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EXOSTATION : Haptic Exoskeleton based control station

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Abstract—**EXOSTATION is a project aiming at building a complete haptic control station, which allows the operator wearing an exoskeleton-based haptic interface for the human to remotely control a virtual slave robot.**
The video presents the results achieved with the final system. It is composed of four main components. A human-arm exoskeleton used as a master haptic interface, its controller, a simulated virtual slave robot and a visualization tool. Demonstration scenarios are presented in the video and show the capabilities of the system

I. INTRODUCTION

EXOSTATION is a project aiming at building a complete haptic control station, which allows the operator wearing an exoskeleton-based haptic interface for the human arm to remotely control a virtual slave robot.
There is a wide range of applications for this kind of system, from virtual reality in the domain of virtual training to the teleoperation of real robot in the field of remote maintenance, exploration in severe environment and space exploration. Indeed, in future space missions, robots could be used as first explorers in hostile environment [1] or as assistants for Extra-Vehicular Activities (EVA). This will require a higher level of cooperation between astronauts and robots. For this, the use of a portable device that would procure the robot operator with force-feedback sensations (also called haptic sensations) would highly increase the easiness of the command task. In this context, ESA has launched the development of a humanoid servicing robot, called EUROBOT [2]. The EXOSTATION project was launched to implement a force feedback exoskeleton master arm to control this robot in its master-slave manual control mode.

II. SYSTEM OVERVIEW

The system is composed of four components [3].

The Sensoric Arm Master (SAM) is used as a master haptic interface. It has a kinematic structure isomorphic to the human arm and owes 7 Degrees Of Freedom (DOF) from the shoulder to the wrist. The total weight of the system is 7kg.

The Exoskeleton Controller (ECO) is divided into two parts. A PC running QNX real-time operating system implements the control strategies of the haptic teleoperation chain. It insures also the communication transfers at a 500 Hz sampling rate, needed for haptic rendering. Secondly, small electronic boards are mounted locally on SAM. Their purpose is to drive individually the joints of the exoskeleton with onboard PWM current amplifiers, encoder and torque sensor interfaces.

The Slave Simulator is a multithreaded application which simulates an anthropomorphic 7 DOFs robot and interaction with virtual environments. The physics engine is build on top of ODE [4].

The 3D visualization client allows visualizing in real time the state of the system (calibration, simulation monitoring).

III. APPLICATION

The video shows various demonstration scenarios which have been implemented in Python scripts [5] in the Slave Simulator.
The selected activities have been chosen to reflect common situations met in robotic manipulation applications. For each of them, the stiffness of the virtual bodies can be modified to show the ability of the system to render various levels of stiffness.
In the Shape Screening environment, the operator can feel the presence of volumes, as sphere, cubes, meshes in his workspace.
Manipulation tasks can also be performed using the system. Virtual objects can be grasped by the operator and he can interact with the environment, for example to build structures. A specific manipulation task is the Peg in the Hole. Although this scenario is more challenging in term of computation load and stability, we succeeded to present a good behavior to the operator. Without visual feedback, it is fairly easy to find the hole and align the peg.

IV. CONCLUSION

This video presents the result of the EXOSTATION project, a complete 7-DOF haptic control chain, developed in the frame of an ESA project.
It shows contacts, manipulation of objects through the use of an anthropomorphic arm robot. Users who tested the system were very impressed by the easiness of operation with the

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exoskeleton and felt the advantages of a force feedback information.

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[4] ODE (Open Dynamics Engine), http://www.ode.org/.

[5] Python Programming Language, http://www.python.org/.