BUILDING AND ARDUINO BASED REMOTE CONTROL OF THE ROBOT WITH 3 DEGRESS OF FREEDOM

**Malik Čabaravdić
Anel Husaković
Mehmed Čobo
University of Zenica
Fakultetska 3
Bosnia and Herzegovina**

ABSTRACT
This paper is related to application-specific device, a prototype of a robotic arm with three degrees of freedom of movement. The paper deals with the creation of virtual and physical 3D model using CAD software and 3D printer resources, as well as using Arduino based embedded system for local control of the robotic arm.
Keywords: Robotic arm, Arduino Uno, Local control, Remote control, 3DOF, Web technologies

1. INTRODUCTION

Nowadays, we often use "smart devices" such as cell phones, computers, small home robots, and the like. Such devices possess small chips so-called. microcontrollers, where all the data necessary for their operation are stored. In this paper, Arduino Uno will be used as a microcontroller to control the servo motors responsible for moving the robot arm segments. Arm is controlled locally and remotely. Local arm control represents control using analogue commands, i.e. via joysticks and potentiometers. On the other hand, remote control of the arm is done through the Android mobile phone application, which means the commands are sent from the cell phone to Arduino Uno via the internet. The arm will be created as a SolidWorks 3D model, which will be used to transform the virtual model into a physical model using 3D printer.

2. MODEL OF ROBOTIC ARM

The requirements that the robot arm needs to fulfil are as follows:
- The minimum weight that the arm can raise is 1N
- Appropriate arm tip movement speed
- Sliding along horizontal and vertical axes
- The arm is controlled locally and remote.

The robotic arm was created in the CAD software SOLIDWORKS. The complete arm consists of a total of 21 parts. In the same software, a load simulation was performed, where it was shown that the segments of the arm can handle external forces applied to it.
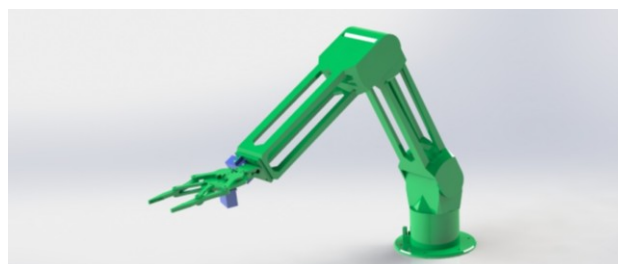
Figure 1. 3D model of the robot arm

2.1. Robotic arm coordinate system

As for the coordinate system of the robotic arm in this thesis, it is clear that the Cartesian coordinates will be used for simplicity. The arm itself has 3 degrees of freedom of movement, so it has 3 variables. The two variables are used to move the top of the arm in the horizontal direction and the vertical direction. The axes are called: "a" - horizontal axis and "b" - vertical axis. With these variables it is possible to perform only the straight movement of the tip of the arm, with limited range due to the physical size of the arm itself. These movements are expressed in the length of [mm, cm]. In order for the arm to move in space, another variable "φ" is required. The variable "φ" allows movement around the axis of the arm's base. When the command for the change of angle "φ" is sent, from the perspective of the layout, arm can move left or right. This movement is expressed in the dimension of the angle, degrees [°].

2.2. The arm driving elements

The drive elements of the arm require small dimensions, yet sufficient force and torque. The ideal drive motor for this arm is a servo motor. The servo motor is actually a dc electric motor that has position control. Servo motors are very powerful in relation to their dimensions, and at the same time extremely fast. Some characteristics of the applied servo motors are presented in the following table.

Table 1. Servo motors properties

Motor name	Torque [Nm]	Angular speed [rad/s]	Mass [g]	Torque/Mass [Nm/kg]
TowerPro SG90	0.12-0.18	6.35	9	20.0
TowerPro MG996R	1.0-1.1	6.16	55	20.0
TowerPro MG958	1.5-1.8	6.02	65	27.7

3. CONSTRUCTION OF THE ROBOTIC ARM USING 3D PRINTER

3D printer is a device that converts the virtual 3D CAD model into a physical model. In this process, the *slicer* software for communication between the CAD model and the printer is used. The physical model can be made of several types of plastics (ABS, PLA, ...). The 3D printer that will be used to create a robotic arm is Ultimaker 2+. The CAD model in the .sldprt format must be converted into an STL file, and .stl format. The next step is converting the STL file into a set of instructions in the form of a G-code. The so-called slicer software is used to split the STL model into layers of height from 0.1 to 0.2 mm because the 3D printer builds the physical model layer by layer. The G-code is then saved on the SD card and loaded into a 3D printer. In addition to the card, it is necessary to choose a printing material, such as PLA plastic. From this moment on, the 3D printer begins to execute the code and begins the arm-making process.
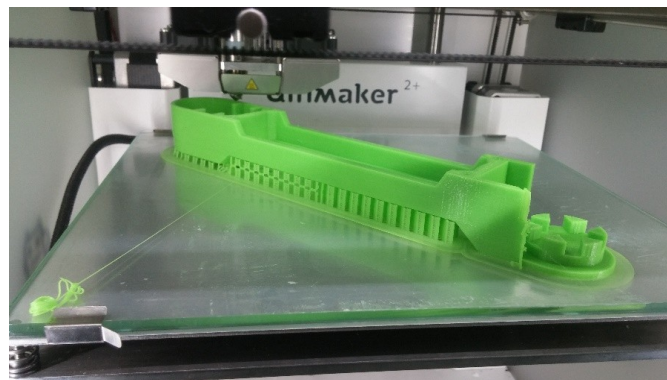

Figure 2. The robotic arm segment during the printing

Figure 2 shows a segment of the arm with a support that supports the places of the model which are in the air. If there is no support, the model will most likely be unsuccessfully printed. The total duration of production of all parts is close to 26 h. During the print process, it is necessary to monitor the progress, as unexpected complications can occur. Figure 3 shows the physical model of arm with local

control (joystick and 3 potentiometers), 220 V power supply, USB cable for connecting to the internet and a box where Arduino Uno and other components, such as wires and voltage converters, are located.


Figure 3. Actual system with local controls and power supply

The future work of this robotic arm will be based on remote control.

4. CONTROL

It is possible to control this robot in two different ways: locally and by remote control. Furthermore, both means of control can be executed at the same time, without the need for changing the working mode from one to another. Local control is realised with help of devices physically attached to the robot which are shown in Figure 4. In order to move the tip of the robotic arm back and forth or up and down, one has to use joystick. Rotation around the base is executed by using the potentiometer attached next to the joystick. The other two potentiometers are used for jaws control. Potentiometer commands are executed linearly, which means that the angular change of the potentiometer is proportional to the change of the robotic arm's angle, while joystick commands are converted using mathematical formulas into angles.
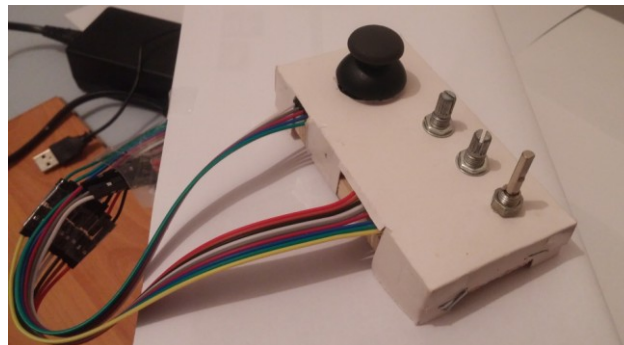
Figure 4. Local control of the robotic arm

The second way of controlling this robot is remote control by means of the internet. Android smartphone is used as a control device, and Blynk application as an interface. Arduino Uno has to be connected to computer using USB port and allowed to use the Internet which is done through Command Prompt on Windows. Besides the default code, Blynk archive has to be enabled and included in the executive code and also some additional parameters have to be set up. Communication between Android application and Arduino Uno is done over Blynk server and the commands are sent each 100 ms. Because the communication is accomplished over the internet, it is possible to control this robotic arm from any place on the world where internet access exists. The following figure shows a screenshot of the Android application. Its interface resembles other physical devices, moreover joystick and sliders in this app have the same properties as a real device.
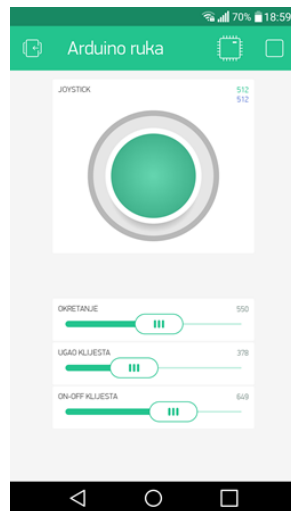
Figure 5. Interface of the Android application for remote control

5. CIRCUIT SCHEME

Although there is a lot of components, the scheme of this circuit isn't much complicated. The joystick and the potentiometers are connected to the analogue pins and servomotors to the digital pins. There are two separate power supplies for servomotors, and the USB port is used to power up the Arduino Uno.
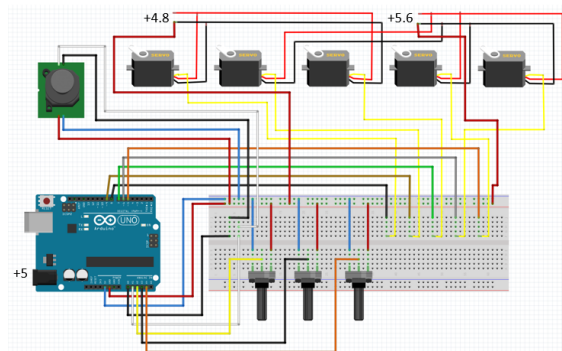

Figure 6. Breadboard circuit

6. CONCLUSIONS

The final prototype of the robotic arm has fulfilled the expectations and is able to execute all planned actions. Two ways of control came out to be a very good solution. Advantage of local control is very short response time, and advantage of remote control is that the operator doesn't have to be right next to the robot. Movement of the robotic arm was intended to be linear, but there are visible imperfections which isn't the case with professional robotic arms. The main reason of those imperfections is the usage of servomotors as operative members since they don't have tendency to rotate smoothly and are adapted to fast movements. Making parts using a 3D printer is also a great advantage. Dimensions of the members are very precise, and the whole process is completely automatic. The code making of the executive program isn't a difficult task as long as one knows basics of programming and electrical components.

7. REFERENCES

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