

Movement of a Robotic Arm through Bluetooth Communication Between an Arduino and an Android Application

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Abstract

In recent years, many of us have witnessed the increase of products that make use of wireless communication. The Internet of Things is one of the promising technological advancements that put a strong emphasis on wireless communication between objects.

This project demonstrates a possible way to manoeuvre a robotic arm through Bluetooth communication between an Android application and an Arduino circuit. For this specific project, I make use of an OWI robotic arm from the OWI Arm Edge Kit, as it is an affordable option which makes it perfect for small-scale projects and it uses simple DC motors on each joint to enable its movement. I replace the embedded circuit that the OWI kit includes with a custom one designed with the use of an Arduino board and H-Bridge Chips. To control the movement of the arm I built an Android app that allows an android phone that has an inbuilt Bluetooth functionality to communicate with the Bluetooth module that exists on my custom circuit, thus allowing me to perform targeted movements.

1. Introduction

Robotics is one of the fields that has impacted humans lives for many years. These days, we see robotics used in several areas such as the medical sector, industrial, educational, and currently we even see household robots. The robotic world has received mixed reactions from people because some industries have been constantly replacing human workers with robotic counterparts. A robot can be user-controlled, semi-autonomous, or completely autonomous.

Nowadays, with the evolution of technology, we have reached a point where the purchase of an affordable hobby robotic arm such as an OWI-535 robotic arm edge is feasible. This enables robotic kits to be easily accessible for schools to introduce to students.

There have been several related academic journals to this; I will specify some examples in relation to building a robotic arm from scratch, to then control the movement of the robotic arm with the use of a desktop application and an Arduino, publication by the Technological Educational Institute of Thessaly^[1], or wireless

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mobile communication with the use of an Arduino Mega publication by the Universiti Tun Hussein Onn in Malaysia^[2]. In addition to these, there have been a couple of hobby projects that helped me build various elements of my projects, LuckyLarry website^[3] and Mayoogh^[4].

A robotic arm works as an imitation of a human arm and is able to carry out different duties similar to that of its human counterpart. However, in robotics, we have something called degrees of freedom, which are modes through which a mechanical device or system can move. The human arm has 7 Degrees of Freedom (DOF) and each task carried out by the arm uses a specific number of DOF. The arm I am using has 5 DOF which means it can position itself on the XYZ axes in fewer combinations than a human arm is capable of.

In this project, I make use of wireless communication, specifically the Bluetooth protocol through which we can send and receive data. Wireless communication has enabled us to make things more accessible to people with specific disabilities or restrictions as well as simplify a number of daily tasks.

2. Methodology

2.1. Overview

This project merges different fields of technologies such as mechatronics, embedded systems, and robotics. A blend of hardware and software engineering. It initially started on a breadboard and evolved into a PCB circuit with the hopes of simplifying the complexity of the wiring of the initial

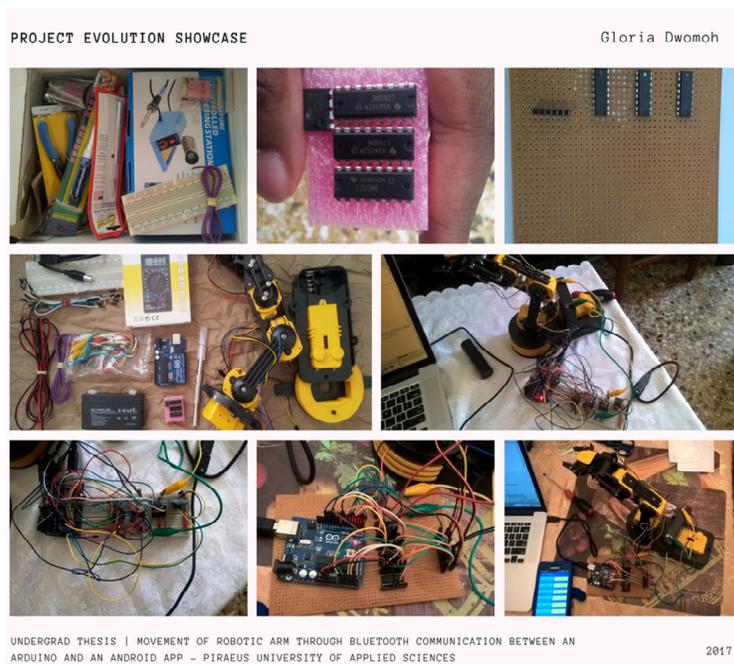


Fig. 1: Project Evolution

circuit design.

2.2. Mechanical Design

As said earlier, we are using the OWI Robotic Arm which has 5 DOF. The OWI Arm can lift an object up to 100 grams (3.5 ounces), move it horizontally, and place it in the X-Y-Z axis area of a space, changing the orientation of the object along two axes. It uses five motors with gearboxes and it is capable of doing a 120-degree wrist movement, elbow movement of 300 degrees, shoulder movement of 180 degrees, base movement of 270 degrees, and grabbing movement 0 - 1 (i.e. grip open/close with grip width of 0 - 4.5 centimeters which is equivalent to 0 – 1.77 inches). In addition, it also has an LED light in between the gripper.

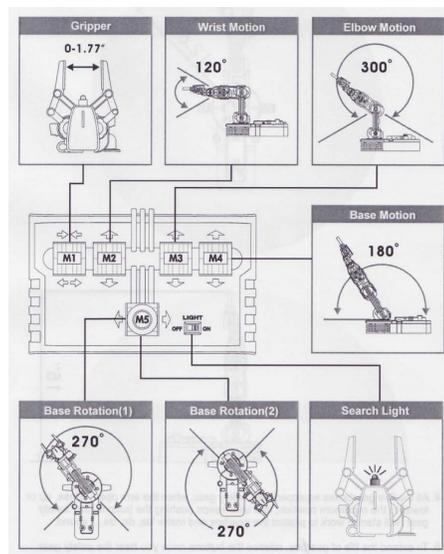


Fig. 2: Robotic Arm Motions

2.3. System Architecture

Below you can see the basic components of the system architecture of this project.

Module	Specification
Controller	RobotArmProject (Android App)
Programming Languages Used	Java, XML, Arduino Language
Actuator	DC Motor
Robotic Arm	OWI – 535 Robotic Arm Edge
Bluetooth Module	HC-05 Wireless Bluetooth Serial Transceiver Module
Board	Arduino Uno

Table 1: Specifications of Project

2.4. Electrical Design

The electrical aspect of the project is comprised of a circuit that makes use of H-Bridge chips, specifically the L2930NE model, the Bluetooth module, and an Arduino Uno. An Arduino is an open-source online platform based on a combination of hardware and software. Using the H-Bridge chips we are able to move the arm in several directions; e.g. frontwards and backwards, and each chip can control two motors. The L293 type of H-Bridge is a chip that is designed to provide bi-directional drive voltages up to 1 Ampere at voltages from 4.5 volts to 36 volts. The Arduino can then digitally control the H-Bridge chip to enable or disable a motor and change its direction.

To design the circuit I used a software called Fritzing. Initially, I did the circuit on a breadboard, but later on remade it on a perfboard (DOT PCB) to reduce the wiring cables needed and to make it more visually appealing. For the previous reason, the PCB circuit has a slightly different positioning than that of the Fritzing design. However, understanding this circuit makes it easier to understand the placement of the components on the PCB.

The battery used to power the original project is not a 9-volt one as shown in the image below, but a lead-acid battery of 6 volts and 1.3 Ampere hour, in addition to the 5-volt power provided from the Arduino. Each DC motor represents a motor existing on the robotic arm.

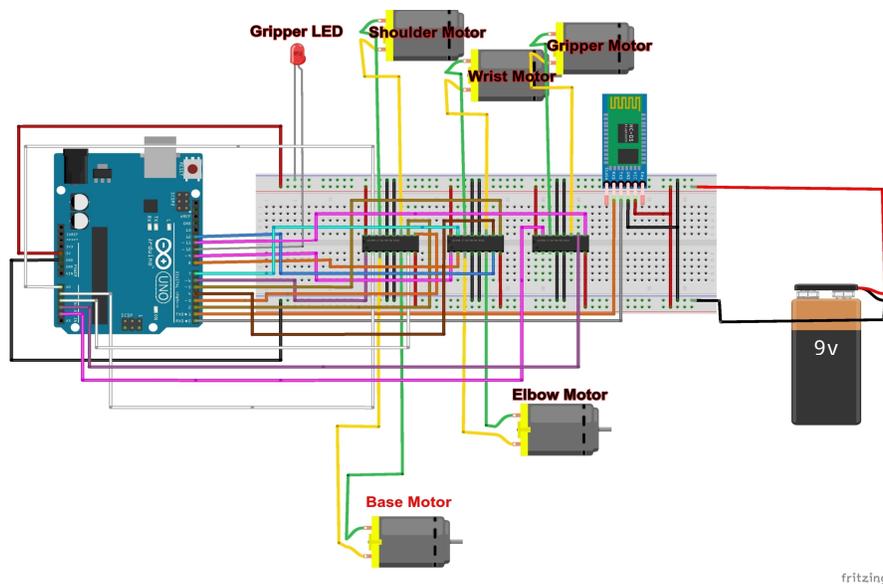


Fig. 3: Circuit Design

2.5. Arduino Programming

In the Arduino code, I set the pins of the Arduino that send data to the H-Bridge chips as outputs. When the Bluetooth module receives the data that I have assigned to the pressed button

of the Android application, it activates specific pins of the Arduino and sends that information to the right pins of the H-Bridge. Each H-Bridge chip has 4 output pins, each 2 pins are connected to a DC motor and are activated only when I transmit a specific data value to the HC-05 Bluetooth module.

2.6. Android Application

To control the robotic arm, I created an Android application that first checks if the phone has a Bluetooth function and if it is activated. If the android phone has a Bluetooth but it is deactivated, it prompts the user to activate it. Once activated, the user can now scan the network for paired devices. The application then enables you to connect with the Bluetooth of a paired device--in our instance the HC-05 Bluetooth Module. Once that connection attempt is successful, you are then taken to a different activity which gives you the ability to control the robotic arm.

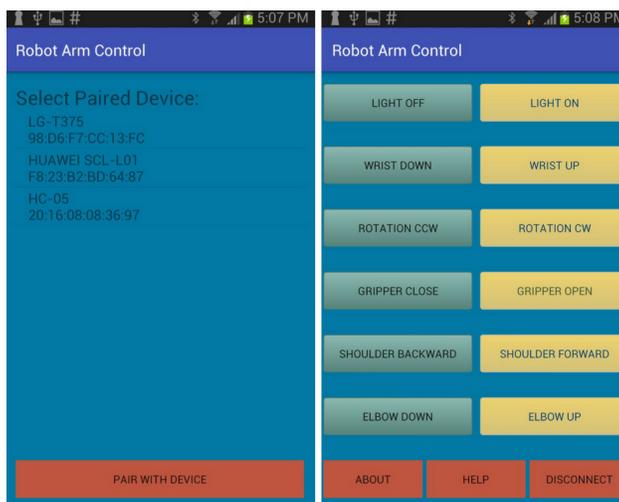


Fig. 4: Android Application Screenshot

3. Experimental Results

Overall the objectives of this thesis have been achieved. The substitution of the arm's original controller, which is a wired hand controller with a Bluetooth powered Android application, was successful. The robotic arm responds to the commands given to it wirelessly from the Android application through the use of Bluetooth communication. The arm successfully lifts objects lesser or equal to 100 grams (3.5 ounces). It moves at a decent speed, and through the pulse-width-modulation functionality of the Arduino we can increase or decrease the speed of the movement of the arm as per our needs.



Fig. 5: Components of project

4. Recommendations

Troubleshooting projects that involve hardware, software, robotics, and other technologies can be quite challenging. In order to be effective in such projects, I found that it is paramount to be able to create separate smaller test cases on each technology independent of the other components. For example, someone is trying to control the arm, but it does not respond. When trying to troubleshoot this case we might first like to check if the Android application communicates with the Bluetooth module. Testing that on the existing circuit will yield to disappointing results as it is unclear if the issue is the Android Application, the Bluetooth module, the circuit, or the robotic arm. The best approach I have found is to test a component or a pair of two components, exclusively, and only combine different technologies once I confirm that they work independently.

It is possible to create your own robotic arm, however it might increase the cost and time needed to come into the completion of a replica of this project.

In addition to that, in the future, this project could be expanded to allow the arm to move around through a set of wheels. The robotic arm can be further enabled by the usage of artificial intelligence in combination with computer vision to give it the ability to recognize and grab objects.

5. Conclusions

Once you get one motor responding to the signal received by the wireless Bluetooth communication protocol, the same method is applicable to all the other motors available on the arm.

Controlling a robotic arm wirelessly has a lot of benefits in relation to how it improves the efficiency of ways to control a robot. Distance no longer becomes a limitation as long as the Bluetooth modules HC-05 and that in the Android phone communicate. Wireless communication is a powerful thing that empowers technology to be able to improve the accessibility of tools for a wider audience.

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