Indirect-type Teleoperation Interface for Humanoid Robot Based on Choreonoid Framework*

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***Abstract*— We present an "indirect-type" teleoperation interface for biped humanoid, designed for disaster response applications [1]. Since a humanoid has many DOFs, it is necessary to develop an interface with appropriate granularity of tasks, taking into account low communication bandwidth. We have developed an interface based on Choreonoid framework [2] [3] integrating several functionalities such as point-cloud sensing, whole-body motion planning for reaching, and bipedal walking through a plugin mechanism. We have been validating the interface by rough-terrain walking and valve manipulation with HRP-2 humanoid robot.**

I. INTRODUCTION

Humanoid robots have a potential to do various tasks at such disaster places because their human-like bodies are suitable to work in the human-life environments, which are designed for humans. DARPA Robotics Challenge (DRC) is a good practical example to verify the idea of using humanoid robots for the disaster response, and we also assume tasks required in DRC in this paper. Taking into account limited bandwidth in disaster response applications and large number of DOFs to control, we are developing an "indirect-type" teleoperation interface for a bipedal humanoid robot possessing certain amount of autonomy.

In the indirect-type interface we develop, the basic operation procedures are as follows:

1) Communication to get the current robot state and environments is specifically requested and the obtained information is presented on the interface
2) Seeing the obtained information, the operator specifies the command the robot should do next
3) The expected result of executing the command is presented, and the command can be actually executed by giving the go sign if the expected result is acceptable
4) The above process is repeated to complete a task

Although a similar type interface allowing high-level teleoperation commands has been developed [4], we design a set of operation commands with finer granularity in order to obtain flexibility in task executions.

II. OVERVIEW OF INTERFACE

All the functions provided for the operator are integrated into a graphical user interface (GUI) which runs in a terminal PC. We employ the robotics application framework called Choreonoid [2] as the base of the GUI, and the functions specific to the tele-operation are additionally implemented as a plugin of Choreonoid as shown in Fig. 1.

The GUI and the robot are connected by the gateway components. The data from the robot is received by the GUI gateway and it updates the data managed in the GUI side, and the commands specified in the GUI are sent to the robot through the gateway.

The robot used in our system is the humanoid robot HRP-2 with 7-DOF arms and grippers. It is equipped with some camera devices and a laser range sensor, and the measured data is sent to the GUI when the operator requests it.

We have designed such commands as data acquisition from LRF and cameras, walking, reaching and manipulation with grippers. These commands are designed in a relatively general manner so that various tasks can be handled by combining a small set of command types. This can also leads to increase the ability to handle tasks the details of which are not known a priori.

III. TASK EXECUTION THROUGH GUI

This section evaluates the interface by presenting the experiments on performing actual tasks. The target tasks are walking on uneven terrain and rotating a valve; the task settings are based on the corresponding DRC tasks. We used dynamics simulation for the evaluation. Choreonoid [2] was used as the simulation platform as well as the platform of the tele-operation interface.

A. Walking on Uneven Terrain

In a disaster response, moving on uneven terrain is a very common task. To test the tele-operation in such situation, we used the environment model shown in Fig. 2. The goal of this task is to move over the entire terrain. Th basic process of performing the task is as follows:

1) Measure the shape of the terrain in front of the robot
2) Find a good foot step plan to the next standing point within the measured area
3) Execute the foot step plan and check the result
4) Repeat the above process until the robot reaches the goal

Fig. 3 shows a part of this process. We verified that the robot was able to complete the task by applying the above process. We expect this operation could be almost automatic in the remaining area because the robot was able to walk stably just by iterating the measurement and walking while moving the walk destination forward at a certain distance.

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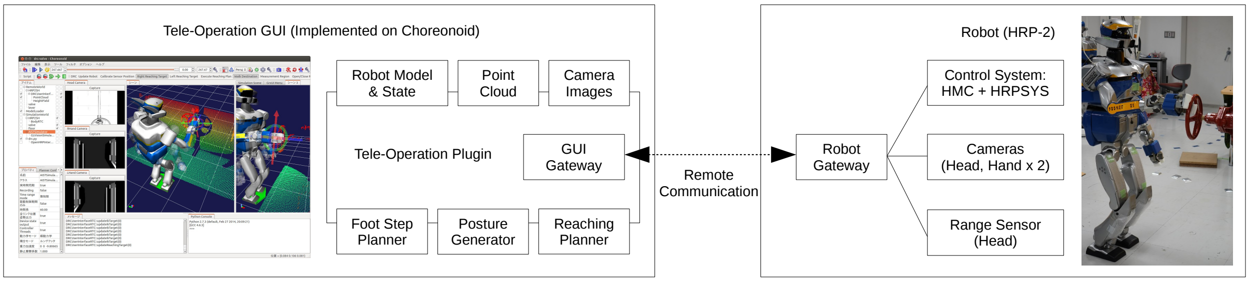

Fig. 1. Composition of Teleoperation System

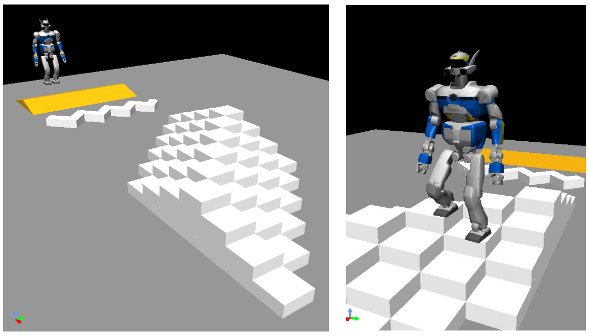

Fig. 2. Terrain task. The left image shows the terrain and the initial position of the robot. The right image shows the robot walking on the terrain

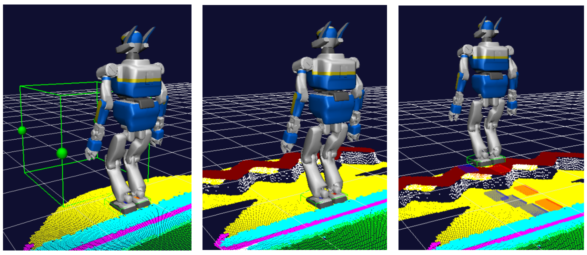

Fig. 3. Measurement of terrain and foot step planning on the terrain

B. Rotating a Valve

As an example of manipulating an object, we tested the task of rotating a valve. Figure 4 shows the sequence performed to achieve the task. We verified that the robot was able to locate the valve using range data, walk to an appropriate position and to rotate the valve through the GUI based on the commands we have prepared. The above process is flexible enough to adapt to various valves.

We are currently testing the performance of the developed teleoperation interface for the real hardware HRP-2 to execute those walking and manipulation tasks. The interface will be improved based on the feedbacks obtained from experiments.

References

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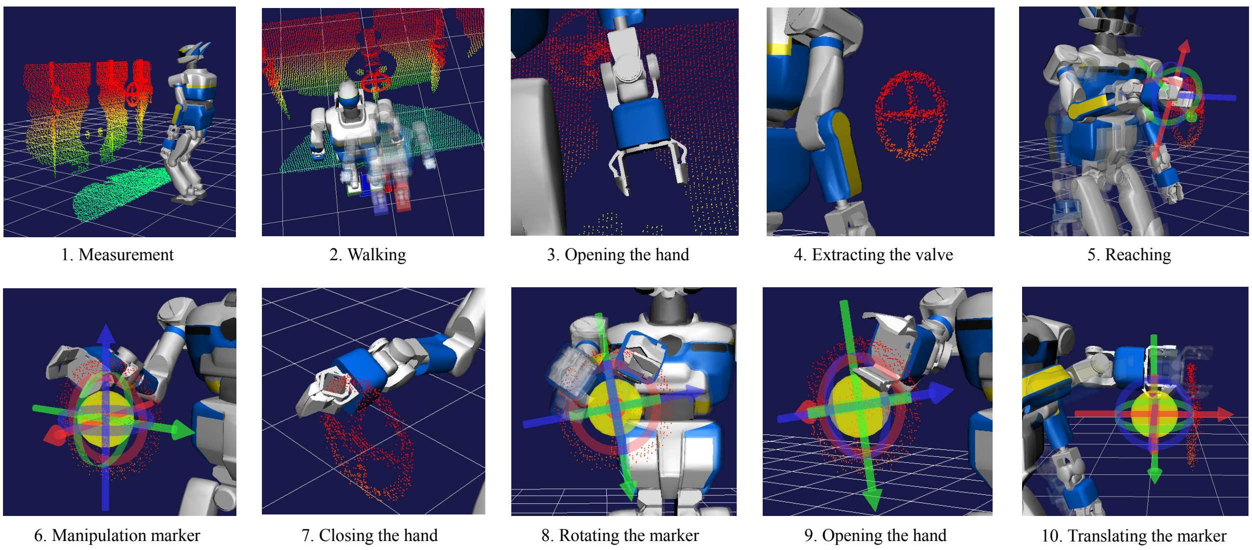

Fig. 4. Operations of the valve rotation task