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Augmented Reality Based Teaching Pendant for Industrial Robot

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Abstract: Robots have been used in various fields such as homes, manufacturing, and business. Remote robot control has been actively studied. Most of industrial robots are still programmed using the typical teaching process, through the use of the robot teach pendant. New and more intuitive ways for robot programming and control are required, smart phone are being used for controlling and programming industrial robot. In this research work, we present an idea of augmented reality based teaching pendant on smart phone. Incorporation of augmented reality into Smartphone based teaching pendant will help user to program industrial robot more intuitively.

Keywords: Augmented Reality (AR), Teaching Pendant, Smartphone Application.

1. INTRODUCTION

Industrial robots are currently employed in a large number of applications, and are available with a wide range of configurations, drive systems, physical sizes and pay loads. Programming and controling an industrial robot through the use of the robot teach pendant is still a tedious and time-consuming task that requires technical expertise. Therefore, new and more intuitive ways for robot programming and control are required [1]. In the last few years the robot manufacturers have made great efforts to make user friendly teach pendants, implementing intuitive user interfaces. Nevertheless, it remains difficult and tedious to operate with a robot teach pendant, especially for non-expert users.

Mobile devices, like cellphones or smart phones, can nowadays be used to monitor and control remote devices like technical systems. Heß [3] et al. presented a proof of concept related to controlling robot with mobile devices. Using smartphone as a special kind of robot control unit, there is an increase of intuitive motion control and flexibility in programming Industrial robot [6].

In this research work, we present an idea of augmented reality based teaching pendant on smart phone. The rest of the paper is organized as follows. Section 2 briefly describes background and motivation behind this work. The proposed idea is presented in section 3. The results and discussion are presented in section 4, and the conclusions are presented in section 5.

2. BACKGROUND AND MOTIVATION

2.1 Existing Teaching Pendants

A teach pendant is a handheld device that is used with a robot controller to move, program, and run industrial robots. It normally has a display, keypad, and an emergency stop switch. The programming language varies with manufacturer and controller model, but several newer teach pendants have Windows-like set-ups for easy use [2].

Fig. 1: Typical Teaching Pendant.

2.2 Smart Phone based Industrial Robot control

The features that a decade ago where only available on powerful workstations are today available on every day devices like cellphones. The always faster and feature richer mobile devices are constant able to run more and more complex services. Today these mobile devices, together with the available fast wireless networks, can already serve as mobile remote controls for technical systems. Heß [3] et al. presented a proof of concept related to controlling robot with mobile devices. In their work, A mobile robot running a server program on its on board computer, connected to the faculties Wireless LAN, can be controlled through a small client written in JavaMe and runnable on most mobile devices.

Bob Emmanuel Onyenike [4], in his thesis, presented the idea of Smartphone controlling the robot and camera devices. In his work, application running on the mobile phone, establishes a TCP/IP socket connection to the Server application launched on the workstation. After establishing connection with server, mobile phone application, sends the command to control the movement of both the camera and the robot.

Choi et al. [5] presented an image-based remote video conferencing robot controlled by smart phone.

They are of the view that controlling this video conferencing robot using a smart phone, instead of a PC, enables users to improve their mobility and convenience.

Lambrecht et al. [6] demonstrated control of industrial robot, KUKA KR 6, using smart phone. Based on the special sensory capabilities of modern smartphones they implemented a novel form of motion control using the acceleration sensor. Based on the approach of an accelerometer-based control of an industrial robotic arm, they translated manual conducted postures of the smartphone to robot commands.

2.3 Augmented Reality application in industrial robot control

Augmented reality (AR) is a live, direct or indirect, view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulable. Artificial information about the environment and its objects can be overlaid on the real world [7].

Bischoff et al. [8] showed that AR has much potential for teaching students how to operate industrial robots. The driving force behind their work is the fact that new markets and applications can only be conquered if robot programming and operation become easier. They performed experiments and conducted surveys to show the usefulness of AR in various human-robot interaction scenarios.

Ameri E et al. [9] designed more user-friendly industrial robots with a new interface which uses augmented reality (AR) and multimodal human-robot interaction. They showed that such an approach allows easier manipulation of robots at industrial environments. Fig. 2 shows their experimental robot, Camera is mounted on the end-effector. Fig. 3 shows AR view of their application where yellow lines indicate paths and red cubes indicate gripper actions.

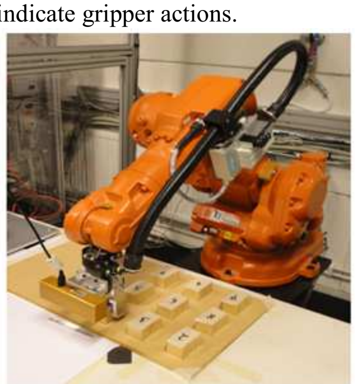

Fig. 2: Camera is mounted at the top of gripper [8].

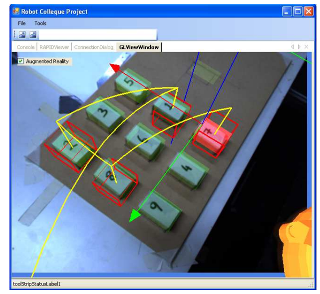

Fig. 3: Augmented Reality view [8].

3. PROPOSED IDEA

Having emphasized the importance of intuitive teaching pendant and application of Augmented reality in industrial robot, we present our idea Augmented reality based teaching pendant on smart phone. This is a smartphone based teaching pendant app. for industrial robots. Fig.4 shows the overall diagram of the proposed system.

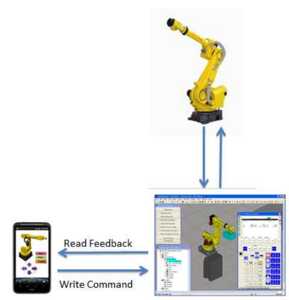

Fig. 4: Proposed System.

Industrial robot is connected to Robot simulator. Robot simulator contains the 3-D model and Joint information of the robot and can issue joint drive command to industrial robot. Smart phone connects to a server application, through TCP/IP, on robot simulator. On smart phone we have an augmented reality based intuitive teaching pendent interface as shown in fig. 3.

Fig. 5: Smart Teaching Pendant.

First the smart phone camera is pointed towards industrial robot and live video (real-data) is viewed from smart phone. Then user is asked to tap the base of industrial robot as shown in Fig. 5. Then smart phone communicates with robotic simulator and loads model and joint information (meta-data) of this industrial robot and overlays the joint information (meta data) on the live video of industrial robot (real data) as shown in Fig. 6.

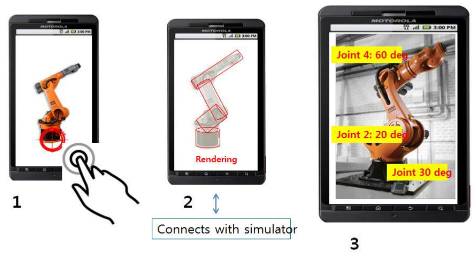

Fig. 6: Augmented reality view of industrial robot.

Fig. 7: Augmented joint drive.

Our proposed teaching pendant also has the feature of augmented reality robot drive which is a more intuitive and user friendly way of driving industrial robot. Smart phone, after loading robot model from robot simulator, draws boundary on the screen as shown in Fig. 7. The user can now move end effector using the arrows shown.

Fig. 8: Successful move.

Based on the robot model, smart phone app can also show safe moves for end effector. These safe moves are shown by green boundaries and unsafe moves are shown in red as shown in fig. 8. Example of unsafe move is depicted in Fig. 9 where user has given the command of joint drive but , based upon robot model, smart teaching pendant has predicted this joint drive to cross joint limit. So it notifies the user about possible unsafe move by haptic feedback.

Fig. 8: Unsuccessful move

4. DISCUSSION AND FUTURE WORKS

The idea of smart phone based teaching pendant has been demonstrated by Lambrecht et al. [5]. In their work, they are using smartphone as a full-fledged teaching pendant. Based on the approach of an accelerometer based control of an industrial robotic arm, they translate manual conducted postures of the smartphone to robot commands. In addition to motion control of single axis or motion control of the end effector the smartphone application enables simple textual programming tasks.

In our proposed idea, we have moved a step forward and incorporated augmented reality into smartphone app for better control of industrial robot. Incorporation of AR will help user to program industrial robot more intuitively. Augmented joint drive feature presented above will help user to predict next possible safe movement of end-effector, thus minimizing the risk of accidents.

In future we plan to implement this idea onto smartphone. Samsung Galaxy Note is chosen as implementation platform since it has more computation power and has larger display as compared to normal smartphone. OpenGL will be used to draw 2D industrial robot model on live robot preview.

4. CONCLUSION

In this research work, we present an idea of augmented reality based teaching pendant on smart phone. Due to implementation of smartphone as special kind of robot control unit, there is an increase of intuitive motion control and flexibility in programming the robot, using a commonly used device instead of a normative manufacture-specific manual control unit. Incorporation of augmented reality into smartphone based teaching pendant will help user to program industrial robot more intuitively.

5. ACKNOWLEDGEMENT

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