# CAD-AR: An Intuitive Robotic Teaching Pendant for Skill-based Industrial Robot Programming

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***Abstract*— Traditional industrial robot programming methodologies are often time consuming, non-intuitive, and visually non-collocated with user's intended task. These factors hinder the adoption of collaborative robots that supports the new transformable production paradigm for smart factories. We outline a pilot user study for a multimodal robot programming system that allows intuitive motion planning, offers safety previews, and achieves better efficiency.**

**Our robot programming environment builds on skill-based task programming, and is augmented with gesture recognition, speech recognition, immersive 3D object manipulation, and Augmented Reality (AR) simulations. In our pilot study, we found that gesture recognition and virtual fidelity to the real robot are crucial to developing a usable and accurate programming system.**

## I. INTRODUCTION

Industrial robotics has revolutionized the manufacturing industry, and the introduction of collaborative robotics is the necessary next step in this process. Along with the expansion of robotic applications and functional complexity, there is a rising demand for reprogrammable and redeployable robots [1]. To achieve a quickly transformable production environment, an intuitive robot command interface is the key to introducing flexibility.

Our research is focused on developing an interaction environment that can offer the expertise of Computer Aided Design (CAD) to simulate predicted motions and precisely define complex spatial relationships, without requiring experience. To simplify the input interface for non-designers, we shift the method of programming from robot kinematics to pre-programmable skill primitives [2].

## II. MULTIMODAL CAD-AR ROBOT PROGRAMMING INTERFACE

Our proposed multimodal AR, CAD inspired, robot programming system is for operators with no CAD background. Thus, we must maximize intuition and accuracy. Our objective is to combine the interactive aspect of traditional robot teaching with CAD's precision and preview abilities, using AR as a platform.

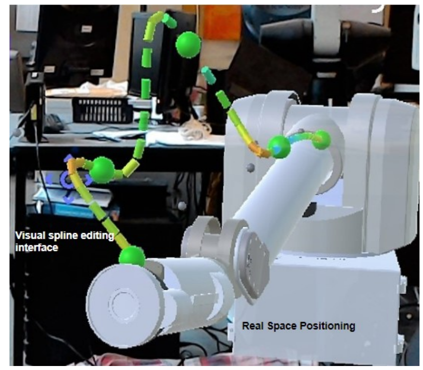


Fig. 1. An important part of robotic programming is trajectory editing. The user may edit the position (green) via points or the path direction (grey). Path colour indicates the velocity of the trajectory along the path.

As a first step, we have built a proof of concept prototype to explore this interaction modality. This paper will present some of our initial findings and challenges.

### A. System Description

The CAD-AR robotic teaching interface is implemented using a Microsoft Hololens[1] and a 7 degrees of freedom Barrett WAM™ robotic arm[2] (herein referred to as "the WAM"). Software for the Hololens is developed using Unity and Microsoft Visual Studio in C#.

The WAM controller is a C++-based Robot Operating System[3] (ROS) package that communicates to the robotic arm via CANbus. It provides positional commands and queries to the WAM in both Cartesian space and joint space. Communication between the controller and Hololens is achieved using ROSbridge [3] in Unity and Linux.

### B. Proposed Workflow

The pilot study uses the following speech-based workflow:

1) **"Come here"**: the virtual WAM moves towards relative position of user and generates via points (cubic spline)
2) **"Try again"**: resimulate the WAM motion
3) **"Edit"**: modify via points (see Fig.2 left)
4) **"Do it"**: the real WAM receives position updates at 60 Hz to achieve virtual trajectory (see Fig.2 right)
5) **"Reset"**: move the real WAM back to initial position

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[1]https://www.microsoft.com/en-ca/hololens
[2]http://www.barrett.com/products-arm.htm
[3]http://www.ros.org/