From ROS to Unity: leveraging robot and virtual environment middleware for immersive teleoperation*

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Abstract— Virtual reality systems are often proposed as an appropriate technology for the development of teleoperational interfaces for autonomous and semi-autonomous systems. In the past such systems have typically been developed as "one off" experimental systems in part due to a lack of common software systems for both robot software development and virtual environment infrastructure. More recently, common frameworks have begun to emerge for both robot control (e.g., ROS) and virtual environment display and interaction (e.g., Unity). Here we consider the task of developing systems that integrate these two environments. A yaml-based communications protocol over web sockets is used to glue the two software environments together. This allows each system to be controlled using standard software toolkits independently while providing a flexible interface between these two infrastructures.

Index Terms— robotics, teleoperation, virtual reality.

I. INTRODUCTION

There has long been an interest in developing virtual environment-based interface technologies for the control and supervision of autonomous and semi-autonomous devices. The basic concept can be traced back to early work in telexistence (see [1]): By providing an operator with a perceptual environment that is consistent with the experience that they would have experienced had they been co-located with the remote device then operator performance would be improved. Virtual reality would seem an appropriate technology to provide these essential perceptual cues. Given the potential such an interface might provide, a number of different experimental and operational systems have been developed. For example, systems have been developed for space operations (e.g., [2]), off-road vehicles (e.g., [3]) and unmanned aerovehicles (e.g., [4]), to name but a few. Although these and other systems have had their successes, one aspect that has limited the adoption more generally of the concept has been the lack of a common and easily accessible software infrastructure for both robot control and virtual reality systems. Fortunately, the last few years have seen the development and adoption of a number of standard software systems for both robot control and virtual reality infrastructure. Here we explore how these advances can be exploited in the development of a virtual reality-based teleoperational interface for autonomous robots.

A. Autonomous robot middleware

There have been a number of attempts to develop a standard robot middleware. Early efforts at developing such software infrastructures for robot control include Ayllu [5], Player [6] and COLBERT/Saphira [7]. Although these efforts advanced our understanding of the requirements for autonomous robot middleware, for a number of reasons these systems did not find wide-spread adoption in the academic and industrial communities. Different systems had different detractions, but often systems were targeted at specific hardware platforms/sensor platforms, or had limited computing hardware/operating system or language support. Over the last decade the ROS (Robot Operating System) [8] has emerged as a standard software middleware for the development of autonomous systems. Within ROS, overall robot control is modelled as a collection of asynchronous processes (known as nodes) that communicate via message passing. Although ROS has been ported to a number of different hardware platforms and bindings exist for a number of different languages, support is primarily targeted towards Ubuntu, with software libraries targeted at C++ and Python. A very limited level of support exists for lower performance devices (e.g., Android platforms) but the limited memory footprint on such devices makes development and deployment more complex.

There are a number of reasons why ROS has emerged as a standard software middleware for robot software. First, the software makes few assumptions about hardware or networking – although it does rely on reliable TCP/IP communication. Second, the software model of independent communicating agents allows for great modularity, including the integration of software across multiple hardware sites – including remote sites. Third, there is support for a large number of robots and sensors. Finally, there exists a large number of software tools and libraries for common robot tasks.

Figure 1 illustrates a ROS-based robot system. Figure 1(a) shows a robot based on the P3-AT platform developed by Mobile Robots. The robot relies on skid-steering, and is controlled by a PC104 computer mounted inside the robot proper. The robot exposes the sensors/locomotion system in terms of a small number of ROS nodes. A standard laptop mounted on top of the robot runs Ubuntu, and hosts two laser scanners one mounted in the horizontal plane, the other in the vertical, and communicates with the ROS environment

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