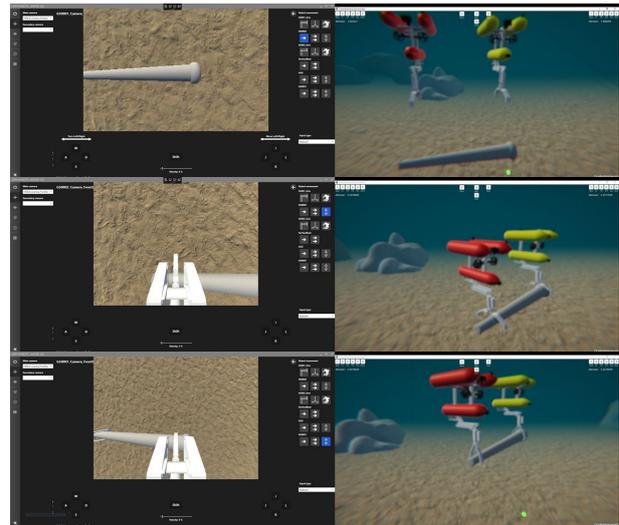


Figure 5: User interface interaction with the underwater realistic cooperative scenario using the cooperative mission plan. The scene point of view is obtained through a third auxiliary robot



Figure 6: The experiment performed in simulation with underwater robots has been performed as well in reality using two robotic platforms in a CERN experimental area [5]. The planned cooperative mission has not been changed for the real experiment, but only the HRI configuration has been changed to the new setup.

References

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