Marker Based Task-Level Teleoperated Manipulation

Rafael Cisneros[1]
rafael.cisneros@aist.go.jp

Takeshi Sakaguchi[1]
sakaguchi.t@aist.go.jp

Shuuji Kajita[1]
s.kajita@aist.go.jp

***Abstract*— This paper presents the method used by our team, AIST-NEDO, at the DARPA Robotics Challenge (DRC) to deal with the requested manipulation tasks by means of a task-level teleoperation, by considering a degraded communication between the user and the robot and that the environment was not known in advance. The method basically consists on the use of 3D models of objects (from now on referred as "markers") which, once aligned with the actual attitude of the real objects that they represent, provide a reference frame in which the motion can be described, in order to successfully realize a manipulation task in a non-structured environment. These markers can represent the object being manipulated, some reference object in the environment and the hands of the robot. This method is illustrated by means of describing three representative tasks (which where requested during the DRC) and presenting the corresponding results obtained during the competition.**

I. Introduction and Motivation

Disaster response is attracting attention from the robotics research community, and even more since the Fukushima Daiichi nuclear power plant accident that followed the 2011 Great East Japan earthquake and tsunami. As a concrete materialization of this increasing interest, a challenge is proposed by the American Defense Advanced Research Projects Agency (DARPA) to use robots in disaster-hit facilities that were made too hazardous for direct human operator intervention. It is worth noticing that the challenge does not impose any constraint on the design of the robot, but since the environment (industrial ladders, doors, valves, cars) as well as the tools (levers, drills, hammers) were meant to comply with the human morphology, it is a natural option to develop the necessary means to make the humanoid robots capable of performing inspection and disaster recovering actions inside a non-structured environment [1].

This environment can be considered to be "kind of" known in the sense that we know which actions are required in advance and that we have a rough idea of its spatial distribution, maybe altered due to the disaster itself. Then, only very limited assumptions about the structure of the environment can be made beforehand, in contrast to structured scenarios where semantic knowledge of their structure can be leveraged for highly autonomous robots operating in them [2].

It is also mandatory to consider that within a disaster-hit facility it is not possible to rely on a stable, wide bandwidth wireless communication system with the robot. The signal may be degraded and blackouts may occur frequently. Then, it is not feasible to consider a purely teleoperated robot. First, because of the high dimensionality of its control system, and second because the capabilities of the robot and the operator should include near real-time feedback without disruptions in the communications as well as transmission of large amounts of data to the operator. On the other hand, a fully autonomous robot navigating and interacting in an unconstrained environment should include extensive databases of information about possible objects of interest to be found, highly efficient grasping algorithms and the ability to react to unforeseen situations, which are still unsolved problems [3]. A feasible alternative is the development of supervised semi-autonomous high Degrees-Of-Freedom (DOF) robotic systems; that is, task-level teleoperated systems in which the operator cognitive burden is minimized by lowering the control space dimensionality [4], such that these operators function as supervisors setting high level goals, assisting the robot with complex perception tasks, directly changing robot parameters to improve its performance and making decisions when facing unexpected situations [2].

II. Related Work

III. Teleoperated Manipulation Method

A. Manipulation Marker Alignment

The robot must achieve a proper stance with respect to the object(s) representing the target of the task, such that they be inside of the dextrous workspace of the hands of the robot.

B. Manipulation Marker Based Motion Description

C. Dealing with Uncertainties

IV. Examples

A. Opening a Door

B. Pulling and Inserting a Plug

C. Opening a Box and Pressing a Button

V. Results

VI. Conclusions

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[1] R. Cisneros, T. Sakaguchi and S. Kajita are members of the Humanoid Research Group of the National Institute of Advanced Industrial Science and Technology (AIST), 305-8568 Tsukuba, Japan

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