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A Voice Controlled Pick and Place Robotic Arm Vehicle Using Android Application

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ABSTRACT: *Robotics has become an interesting area of research in the field of Electrical Engineering. This is due to the vast potential it holds in reducing human effort in performing tasks faster while still maintaining operational accuracy. The recently introduced Android operating system used in many devices such as mobile phones, tablets and digital cameras is user friendly and can be extended to control smart and intelligent systems such as robots. This paper designed and developed a pick and place robotic arm vehicle using an android application to control the robot through voice commands. Arduino programming language, which is an open source and simplified version of C++ known for its friendly architecture was used to program the controller (ATMEGA328P). The integration of control unit with blue-tooth device was done to capture and read the voice commands. The robotic vehicle then operates as per the command received via android application. The device was designed to lift a maximum combined mass of 250g and it can communicate at maximum distance of 12m with high precision.*

Keywords: *Robotics, android, accuracy, intelligent, controller and precision.*

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I. INTRODUCTION

A robot is an integral part in automationof flexible manufacturing systems that are greatly in demand these days. Robots are now more than justmachines; rather robots have become the solution of the future as cost of labor and customers' demands keep increasing. Though the cost of acquiring a robotic system is quite expensive, but as today's rapid development and a very high demand in quality with ISO (International Standard Organization) standardscan only be guaranteed using robotic systems.

Robots are indispensable in many manufacturing industries, because the cost per hour to operate a robot is a fraction of the cost of the human labor needed to perform the same function. Moreover, once programmed, robots repeatedly perform functions with a high accuracy that surpasses that of the most experienced human operator [1, 2]. Human operators however remain more versatile as reprogramming and parts replacement may be required in order to alter the nature of operation of robots when tasks change. Thispaper is aimed at designing and developing a pick and place robotic arm vehicle with a circular plastic gripper in order to accommodate varying dimensions of objects. The robotic vehicle is android voice application controlled for remote operation.

There are so many hazardous situations in day to day life. There are so many occasions where the human can't work .In such situations, without a considerable amount of safety precautions like in the disposal of hazardous wastes, radioactive substances, remote handling of explosive devices and lighting and hostage situations among others, work is impossible. These robots can safely work at hazardous conditions ensuring the human safety and replacing massive human work force. It can be also applied in medical sciences, surgeries, defense, artificial intelligence, super markets, and also in manufacturing. Android is a new operating system which has now taken center stage in many of our electronic devices and as such incorporated in the project.

This robot can safely work in hazardous and risky conditions ensuring human safety and replacing massive human work force.

II. LITERATURE REVIEW

Research and development of future robots is moving at a very rapid pace due to the constantly improving and upgrading of the quality standards of products.

[1] presented a voice controlled vehicle with a movable front camera controlled by voice commands of an assigned user. The communication was via wireless system (ZigBee). Commands planned to be used for control are defined on EasyVR voice recognition module (GUI software) using throat microphone. Eight commands were programmed for the device operation. The commands were converted into digital signals by voice module. The speech from the user is compared with that of the EasyVR. If synchronized, the digital signal is send via the ZigBee transmitter module to the vehicle which is received by the ZigBee module receiver which further sends it to the microcontroller (ATMEGA328) to analyze and issue an expected operation. The major setbacks of the work are phrasal commands (such as "turn right", "the camera down"), singular voice recognition, low data transfer associated with the ZigBee technology, additional hardware (i.e. EasyVR shield speaker) and high susceptibility to noise.

[3] presented the design analysis of a remote controlled pick and place robotic vehicle. The design includes a robotic arm having five degree of freedom with its base resting directly on top of the vehicle, a body having four drive wheels coupled to the ends thereof. The wheels were selectively powered to propel the vehicle. Their design also involves the hardware, software part and implementation of both designs. The motion results obtained were very satisfactory but due to the number of motors clustered on the robotic arm, maximum weight carrying capacity will be affected by the weight of the motors.

[4]developed a pick and place robotic vehicle with a soft catching gripper. The robotic vehicle is android application controlled for remote operation. At the transmitting end using android application device, commands are sent to the receiver to control the movement of the robot either to move forward, backward and left or right. At the receiving end four motors are interfaced to the microcontroller (ATMEGA16) where two for them are used for arm and gripper movement of the robot while the other two are for the body movement. The android application transmitter acts as a remote control while the receiver end Bluetooth device (AUBTM-20) is fed to the microcontroller to drive DC motors via motor driver IC for necessary work. However, remote operation is achieved by a GUI (Graphical User Interface) based touch screen operation.

[5]designed a Voice Controlled Robot (VCR) which is a mobile robot whose motions can be controlled by the user by giving specific voice commands using same technology of ZigBee and EasyVR as [1]. The speech is received by a microphone and processed by the voice module. When a command for the robot is recognized, the voice module sends a command message to the robot's microcontroller (ATMEGA2560). The microcontroller analyzes the message and takes appropriate actions. The walking robot is controlled by servo motors. Furthermore, a camera is mounted on the head of the robot to give live transmission and recording of the area. The work suffers similar problems as [1] in addition to unauthorized usage due to absence of password.

[6] designed a wireless robot arm control for picking and placing an object using android application. The android application acts as a remote transmitter having the advantage of adequate range, while the receiver Bluetooth device is connected to the microcontroller to drive D.C. motors via motor driver I.C. for necessary operation. The microcontroller used was Atmega328 and Arduino software used to program it. The maximum upward and downward motion of the arm was limited by a mechanical push button type switch. The vehicle was able to move along surfaces being smooth or rough in the direction of forward, backward and left and right while able to carry a maximum weight of 2kg.The device was however on screen remote controlled rather than voice controlled.

[7] constructed a voice controlled robotic vehicle using 8051 microcontroller. The two wheel robot powered by D.C. battery used an android application called *AMR Voice* as the transmitter and a HC-05 blue tooth I.C. as the receiver. The robotic vehicle was able to move forward, backward, left and right using the voice commands but had no appendage which also limited its application to motion only.

[8] used android mobile phone Bluetooth to control robot's operation using 8051 microcontroller. Remote buttons in the android app were used to control the motion of the robot. The robot was able to move forward, backward, left and right side using the android application. The device can be reprogrammed but the absence of an appendage limits its application to motion only.

[10]presented a robotic vehicle system for disabled people controlled either by oral commands or by human computer interface (HCI)) using a Microcontroller. A disabled person sitting in the vehicle can control it by giving oral commands, if he is further unable to control, it can directly be controlled from the base station using oral commands or by using GUI. These commands will be issued at the base station on a PC connected with a sound card and a Microphone. The commands issued will then be relayed over an RF channel and will be received by the Module-2. Here, the system will require the training from the user (for the accent) after which the device will start understanding the commands issued.

[11] provided a strategy which can be used in controlling a robotic vehicle through connected speech input. The speech recognizer platform is an Android smart phone which communicates with the robot using

Bluetooth Connectivity. Additionally the robot also has the capability to detect obstacles and inform the user to use a different command. . The robot can either maintain preset linear speed or can have variable speed on flat surfaces. The voice recognition is maintained with help of a micro controller; an Arduino (MEGA). Five basic commands are used to steer the robot i.e. forward, right, left, reverse and stop. To detect and avoid obstacles, an ultra-sonic module is implemented, programmed to stop the robot if there is any obstruction in its way. The project could have however been better utilize with an appendage included.

A careful study and analysis of the previous works stimulated an integrated and enhanced approach to the voice controlled pick and place robotic arm vehicle using Android application. This paper seeks to make improvements on the previous researches by utilizing voice commands for both arm and vehicle control using the widely accepted android application.

III. METHODOLOGY

The project consist of two main sections; hardware (which entails the physical components of the system) and software (which is the encoded computer instructions allowing signal processing to be achieved). The block diagram of the proposed design can be seen in Figure 1.

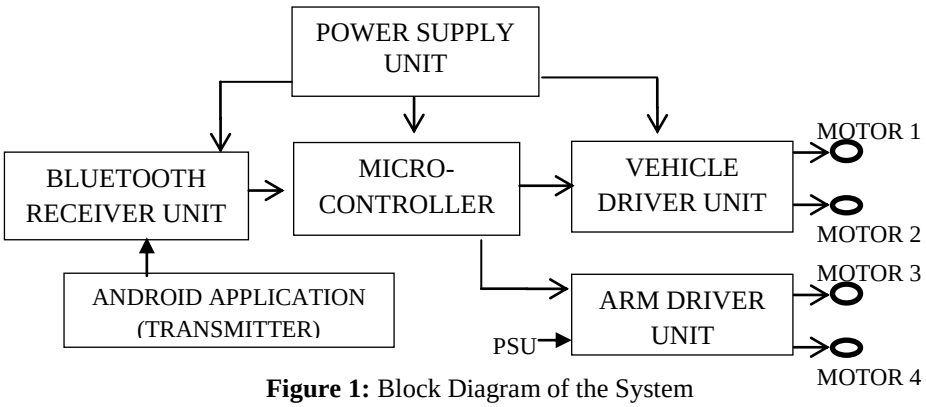

Figure 1: Block Diagram of the System

3.1 Hardware Section

The hardware components consist of the low power 8-bit microcontroller ATMEGA328P, HC-05 module Bluetooth device capable of transmitting up 30m distance, external oscillator and coupling capacitors.
The ATMEGA328P controller has the following specifications:
Operating Temp: -40 to 105°C
Max Current: 100mA
Operating voltage range: 1.8 -5.5V
Operating frequency range at voltage range: 0 - 20MHz

3.1.1 Maximum weight capacity

Using the formula,

$$Moment = Force(F) \times distance\ (L) \qquad \ldots(1)$$

The maximum amount of torque to overcome by the motors can be calculated. Weight of the arm based on type of material to be used for construction (plastic) is estimated at 50g.For a maximum weightlift (combined mass of arm and load) capacity, 250g or 1/4Kg was used in the design. Therefore, to lift a maximum of **200g** load, 12V, 7W, D.C. motor was selected.

3.1.2 Motor driver

Based on the motor specifications, the specifications of the L293D motor driver is quadruple high and current half H-bridge driver, designed for bidirectional drive of inductive loads such as relays, stepper motors, D.C. motors etc. The internal circuitry of the DC motor driver is as shown in Figure 2. The bi-directional rotation of motor as indicated on Figure 2 can best be explained as shown in Table1.

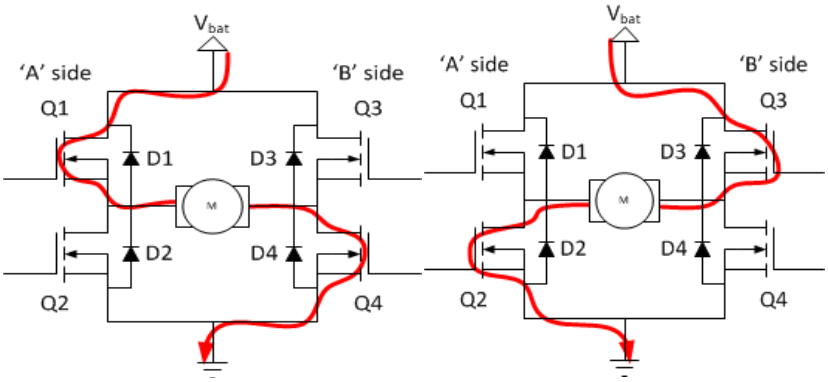

Figure 2: Internal H-Bridge Concept of L293D Motor Driver

Table 1: Bi-Directional Rotation of A D.C. Motor

S/N	Q_1	Q_2	Q_3	Q_4	Direction of Motor Rotation
1	ON	OFF	OFF	ON	Clockwise
2	OFF	ON	ON	OFF	Anti-Clockwise

3.1.3 Liquid Crystal Display (LCD)

Liquid Crystal Display (LCD) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. A **16x2 LCD**means it can display 16 characters per line and there are two such lines. This LCD has two registers, namely, Command and Data.

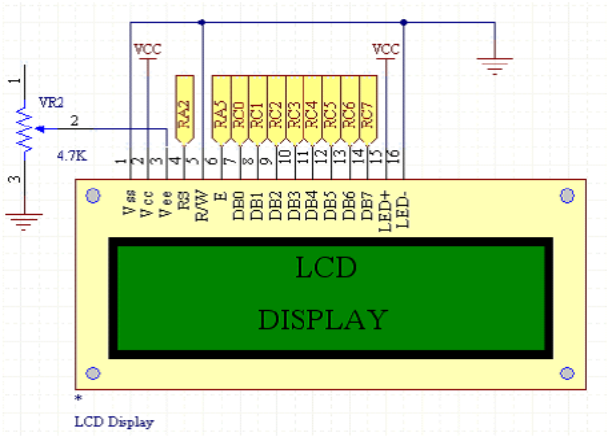

Figure 3: L.C.D. Display

3.1.4 Power consumption of circuit

The total power consumption can be summarized as shown in Table 2. This is a direct collation of all the individual power requirements of all the individual components for the smooth operation of the system.

Table 2: Total Power Consumption

S/N	Unit	Power Consumption (W)
1.	Microcontroller	0.5
2.	Motor Driver	0.001
3.	Bluetooth module	0.25
4.	L.C.D. module	0.015
5.	Wheel Drive Motor (2 sets)	12
6.	Gripper Drive Motor	6
7.	Robot Arm (Fully Loaded)	7
	Total	**25.766**

3.1.5 Current consumption of circuit

Supply current to drive the system can be obtained from the voltage-current relationship;

$$P = I \times V \qquad \ldots (2)$$

$$\gg 25.766 = I \times 12, hence I = 2.15A$$

3.1.6 D.C. Battery Source

From the power requirement of the circuit, a 12V 2.5A standard D.C. battery is required. The overall system circuit requires two voltage levels of 12V and 5V to power Vcc2 of L293D motor and other sections respectively, hence the need for an LM7805 CMOS voltage regulator with an input voltage range of 7-35V.

3.1.7 A.C. Source

An alternative power source from mains was also considered to power the system when the battery runs down. The required voltages at input to the system are 12V and 5V DC to power the motor drivers and the Microcontroller I.C respectively, hence a 240V AC/15V AC 3A transformer accompanied by the rectifying and regulating devices are needed. Figure 4 shows the circuit diagram of the alternative AC power supply unit.
The overall circuit diagram of the system with all other unit integrated is as shown in Figure 5.

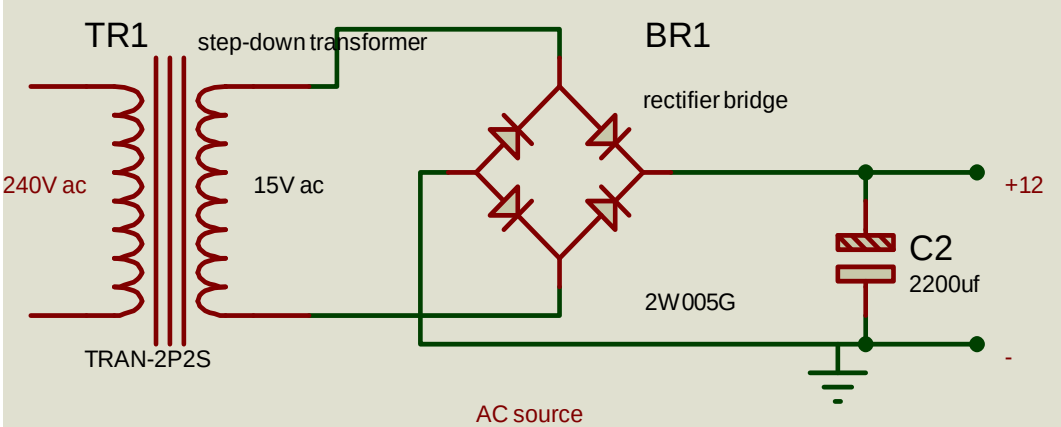

Figure 4: A.C. Power Supply Unit

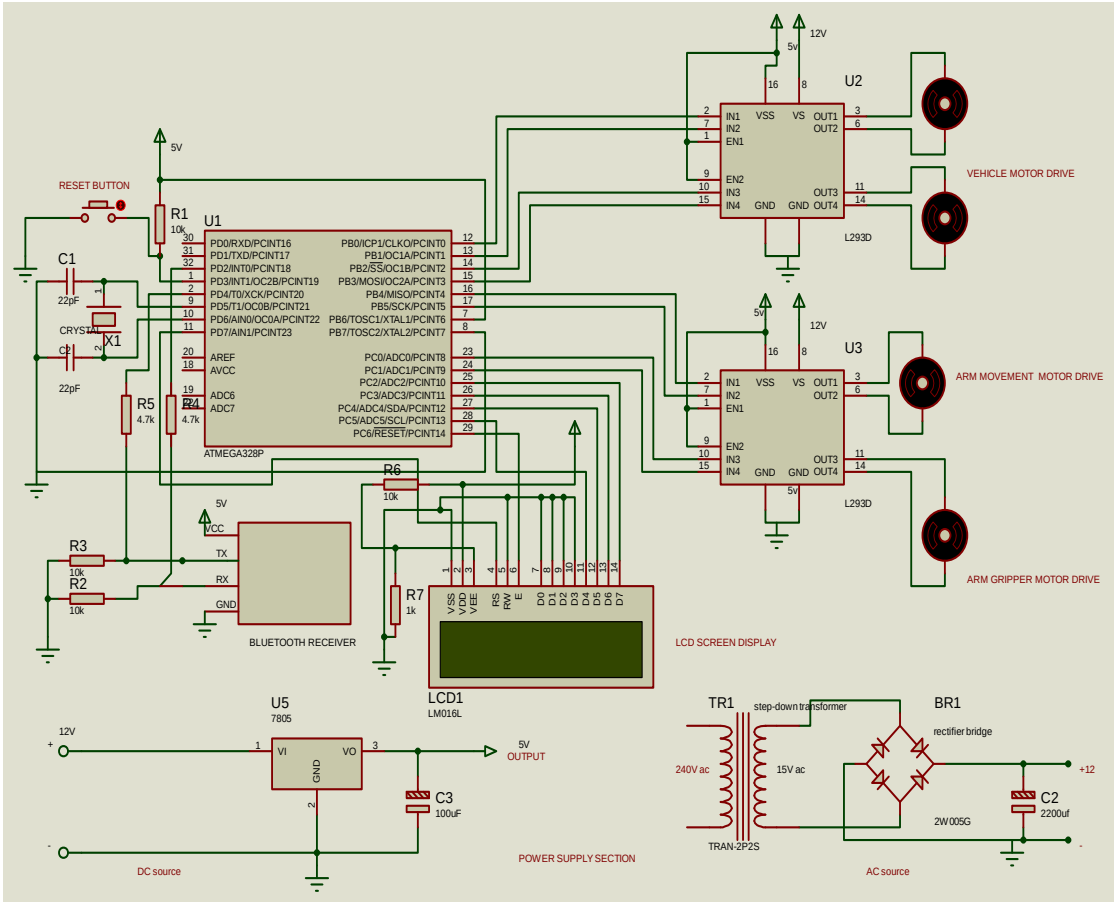

Figure 5: Complete System Circuit Diagram

3.2 Software Section

3.2.1 Programming language

The programming language used is Arduino which is a simplified version and compatible with both C and C++ programs. The Arduino project provides the Arduino Integrated development environment (IDE), which is a cross-platform application written in Java programming language. Applications include Ardupilot, Arduinome, Arduino phone, D.C. motor control etc.

3.2.2 Program architecture

The program is focused on transmitting the commands given by the android application serving as the transmitter to Bluetooth receiver and the controller. A simplified visual approach is depicted in the system flow chart shown in Figure 6.

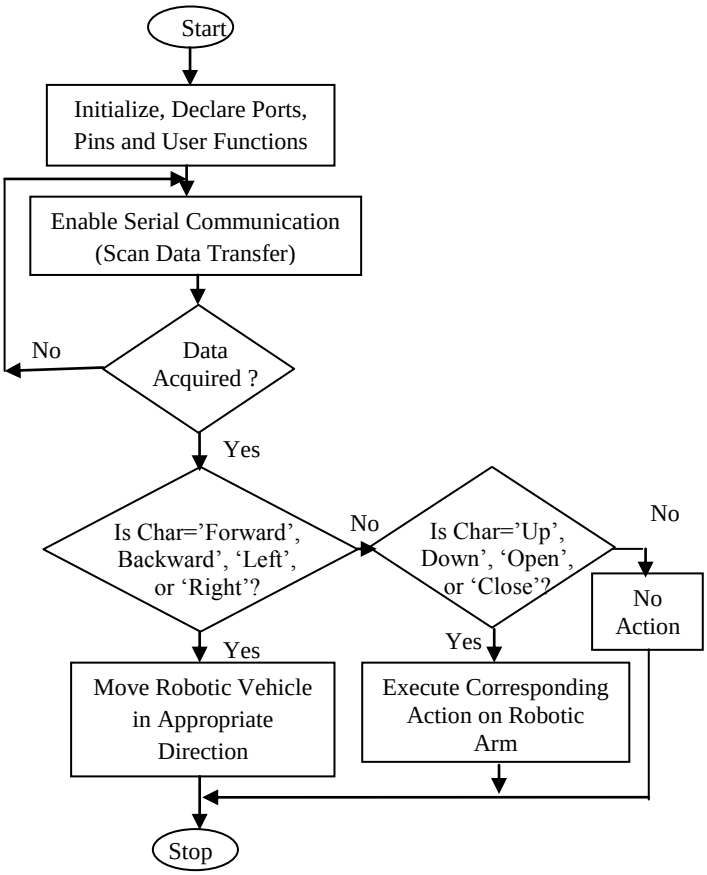

Figure 6: System Flowchart

3.2.3 Android application

Two applications (also apps) are necessary for the operation of voice command recognition from an android device;

"AMR Voice" app which is the main app through which reception of voice commands from user and Bluetooth synchronism is achieved.

"Google Voice Search" app which is the supporting app having a library English (or any chosen speech language) words by which a given command is understood and also translated into a string of characters for transmission to the receiver for necessary decoding.

3.2.4 Android Bluetooth receiver

This device interfaces the given commands to the controller. It is pre-configured as a slave Bluetooth device. Once it is paired to a master Bluetooth device such as PC, smart phones and tablet, its operation

becomes transparent to the user. No user code specific to the Bluetooth module is needed at all in the user microcontroller program.

It has two modes of operation; AT (or Command) mode, where it connected as a master with the Arduino development board and then to the computer system to enable changes in device settings such as name of device, baud rate specification (UART), status of device etc. The other mode is known as Data Transfer mode,where it is connected as a slave configuration to the controller to receive Bluetooth signals from an external source, decode into appropriate translation and pass the instruction to the controller for action.

3.2.5 Execution program

Here a summary of the command instructions written in the Arduino programming environment and intended response for the system is displaced. This is shown in Table 3.

Table 3: Summary of Execution Program

Command	Response of system
"Forward"	Vehicle moves in forward direction
"Backward"	Vehicle moves in reverse direction
"Left"	Vehicle moves in left direction
"Right"	Vehicle moves in right direction
"Up"	Arm moves in upward direction
"Down"	Arm moves in downward direction
"Open"	wrist opens
"Close"	wrist closes
"Stop"	System stops operating

IV. TESTS, RESULTS AND DISCUSSION

This section deals with the description of tests performed on the various units of the system and as well the overall system and their corresponding results. To achieve the effective testing of these various components, the following tools were used.

i) Android AMR voice command App.
ii) Multi-meter
iii) Tape(3.5M)
iv) Meter rule
v) Tape rule
vi) Protractor
vii) Weighing scale(spring balance)
viii) Weights (20g, 40g, & 50g)
ix) Choke resistor(5W, 5.6Ω)

4.1 Tests

Tests were carried out on electrical and mechanical sub-systems of the device as follows which were finally summarized in Table 4;

i) No- load test

The regulated output voltage from rectifier ($V_{D.C.No\text{-}load}$) was measured without attaching any load using a multi-meter. Voltage obtained was 4.9V.

ii) Full load test

The regulated output voltage from rectifier ($V_{D.C.\ full\text{-}\ load}$) was measured with load connected (i.e. choke resistor) using a multi-meter. Voltage obtained was 4.76V.

iii) Voice command test

The voice command was tested for vehicle and arm movements using the android AMR voice command app. All commands responded accordingly by the system as can be seen in the table 4 of summary of the commands and corresponding action of the system.

iv) Bluetooth range test

Robotic vehicle Bluetooth receiver was synchronized to the android transmitter Bluetooth at various ranges until the maximum synchronizing range was obtained using a tape rule. Maximum range obtained was 8.5m -12m depending on the location.

v) Maximum weight lift test

Different weights were attached to the motor arm and lifted automatically until the maximum weight it could lift was determined using a spring balance. Maximum mass of object lifted was 50g.

vi) Maximum lift angle test

The robotic arm was raised to the highest point and the maximum angle the arm could raise the load due to jack rod length constraint (1.9cm) was measured using a protractor. The maximum Arm lift angle obtainedwas$\mathbf{15^0}$. Figure 7 shows the completed project vehicle in yellow color, the alternative A.C. source in amber and the object lifted shown with a white cap.

Table 5: Summary of the Commands and Corresponding Action Obtained from the System

COMMAND	VEHICLE		APPENDAGE	
	Right Motor Action	Left Motor Action	Arm Motor Action	Gripper Motor Action
"Forward"	Rotate Clockwise	Rotate clockwise	Off	Off
"Backward"	Rotate Anti-clockwise	Rotate Anti-clockwise	Off	Off
"Left"	Rotate clockwise	Off	Off	Off
"Right"	Off	Rotate clockwise	Off	Off
"Up"	Off	Off	Rotate clockwise	Off
"Down"	Off	Off	Rotate Anti-clockwise	Off
"Open"	Off	Off	Off	Rotate clockwise
"Close"	Off	Off	Off	Rotate Anti-clockwise
"Stop"	Off	Off	Off	Off

Figure 7: The Completed Project

4.3 Discussion of Result

As seen from the results obtained, it can be discussed that the voice commands were successfully executed as programmed. For mechanical section, the intended maximum weight was 250g, but due to the design and construction variation, the effort had to be applied at approximately 45 degrees instead of vertically, causing a change in resultant applied force thus obtaining a maximum weight lift of 150g.

V. CONCLUSION

The voice controlled robotic arm vehicle using android was successfully designed and constructed. The device is fully functional and constructed from readily available components. It can be applied in areas such as seaports, manufacturing industries and also in military.

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