Augmented Reality-based Industrial Robot Control

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Abstract

Most of the interfaces which are designed to control or program industrial robots are complex and require special training for the user. This complexity alongside the changing environment of small medium enterprises (SMEs) has lead to absence of robots from SMEs. The costs of (re)programming the robots and (re)training the robot users exceed initial costs of installation. In order to solve this shortcoming, we propose a new interface which uses augmented reality (AR) and multimodal human-robot interaction. We show that such an approach allows easier manipulation of robots at industrial environments.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Computer Graphics]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1. Introduction

Almost all of the mass-market production plants use robots for different tasks such as welding, palletizing and tending. Although the benefits of using robots in industrial environments is well-known and the cost of robot hardware has decreased, still there are not many small medium enterprises (SMEs) that use them. One of the reasons lies with the (re)programming costs of such robots. SMEs have more dynamic production line, therefore changes in robot tasks will add extra costs for (re)programming them. If industrial robots could be easily programmed by the engineers that work in the production line, they might be more useful in the SME sector. With this sense, we aim to develop an easier interface for interacting with industrial robots.

Traditional way of programming industrial robots involves the use of teach pendant. Programmers use it to move the robot's tool center point (TCP) through the desired points. This approach has several shortcomings: (i) Jogging an industrial robot with 6 degrees of freedom with a joystick with three degrees of freedom is very time consuming and cumbersome; (ii) the operator doesn't get any visual feedback of the process result before the program has been generated and executed by the robot; (iii) many iterations are needed for even the simplest task [PPS*03]. Although 6DOF joysticks are available [SF09], they are not industry standards yet.

New robot programming interfaces should address these shortcoming. A visual feedback of what the robot is viewing and what it is (and will be) doing, can help the operator to understand robot actions, specially with complex tasks. This visual feedback can be in the form of virtual and/or augmented reality and addition of an object-based interface to it, will allow the user to define robot movements based on the objects. This approach would speed up the programming phase of the industrial robot. Our proposed system uses an AR interface on a tablet device. Manipulation is done at physical object level. The user can issue high level commands such as pick or put by clicking on virtual objects in the augmented display, therefore removing the necessity to jog the robot at a lower level. With this approach the user will get more and better feedback about the task and have better control of robot states. The path the robot will take can be virtually drawn and the robot can be virtually simulated removing the necessity of doing several iterations by the robot. Furthermore, it can provide usability of previously learned/taught skills at higher levels.

Augmented reality (AR) is a term used for overlaying computer generated graphics, text and three dimensional (3D) models over real video stream. Virtual information is embedded into the real world, thereby augmenting the real scene with additional information. Augmented reality proved to be useful in several industrial cases, for visualizations. Regenbrecht et al. [RBW05] have applied AR

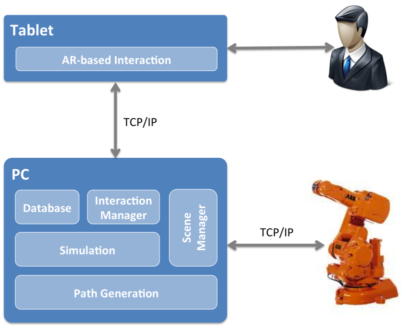

Figure 1: *Show the block diagram of the whole system, including the tablet device, PC server and the robot controller.*

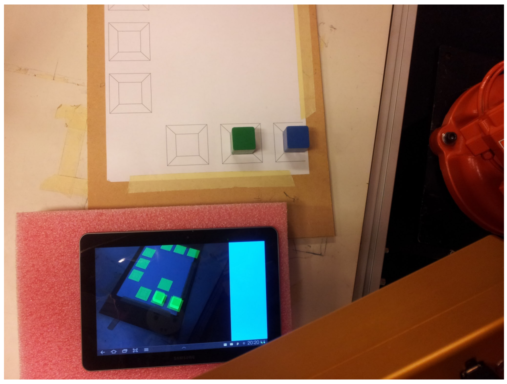

Figure 2: *Shows a screenshot of the system alongside the real workbench.*

in different automotive and aerospace industrial scenarios successfully. Their field of research included applying AR technology to service/maintenance, design/development and training. However AR can be very beneficial for programming industrial robots as well, whether it is remote or local.

2. Architecture

The proposed system consists of three physical parts; a tablet device, a standard PC server and the robot controller and the physical robot itself (See fig. 1). The tablet device works as the user interface to the system. It includes an augmented reality interface that shows the robot's view of the workspace. Users can interact with the virtual objects and the input from the tablet is transferred to the PC for processing and then the processed results are transferred back to the tablet device as output to the user. If the user accepts the current program then the PC side server compiles the robot program into RAPID language and sends it to the robot controller to be executed.

2.1. Tablet device

For this project, a tablet device with 10.1 inch screen that can handle multi-touch is used. The tablet runs on Android operating system. Since the computational capabilities of these devices are limited, most of the work needs to be done else where, therefore the tablet side user interface is designed as a thin-client. The tablet is only responsible for drawing the objects and getting the user input. PC server transfers an image of the robot's view alongside information about the objects to the tablet. The tablet then draws the objects as overlays on the received image, which generates and augmented reality view for the user. These objects can be selected by the user for various commands. The command and target objects are then send to the server for processing. Results of the process will be sent back to the tablet in the form of new object locations and paths that robot's TCP will take to perform them. User can then confirm the actions which in turn will be performed by the robot.

2.2. PC server

The PC server is responsible for all computations. It contains a simulation environment which can calculate forward and inverse kinematics of a general 6 Degree of Freedom (6DoF)industrial robot is used to verify the reachability of the target objects and collision between objects. It also acts as a visual feedback to user displaying the intentions of the robot [AAcA11].

3. Conclusion

In this work in progress paper, an augmented reality interface which runs on a mobile tablet device has been partially developed. However, this is still on going work. This proposed interface can help to overcome some of the problems introduced through using of flex pendant.

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