REMOTE LEARNING: ANDROID OPERATED EDUCATIONAL ROBOT ARM WITH 6 DOF

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Abstract: This paper addresses an intelligent optimal control for a flexible robot arm that is driven by a permanent-magnet synchronous servo motor. An intelligent optimal control of robot arm with 5 axes with servo gripper is proposed by the instructions given through Android device (android app on smart phone). This proposal was addressed to fourth-year engineering students and combines knowledge from android java programming and robotic control to complete an automation project task. The educational robotic arm initially learns to pick up a randomly placed target from a target surface and move it to a predefined destination after which it repeats the contouring process under the presence of the target. This paper presents an off-line trajectory generation algorithm and, therefore, it possesses significant industrial implications, as no hardware changes are needed for its implementation. The proposed method has been experimented with Dexter ER-1 Robotic Arm for optimum project based learning.

Keywords: Robotic arm, Android Smartphone, Bluetooth, Project-based learning.

I. INTRODUCTION

Doing laboratory experiments is a fundamental part of the learning process because it allows theoretical knowledge and concepts to be assimilated and applied, increasing student’s motivation and collaboration. This paper proposes the development of a project-based learning example (PBLE) of controlling an educational robotic arm in a simulated industrial environment. This PBLE was proposed to fourth-year engineering students at Sikkim Manipal University, Sikkim. The learning objective was the development of an educational robotic arm and android device interface to pick up a randomly placed target on a target surface and move it to a predefined destination through Bluetooth communication. During the initial operation, the robotic arm is made to memorize the complete trajectory and continuously follows the same under the presence of the target on the target surface. The design of such systems is an excellent tool for reinforcing applied engineering concepts. It is important for instructors in robotics to understand, however, that robotics is not just a tool to teach other aspects of engineering. Rather, it is a robust and mature discipline in its own right, with important applications in a wide range of fields.

The field of robotics have influenced almost all areas and it reduces the work of humans. This easiness provided by robot has made it to become more widespread across various industries ranging from manufacturing to health care. One such advancement is shown in this project. The materials available in the laboratory for the PBLE were an automation cell (Fig. 1) with a fixed target on the target area, a force sensitive resistor(FSR), an educational robotic arm, a destination container, Bluelink module, Atmega 328 microcontroller and android device(smart phone).

This paper is structured as follows: Section 2 describes the hardware and software used in this paper, Section 3 the proposed system used, Section 4 the results obtained and Section 5 the final conclusions.

II. HARDWARE AND SOFTWARE USED

Figure 1 shows the automation cell required for the development of the proposed PBLE. The most important elements are a fixed target on the target area, a force sensitive resistor(FSR), an educational robotic arm, a destination container, Bluelink module, Atmega 328 microcontroller and android device(smart phone). Eclipse and Arduino developing environments are used for creating applications for successful operation to control the robotic arm.

2.1 Educational Robotic Arm

The robotic arm used in this paper is the Dexter ER-1 Heavy Duty Robotic Arm (see Fig. 2) whose technical specifications and operational data are available in . This educational robotic arm was designed to operate like an industrial robotic arm with 5 Axis robotic Arm + Servo Gripper and stepper motors in each
Servo control is done by sending each servo a PWM (pulse width modulation) signal, a series of repeating pulses of variable width. Servos are connected through a standard three-wire connection: two wires for a DC power supply and one for control, carrying the pulses. The parameters for this pulse are that it has a minimum pulse, a maximum pulse, and a repetition rate.

2.2 Bluelink - Bluetooth Module
Bluelink is a compact Bluetooth Module (5V Serial TTL). The module has built-in Voltage regulator and 3V3 to 5V level converter that can be used to interface with 5V Microcontrollers. The module has only 5 pins (Standard 2.54mm berg strip) VCC, GND, TX, RX and RESET. The module is factory configured in Transparent Mode and hence there is no command required for normal operation. The technical details and its command formats are available in.

It is connected in receiver mode and is always ready to receive data (ASCII format) from the paired smart phone. The received data is then passed on to the microcontroller for further operation. Depending on the data (ASCII format) received from the Bluelink, microcontroller rotates the respective servos along with storing each instruction received in its EEPROM memory.

2.3 Force Sensitive Resistor
A force sensitive resistor with a square sensing area of 1.75x1.5”is used. This FSR will vary its resistance depending on how much pressure is being applied to the sensing area. The harder the force, the lower the resistance. When no pressure is being applied to the FSR its resistance will be larger than 1MΩ. This FSR can sense applied force anywhere in the range of 100g-10kg. Two pins extend from the bottom of the sensor with 0.1” pitch making it bread board friendly.

2.4 Eclipse And Arduino
The Eclipse (software) is used to create an android application for controlling an educational robot arm. This application developed in Eclipse makes the Bluetooth control via smart phone possible which runs on smart phone itself. This program sends from the phone the servo number and its required angle of rotation corresponding 2byte command to the Bluetooth module on the robot. Simple commands are then issued to the servo microcontroller from the Bluetooth module. This hierarchy allows easy and efficient changes in the implementation of the command scheme without requiring a redesign of the entire servo firmware package.

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).

Figure 4 explains the complete block diagram for the operation of the proposed system.

III. THE PROPOSED SYSTEM
A person operates the android device with an established connection to the MCU board. To develop it we use the eclipse for coding (java) and Android SDK for development of the apps. In this we write two set of coding. One is Bluetooth adapter coding to connect Bluetooth shield with mobile Bluetooth. And next is sending commands to the Robot to move in user desired direction. A signal is generated against each button which represents specific movements for a specific servo. These signals are received by pin 2(RX) on the MCU board from the Bluetooth module. The communication between the Android device and the MCU board is established with an
‘OPEN’ button in android application particularly developed for this project. Similarly, the established connection is disconnected using ‘CLOSE’ button (Fig.5). The current status can also be viewed on the ‘status’ edit bar. Simple commands are then issued to the servo microcontroller from the Bluetooth module.

The communication between Bluetooth module and microcontroller requires the submission of ASCII orders through the software serial port (2,3 pins). Unfortunately on the event of using multiple software serial ports, only one port can receive data at a time. The servo control function in MCU generates the different pwm signals to control 5 servos and gripper. The microcontroller interprets the commands issued by the Bluetooth module, and produces the proper sequence of timed pulses necessary to move the eight servos to the desired positions (increase or decrease the servo angles). The microcontroller produces a 50Hz sequence of pulses, the duty cycle of which controls the commanded angle of each servo. For example, a 600us pulse could command the servo to move to its full counter-clockwise position; a 1320us pulse could command it to the centre, or neutral, position, and a 2040us pulse could command it to move to the full-clockwise position. By varying the time that each control line is driven high by the microcontroller, the servo angles, and therefore the robot gait, can be controlled.

The microcontroller program reads the complete loop of data in EEPROM memory and the gripper is placed in the correct position. This makes the control of the robotic arm very simple following the initial complete operation of picking up a target and placing it inside the destination container. After the complete sequence of intermediate positions, the robotic arm is again set to its initial or zero position for the next operation. But the next operation is only executed under the presence of the target on the target surface which is continuously sensed by Force Sensing Resistors (FSR). The sensed value is continuously fed to the microcontroller through analog pin0 which initiates the complete cycle of operation. For example, the diagram of figure 6 details a visual control loop algorithm based on a trial and error approach.

IV. RESULTS

The proposed methodology permits a non-skilful person to automatically link with a variability of engineering robotic apparatus. Figures 7-8 show several images obtained during the practical development of the PBLE by the students. Further operational details can be viewed in a video available on YouTube.

As a summary of the results, Figure 7 shows an image obtained during the development of the visual feedback loop to pick up the target object. Figure 7 shows the robotic arm going to the predefined Position 1 and, finally, Figure 8 shows the robotic arm trajectories of opening the gripper and releasing the object in the destination container.

The opinion of the students about the project was positive. The possibility of the applications of knowledge from different fields was also appreciated by the students. The main objective was to make the robots more user-friendly and be able to communicate with them as we can communicate with other people around the globe. Thus we decided to design a simple prototype of a robot that can be controlled via smart phone.

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CONCLUSION

This paper describes a project-based learning example addressed to fourth-year engineering students. This paper has successfully demonstrated the application of an intelligent robotic arm control system using an Android device. The proposition of the control scheme is to achieve good tracking performance with the flexibility of easy learning method. The design procedure of the proposed optimal control system was described in detail. Moreover, experimentation was carried out using different reference trajectories to verify the effectiveness of the proposed control system.

REFERENCES

[15] https://www.youtube.com/watch?v=U0lj4KQYRd

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