A human-humanoid interface for collaborative tasks

Paolo Pierro, *Student Member, IEEE*, Daniel Hernández, Miguel González-Fierro, Lorenzo Blasi, Andrea Milani and Carlos Balaguer, *Member, IEEE*

I. INTRODUCTION

This paper deals with the collaboration between humanoid robots and humans in order to achieve tasks in space environments. In this research we use the robot HOAP-3 teleoperated by a human agent.

The small humanoid robot "HOAP-3" is about 60cm high and its weight is about 8 Kg, so that it becomes quite easy to control and move while maintaining the whole stability.

The robot is able to explore the surroundings and detect an object that is placed in the scenario. The robot can go towards the object and take it. A human machine interface (HMI) and a high level command protocol have been designed to help the operator in moving the robot. As a control device we use a lightweight and portable tablet pc.

II. THE HUMAN-MACHINE INTERFACE

An HMI was developed for the teleoperation of the robot HOAP-3 in the lunar scenario. Using the HMI a human agent can work collaboratively with the robot in the achievement of the proposed tasks.

The HMI allows an operator to see the environment from the robot cameras, as well as to control various movements of the robot and give orders for doing some tasks, e.g. "grab object".

The HMI provides several functionalities to the human agent working with the robot:

- video feedback from robot cameras and visual cues of object recognition;
- control movement of the robot head (pan and tilt);
- control walking and turning movements of the robot.
- command the robot to perform higher order task, such as go to specific location, grab object or drop object.
- communication feedback with a log of the commands between operator and robot.

The developed HMI is shown in Fig. 1.

P. P., D. H., M. G. and C. B. Authors are with Universidad Carlos III de Madrid, Avda Universidad 30, 28911, Leganés, Madrid, Spain, (e-mail: {ppierro, mgpalaci, dhgarcia, balaguer}@ing.uc3m.es). L. B. and A. M. Authors are with Hewlett-Packard Italy Innovation Center, via Grandi 4, 20063 Cernusco sul Naviglio (MI), Italy (e-mail: {lorenzo.blasi, andrea.milani}@hp.com).

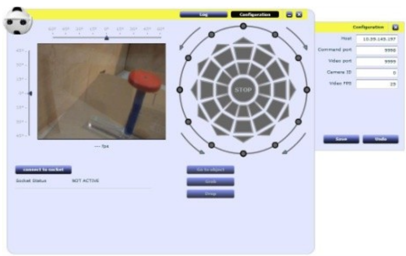

Fig. 1. The HMI for teleoperation of robot HOAP: On the left there is the video panel and the head movements controls. On the right side of the HMI there is the communication configuration panel. On the bottom side there is the 'connect' button and the communication log. On the center wheel of the HMI there are the walking and turning movements' controls and the higher order command buttons, 'Go to object', 'Grab' and 'Drop'.

III. THE COMMAND PROTOCOL

There are very few published works about commands for robots' teleoperation. Most of the presented protocols are very simple and allow only low-level commands, mostly aimed at directly controlling robot's actuators [1], [2], [3]. Only one protocol allows multiple clients connecting to the same robot [4], but no device locking is present and no queuing of commands is done. Thus, in order to control the robot, we designed from scratch a Robot Command Protocol (RCP). Design goals for the protocol are: simplicity, generality, flexibility and expressiveness. The protocol should be simple in that no unneeded features should be added; the protocol should be general and flexible enough to be used for several use cases without modifications. A powerful characteristic that leads to both flexibility and expressiveness can be identified as orthogonality, which can be achieved by clearly separating disconnected functionalities while at the same time allowing their combination without unneeded constraints. RCP is a text-based protocol which has its roots in Unix protocols like SMTP or FTP. Each RCP command is a text string terminated by a newline character. Using text commands has several advantages. First of all the resulting protocol is simple to understand and implement; this means that support for robot control can also be easily added to programs different from our HMI. Moreover, the protocol is lightweight; since the robot has limited computational resources that can be dedicated to command parsing, this was an important design goal. Finally, the human-readable text commands make debugging easy. Communication traces can be understood immediately and you can even do simple tests by typing commands directly in a telnet session. Our protocol is concerned with application-level communication

TABLE I
RCP SUB-PROTOCOLS

Name	Number of commands
Connection	2
Control negotiation	2
Basic movement	3
Direct command execution	1
Configuration	2
Sensor reading	1
Positioning	2
Notification	tbd
Goal-setting	1
Object grabbing	2
Strategy selection	2

only; we assume that a reliable channel (in our case a TCP/IP connection) is used for transmission. The protocol is also general in that it hasn't been designed for a specific target robot, but for a generic target robot described by a high-level robot model.

RCP was originally defined in [5] and can be decomposed into several sub-protocols, like the RoboLink protocol [6] is organized into "profiles". Each sub-protocol contains a set of commands used for a single purpose. The list of RCP sub-protocols is shown in Table I.

IV. EXPERIMENTAL RESULTS

In order to evaluate the teleoperated system proposed in this paper, several tests were conducted with the HOAP-3 robot. The robot walks in an enclosed corridor while being teleoperated by a human agent. Trough the HMI the operator sends walking and turning movement commands. Video feedback from the robot cameras indicates to the operator that the robot has located the 'antenna'.

Fig. 2. a) the recreation of lunar scenario. b) HOAP-3 teleoperated through a corridor looking for the 'antenna'.

Then, the robot approaches the object to a close enough distance so that it can grab it when requested by the human operator.

Then the robot computes the best trajectory for the grasping movement and performs accordingly to the operator decisions. Fig. 3 shows the experimental setup for the demonstration conducted with the proposed teleoperated system. A human agent works collaboratively with a humanoid robot by supervising, controlling and helping in the decision taken by the robot.

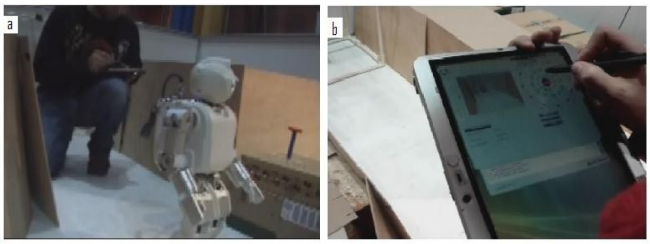

Fig. 3. Demonstration of the proposed teleoperated system on a 'lunar scenario' a) Robot HOAP-3 and a human operator work collaboratively on finding and moving the 'antenna'. b) The operator teleoperates the robot with the HMI using a pocket PC.

V. CONCLUSIONS

A teleoperation system for control of a humanoid robot has been presented in this paper. A collaborative working environment was demonstrated; using a lunar scenario a humanoid robot and a human operator work together in achieving a task. Walking patterns for a humanoid robot have been presented with different trajectories for forward, backward, turn left and turn right movements, all tested on a HOAP-3 robot. We have presented a HMI to help a human agent work collaboratively with the robot. The HMI allows the operator to give the robot direct actions commands like "grab and object", "go to a place", etc. The HMI also gives the operator feedback from the robot environment and the state of the robot actions. An RCP for the communication with the robot is presented in this paper. The main goals of the protocol are simplicity, generality, flexibility and expressiveness. The RCP is a text-based protocol, is simple to understand and debug. It is lightweight and general, meaning that it has not been designed for a specific target robot, but for a generic target robot described by a high-level robot model. The system was tested on two different tasks. First the robot walks in an enclosed corridor while being teleoperated by a human agent using the developed HMI. For the second task the robot recognizes an object which it grasps when given the command by the operator. Future works in space collaborative working environments would include working in new tasks with the robot like the construction of a space shelter. Further work on the RCP and the HMI is also necessary to add more features.

REFERENCES

[1] Khepera User Manual, http://ftp.k-team.com/KheperaIII/Kh3.Robot.UserManual.2.2.pdf

[2] B. Ricks, C.W. Nielsen, M.A. Goodrich, "Ecological Displays for Robot Interaction: A New Perspective", in *IEEE/RSJ International Conference on Intelligent Robots*, 2004.

[3] A.F.T. Winfield, O.E. Holland, "The application of wireless local area network technology to the control of mobile robots", in *Microprocessors and Microsystems 23*, pp. 597-607, 2000.

[4] B.P. Gerkey, R.T. Vaughan, A.Howard, "The Player/Stage Project: Tools for Multi-Robot and Distributed Sensor Systems", in *Proceedings of the International Conference on Advanced Robotics*, pp. 317-323, 2003.

[5] L. Blasi, O. Stasse, *Robot@CWE Deliverable D3.3@M22*: Design support software for ROBOT@CWE, Annex II.

[6] AIST presentation at DSIG Plenary Meeting, http://robotics.omg.org/docs/robotics2005-04-Athens.pdf