

# Creating a Shared Reality with Robots

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**Abstract**—This paper outlines the system design, capabilities and potential applications of an Augmented Reality (AR) framework developed for Robot Operating System (ROS) powered robots. The goal of this framework is to enable high-level human-robot collaboration and interaction. It allows the users to visualize the robot’s state in intuitive modalities overlaid onto the real world and interact with AR objects as a means of communication with the robot. Thereby creating a shared environment in which humans and robots can interact and collaborate.

**Author Keywords**—Augmented Reality; Intelligent Robots; Human-Robot Interaction

## I. INTRODUCTION

As humans, there is a limit to what we can mentally process and physically execute. On the other hand, robots find it difficult to emulate traits like creative problem solving, empathy and intuition. Therefore, to efficiently tackle a particular scenario, an ideal human-robot collaboration system would capitalize on the specialized abilities of humans and robots to overcome their respective shortcomings. The key challenge here is that humans and robots use vastly different means of communication. While humans might employ speech, gestures and body language, robots usually rely on digital signalling. This presents difficulties for human teammates in understanding a robot’s goals, intentions, knowledge and planning as it is working alongside them.

We believe Augmented Reality (AR) can be this required bridge from digital to analog and that it can be used to create a shared reality between humans and robots for communicating and problem-solving. To bring this shared reality to life, we have developed an AR framework that is capable of expressing the robot’s sensory, planning, and cognitive information by projecting it visually in Augmented Reality. Furthermore, interaction with AR objects in this shared reality can be used as a basis for interaction with the robot at a high level.

We are exploring applications of this interface in many areas of human-robot collaboration and interaction, including education, navigation in shared spaces, and search and rescue. Our goal is to evaluate and improve this framework while identifying its limitations and further potential.

## II. PRIOR WORK AND MOTIVATION

Augmented Reality is an emerging technology that is increasingly being used in robotics. A significant amount of

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work has been done in exploring uses of AR in robotics such as education [1], target search [2], conveying robot motion intent [3] and teleoperation [4].

Our goal is to go a step further and build a generalized framework that can be easily adapted to any of these tasks. Moreover, we want this framework to leverage the robot’s situational awareness, problem solving, and autonomy, thereby identifying the best modalities to express itself in AR and use that expression and its subsequent reaction from human users to solve problems.

## III. TECHNICAL DETAILS

We are using Robot Operating System (ROS) on the robot end, which is one of the most commonly used software architectures for robots. On the AR device end, we are using Unity as our base architecture given its versatility with devices ranging from iPads to Android phones to Microsoft HoloLens. Figure 1 outlines the overall system architecture.

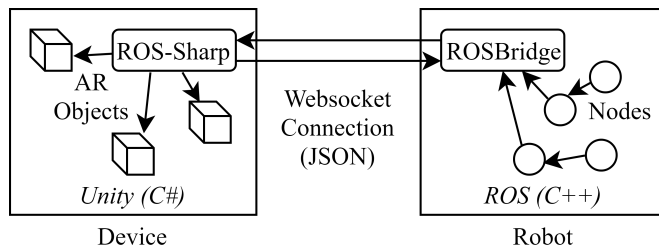


Fig. 1: System Architecture - AR objects are manifestations of ROS Topics

We are using a Websocket Connection between the device and the robot to allow ROSBridge to serialize topics within ROS and send them as JSON to Unity. Within Unity, we are using ROS-Sharp to convert these JSON messages back into C# data structures. We use a similar approach to communicate in the other direction. This gives us real-time, asynchronous and robust data communication within our system.

On the ROS end, we have written additional nodes to sample and compress regular ROS topics to save network bandwidth and prevent latency. Our nodes are also responsible for transforming all the coordinates in these topics to base\_link frame of reference so that they can be projected in AR relative to the robot. We also have an ActionServer that is responsible for taking question/prompt requests from any ROS node in the robot and then forwarding them to Unity, getting a response and dispatching it back to the requester node.

