Towards Intuitive Interaction Among Human-Robot Team Members

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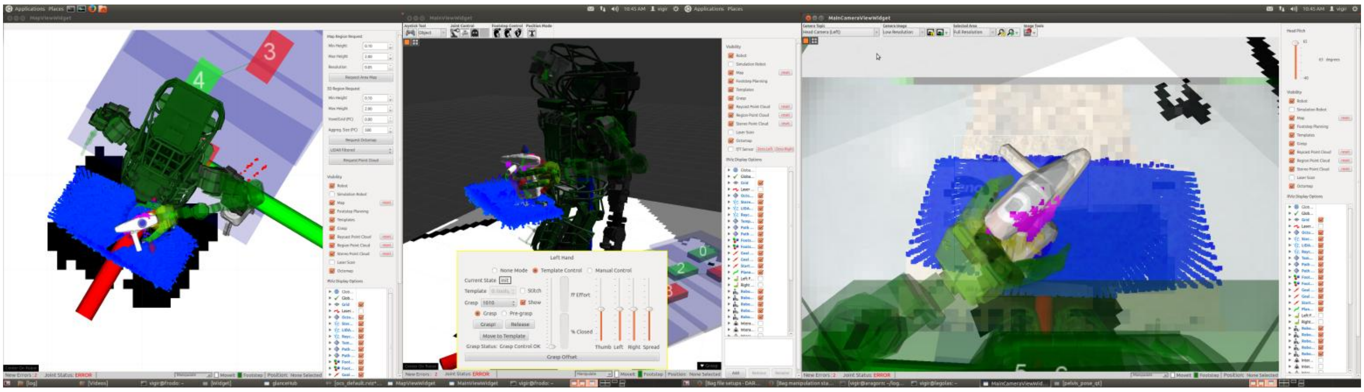

I. Motivation

The disaster relief scenarios envisioned by the DARPA Robotics Challenge will require efficient use of a semi-autonomous humanoid robot performing highly diverse tasks using human tools. The human operator must balance the need to complete tasks in a timely fashion with the risk of damaging the robot and rendering it inoperable for remaining tasks.

Team ViGIR[1] addresses these challenges by focusing on how to "make best use of the human [operator]"[2]. While there are many technical challenges to robust operations within a disaster response scenario, Team ViGIR is focused on improving the ability of the human-robot team to actively collaborate to enable operation in challenging environments. Our approach involves both *Collaborative Perception* and *Collaborative Action*.

II. Approach

The technical foundation of the approach is a collection of distributed processes that provide fundamental system capabilities. These processes, which are developed within the ROS (Robot Operating System) framework, are distributed between computers on the OCS (Operator Control Station) and robot onboard computing. These capabilities include state estimation, perception, motion planning, and control.

We describe capabilities that were developed by the team with a focus on bi-directional interaction between onboard software and human operator capabilities. This includes an approach for collaborative locomotion and manipulation between operator and robot [1,2], leveraging both expertise and cognitive abilities of the operator as well as onboard perception and planning capabilities. We present an approach for providing situational awareness to the operator when faced with bandwidth restrictions that severely restrict the amount of data that can be transmitted between the robot system and human operator.

The overall system is managed and controlled through a set of 2D user interface components that provide an appropriate situation overview. The use of both 2D and 3D visualizations provides the operator situation awareness about the state of the robot and the environment around it, and permits intuitive specification of the tasks and goals through the combination of 2D (keyboard and mouse) and 3D input (3D mouse and motion tracking) [3].

III. Outlook

We are planning to extend the use of motion tracking to use gestures and other elements based on an operator centric design in order to simplify training, and minimize operator workload. These will be used for both high- and low-level tasks, such as composing new behaviors and object manipulation. In addition, we are also planning to include stereoscopic displays and head-tracking to improve depth perception and overall situation awareness. Finally, we will investigate the use of a touch table to improve collaboration and supervision of tasks.

Ongoing research will define the capabilities provided by the system that are *composable* and develop the ability to automatically compose capabilities to generate reactive, behavioral automata on the fly. This will allow the operator

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[1] www.teamvigir.org

[2] Dr. Gill Pratt, IEEE Spectrum Online, 11 Apr 2012, http://spectrum.ieee.org/automaton/robotics/humanoids/darpa-robotics-challenge-qa-with-gill-pratt

to specify tasks at a high level, communicate the task over restricted bandwidth communications, and enable the robot to synthesize the required controlling automata given currently available capabilities. This will enable the robot to autonomously react to changes in the system (e.g. a sensor failure), and successfully complete the task if possible.

ACKNOWLEDGMENT

The authors would like to thank all members of Team ViGIR for their contribution and support which enabled the realization of this work. This work has been funded in parts by DFG Research Training Group 1362 and Defense Advanced Research Projects Agency (DARPA) under Air Force Research Lab (AFRL) contract FA8750-12-C-0337; the views expressed in this paper are those of the authors.

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