Teleoperated control of a humanoid robot

Project plan

Jens Ernstberger

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Motivation

Current solutions for teleoperated humanoid robots are often very expensive and require specialists to be used. To achieve a cost efficient environment for the consumer which is easy to use while still being precise new approaches need to be evaluated. Both tracking technologies and 3D printing have made great progress in the past thirty years and have become more affordable lately.
A ready to use Virtual Reality system from HTC, which provides extremely precise tracking through infrared lasers, is being sold for as low as 799$. With products like these the end consumer might be able to be provided with a comparably low cost solution that enhances their every day life.
A use-case might be to create a virtual presence of the consumer, who is e.g. not able to be physically present due to health related issues. The virtual presence through a teleoperated humanoid robot can help to socialize, communicate and even work in fields that might have never been a possibility without such a system.

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1 Description

Objective & System approach

The goal of this work is to investigate if there is a feasible approach to create a virtual presence using already existing technologies while providing high precision and minimum latency. The idea is to use a virtual reality system with high precision tracking of the users movements to monitor the exact position of the user at any time. The obtained position data should then be processed and sent to the robot with a communication protocol.
The used virtual reality system is the *"HTC VIVE"*, a system that was released in 2016 and consists of two controllers and one head mounted display. This system can be extended with the *"VIVE Tracker"*, a small device which can be attached to anything and is seamlessly integrated with the HTC VIVE basic package.
The robot used for this thesis is the *"Poppy Humanoid"* robot, which is an open-source robotic platform for academic use. Poppy was created in 2012 and initiated during Matthieu Lapeyre's PhD thesis. The goal with Poppy is to provide a community-centered, easy to use and integrate platform that can be used for education, arts and science. Poppy is built with MX-28 AT, MX-64 T and AX-12 A Dynamixel servomotors (in total 25). Each of the Dynamixel servomotors can receive different kinds of orders (goal, torque,...) and communicate with the other servomotors through a embedded electronic board.
The communication between the robot and the virtual reality system is guaranteed by a communication protocol that provides the position data in real time to the Poppy robot (*see Fig.1*). The communication protocol that will mainly be evaluated in this thesis ist the *"Robot Operating System"* (ROS).
The idea ist to create a node for Poppy and a node for the HTC VIVE. The Poppy node should then listen to the data published by the HTC VIVE in order to get into the right position. In order to not destroy the robot or the Dynamixel servomotors used to move the robot another node will need to be created in a simulation environment. The robot will be run in a simulation so that the transformations done to calculate the current position of the robot will not harm the real robot.
The main objective of this work is to make the robot imitate the moves performed with the controllers. An advanced approach would be to mount a stereo camera on the head of the *"Poppy Humanoid"* robot and track the exact movement of the head mounted display. With this approach there exist far more problems that need to be solved. For example the latency of the network & the delay of the servomotors for moving the head of the robot will cause a so called *"Simulator Sickness"*. This is caused by the fact that what you see with your eyes doesn't match up with the movement of the head.

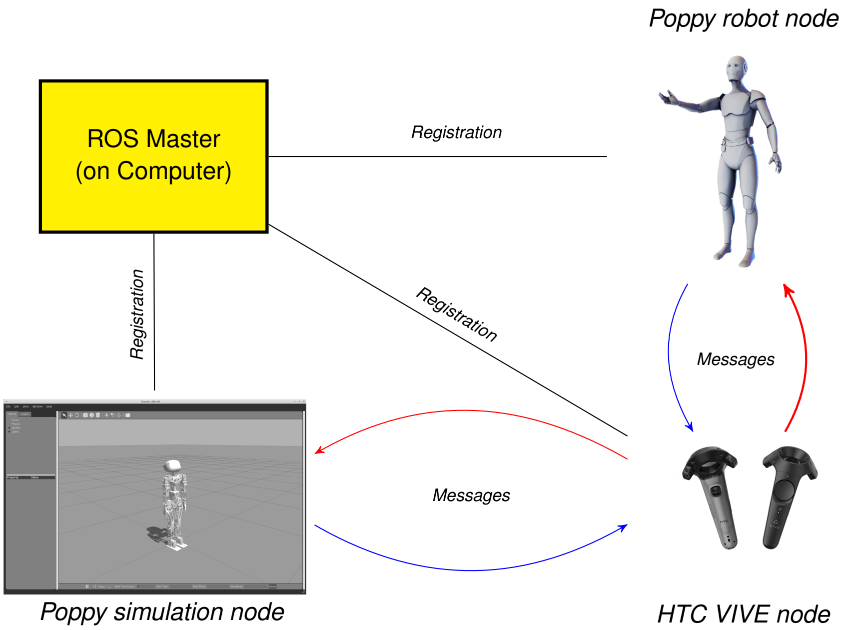

Figure 1: *Communication concept via ROS*

2 Substantial work stages

- **Research & Configuration**
  - Familiarization with principles of robotics and the *"Poppy Humanoid Robot"*
  - Learning of ROS
  - Setup *"Poppy Humanoid Robot"* and the simulation of Poppy Humanoid
  - Familiarization with basic concepts of Virtual Reality and and the HTC VIVE
- **Implementation**
  - Setting up the ROS nodes for Poppy, the simulation and HTC VIVE
  - Getting the tracking information from the VIVE for further processing
  - Developing an algorithm for calculation of the current poses and their transformations
  - Execution of practical tests
- **Analysis**
  - Evaluation based on the collected data
  - Analysis of the practical tests including the occurred problems
- **Documentation**
  - Final written composition of the completed work

3 Timeplan

Months	May				June				Juli			
Calendar week	17	18	19	20	21	22	23	24	25	26	27	28
Research & Configuration	■	■										
Implementation			■	■	■	■	■					
Analysis								■	■			
Documentation										■	■	■

4 Expected risks & problems

As mentioned before one major risk is that the calculated transformations aren't correct and that the robot will therefore be damaged. In order to avoid that an exact simulation of the robot in a simulator to test the commands that are sent will be created.
Another major problem could be the calculation of the exact position of the arm. As the HTC VIVE provides only one controller for each hand of the user (and therefore only one exact point in the 3D world) the angle of the elbow and shoulder needs to be calculated manually based on the position of the controller.
As the system is supposed to work in real-time the delay of the user motion compared to the robot motion needs to be minimized. This latency issue could also be a problem.

5 Changes to the project plan

#	DATE	CHANGE	REASON
1			
2			
3			
4			
5			

6 Supervisor

Stefan Röhrl