VR-Based Approach for Guiding a Robot in Manipulation Tasks

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Learning from demonstration (LfD) is a technique that familiarizes a robot with a certain task through demonstrations, and has been gaining popularity due to the difficulty of manually programming robots to complete specific tasks. Of the three main categories of LfD demonstrations, teleoperation has emerged as more efficient and practical compared to more physical LfD procedures.[1] Specifically, virtual reality (VR) is a type of teleoperation technique that has proved to be a more effective and accurate method of simulating demonstrations compared to other systems such as using a PS3 controller.[2] Using virtual reality (VR), this research aims to develop an LfD pipeline to allow for a faster and easier way of guiding a robot in performing manipulation tasks. A VR LfD pipeline would focus on the extraction of task constraints, task generalization, and motion planning in order to take the poses of a virtual object and translate that data into movements for the robot to execute. This pipeline was mainly developed using Python, C++, and ROS (Robot Operating System).

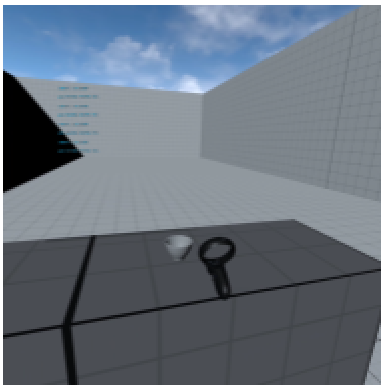

Figure 1. Virtual Environment (VE)

Within this paper, we show that recorded VR motion paths are capable of being interpreted into a set of screw-linear motions and associated inverse kinematic joint-space movements so that the Baxter Rethink Robotics machine executes a replication of the demonstrated task. Using both an Oculus Quest and Quest 2, a series of common movements involving household objects were recorded within Unreal Engine 4 in quaternion rotational and XYZ coordinate form, logged with the Android Debug Bridge, and processed through a WebSocket Python program that automatically sent the resulting pose and grip data to the ROS platform. Within ROS, using algorithms provided by the Interacting Robotic Systems Laboratory (IRSL) at the University, this data was translated into areas of interest, which allowed for the creation of end effector generalized screw-linear interpolation paths between areas of interest. Once the end effector had a set path, an inverse kinematic program (also from the IRSL) was used to calculate the angle and position of each of the related seven joints on the Baxter Robot, determining the pathing feasibility and allowing for execution.

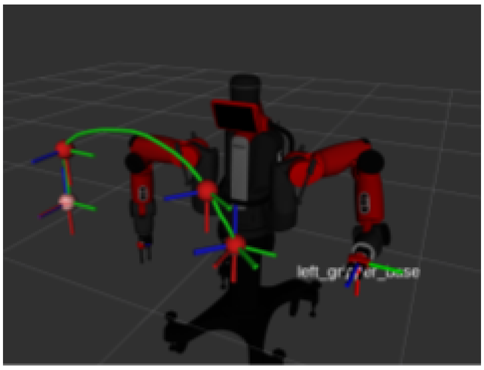

Figure 2. RVIZ Model of Baxter Rethink Robot

While this research could have applications for almost any manipulation task, this study differs from others in that it is specifically intended to assist a robot in learning many routine tasks of daily life that would be of use to those with disabilities, such as pouring a liquid into a cup or stacking objects. To this end, one of the main benefits of a VR LfD pipeline would be giving a capable demonstrator the ability to guide a robot in performing an unexpected task remotely, rather than requiring the robot to be visited in person on every such occasion. This project opens the door for more research into applying and optimizing VR LfD pipelines now that such a pipeline has been created.

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[1] Ravichandar, H., Polydoros, A. S., Chernova, S., & Billard, A. (2020). Recent Advances in Robot Learning from Demonstration. Annual Review of Control, Robotics, and Autonomous Systems, 3(1), 297–330. https://doi.org/10.1146/annurev-control-100819-063206

[2] Jackson, A., Northcutt, B. D., & Sukthankar, G. (2019). The Benefits of Immersive Demonstrations for Teaching Robots. 2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI), 326–334. https://doi.org/10.1109/HRI.2019.8673270