Haptic coupling with augmented feedback between the KUKA youBot and the PR2 robot arms

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***Abstract*— This robotics demonstration will present a haptic coupling between the KUKA youBot and the PR2 robot arms. The demonstration is built on top of the haptic coupling as described in [paperID 1609], but uses a KUKA youBot to replace the lightweight arm, thereby also demonstrating the generality of the approach. Beside haptic coupling, we provide the human operator with visual feedback. To this end, the head movements of the human operator are coupled to the head movement of the PR2 and the images of the eye cameras are displayed to the human operator using a wearable display. By combining these robot platforms together with additional sensors, we demonstrate the strength of current robot frameworks to build advanced and integrated robotic systems.**

Keywords: *mobile manipulation, haptic feedback*

I. Introduction

Haptic feedback and augmented reality are two research fields that were and are highly popular for the past years. A lot of the related work concerning haptic coupling of two robots takes place in the medical field where the focus lies on minimal invasive surgery [5] [4] in which hard constraints are set for the entry point of the trocar in the patient body. These constraints can be met mechanically with specialized robotic designs or by the control software [3], [6].

Significantly less prior art [1] can be found on the needed visual augmented feedback that must be given to operators for haptic control of a robot, especially in the context of using "off-the-shelf" service robots as components.

In this demonstration we show how we couple a KUKA youBot to the Willow Garage PR2 to allow remote "haptic" control of the PR2 robot. Although, currently, it might be a bit of an overstatement saying that this combination of hardware is "common off the shelf", the authors do believe that more and more research groups, industries, and (professional) users will have access to similar systems in the coming decade, *and* will want to couple some of them in a "haptic" set-up as presented in this paper. The authors also realize that using the term "haptic" in the context of the presented work has a very different meaning (performance-wise) than in the dedicated research on haptic interfaces; nevertheless, the concepts (and the subjective feeling of the human operators involved in the experiments) do have a significant haptic component, in the strict sense of the word, namely to get on-line motion/force feedback from the remote system to which the human operator can react without being disturbed too much by performance issues to make the task unbearable or ineffective.

The presented teleoperation application is furthermore an example of the integration of two component-based robotic frameworks namely OROCOS (Open Robot Control Software) [2] and ROS (Robot Operating System).

We start from the existing software implementation for two KUKA lightweight arms and adapt it to use one KUKA youBot instead. The software modifications will be limited to replacing the low level robot components, thereby showing the generality of the approach.



Fig. 1. Illustration of the original setup. In the front the human operator is operating the two KUKA-LWR arms, is wearing VR goggles (displaying the images of the eye cameras of the PR2), and IMU sensor on the head (to couple his head motion to the one of the PR2). In the back the PR2 is used as a slave to perform an "artistic" painting task.

II. Technology used

On the hardware level (Figure 1), the application uses one Willow Garage PR2 robot, one KUKA youBot, a Vuzix iWear VR920 wearable display and a Xsens MTI inertial measurement unit.

On the software level, it uses the ROS build system, the OROCOS component framework together with the ROS integration software, and low-level drivers for the wearable display and IMU sensor.

The demonstration illustrates the flexibility offered by the OROCOS and ROS component based frameworks. These frameworks allow fast implementation and easy interchangeable functionality. This is shown by the fact that functionality can remain while platforms change. As the OROCOS framework is completely integrated in the ROS framework, one can benefit of the advantages of both, without worrying about the connection between them [7]. Furthermore, it also shows the ease of distributed computing as algorithms for this demo run distributed over 5 different computers, while maintaining a loop-closure time small enough for force feedback.

It illustrates the Best-Practice-in-Robotics (BRICS) drivers for the KUKA youBot, the Simple-Open-Ethercat-Master on the youBot connected to OROCOS, and stereo drivers for the Vuzix iWear VR920. Head tracking is done with a Xsens MTI IMU sensor.

A teaser video and more information (including videos and pictures) on the original paper and this demonstration proposal can be found: `http://people.mech.kuleuven.be/~kbuys/iros2011.html`.

III. Demonstration live and interactive aspects

People get a hands-on experience demonstrating the three main features of the application.

Firstly, the haptic coupling between the PR2 robot arms and the KUKA youBot is shown. People can manipulate the PR2 arms and observe the youBot reaction or vice versa. The aim here is not to illustrate the best performant haptic coupling setup, but rather illustrating modern tools combining mechanically very different platforms.

Secondly, by means of the wearable display, we provide them visual feedback of the PR2 eye cameras.

Thirdly, they can wear a hat, with integrated IMU sensor, which couples the PR2 head movement to that of the human. This head movement coupling, together with the visual feedback, improves the human identifying himself as the PR2.

On the software level, we give the audience an impression of how the software architecture looks like by explaining what different components exist, how they communicate with each other, etc . . .. They can see how tightly both the OROCOS and ROS framework are integrated and how easy it is to use both frameworks together.

Furthermore, we will compare the existing implementation using the KUKA lightweight arms with the implementation using the youBot, thereby demonstrating how one can substitute any robot in the system with minimal effort.

By using these two ”off-the-shelf” but eye-catching robot systems in a haptic system, the audience not only can put their hands on these state-of-the-art robot systems, but also gets a technological impression of how well two robot systems can work together in e.g. a haptic way.

IV. Standard platform demo requirements

a) Robot hardware platform: Willow Garage PR2, and one or two KUKA youBots.

b) Sensor requirements: We will use the different sensors available on the PR2 and youBot.

c) Computational requirements: We will use our own laptops in combination with the PC systems on PR2 and youBot. We would like to make use of a wired network infrastructure.

d) Equipment we will bring:

- Two laptops + network cables
- Virtual reality goggles, Vuzix iWear VR920
- IMU sensor, Xsens MTI + hat

e) Special requirements: Some space to drive around with the PR2, a flat table to position the youBot on.

f) Number of people expected to support the demo: Two, Steven Bellens and Koen Buys.

References

see `http://people.mech.kuleuven.be/~kbuys/iros2011.html`.

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