Bachelor's thesis

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CONTROLLING A ROBOT USING ANDROID INTERFACE AND VOICE

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BACHELOR´S THESIS | ABSTRACT
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The objective of this thesis is to develop a program or an Android app to control a robot powered by Arduino using a motor driver shield and a Bluetooth modem. The process involved in building the robot includes the assembling of a chassis used for the robot and programing the Arduino as well as the interface for the android device.

This thesis documents the design process for the robot and programming for the android interface. The details in the thesis give the information about the different aspects of computing involved in whole project.

The outcome of the project is a combination of embedded computing and programming.

KEYWORDS:

Android, Arduino, Bluetooth shield, embedded computing

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FIGURES

ACRONYMS, ABBREVIATIONS AND SYMBOLS

OS	Operating System
MIT	Massachusetts Institute of Technology
App	Application
DC	Direct Current
IIDI	Interaction Design Institute Ivrea
PWM	Pulse with modulation
ICSP	In-Circuit Serial Programming
SRAM	Static random-access memory
EEPROM	Electrically Erasable Programmable Read Only Memory
BlueSMiRF	Bluetooth Serial Miniature RF
ISM	Industrial, scientific and medical
TX	Transmit
RX	Receive
V	Voltage
MHz	Mega Hertz
USB	Universal Serial Bus

1.1 INTRODUCTION

Android is a very familiar word in the world today. Millions of devices are running the Google Android OS and millions are being developed daily. Google has made the Android development platform open to everyone around the world, so there are millions of developers. Although some developers just focus on building the apps or games for the android devices, there are numerous possibilities as well. One of the possibilities of Android development is its fusion with Arduino (a microprocessor), which in itself is a tiny computer. Possibilities from the combination of these two-development platforms cannot be derived from any permutation or combination logics. While there are many results already published, there are more innovations everyday.

This thesis focuses on the outcome of the possible combination of Android and Arduino. Although the project has been carried out numerous times before, this thesis gives detailed information on building a robot which can be controlled by any android device and also through the voice over the android device. This thesis includes two parts: i. the hardware and ii. the Software. The first part focuses on assembling the robot parts and building a circuit and the second part is about programming the interface on the android device.

The thesis is being divided in two aspects of computing and the author had to focus on both aspects. The first part of the thesis, which is hardware, requires a brief knowledge of electronics circuit design and the second part (android interface) was designed using MIT App Inventor.

This thesis starts with assembling the chassis for the robot in Part 1, designing the circuit in Arduino in Part 2 and building the android interface in Part 3.

1.2 CDIO

"The CDIO™ INITIATIVE is an innovative educational framework for producing the next generation of engineers. The framework provides students with an education stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating real-world systems and products. Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment." (CDIO 2012)

CDIO has a numbers of institutions all around the world that are focusing on breeding a new generation of engineers. Turku University of Applied Sciences is also one of the members. Thus, with the aid of TUAS and adopting the CDIO initiative. This thesis aims to provide a guideline to the new students of TUAS in building a simple project. This thesis also aims to educate the new students with the fundaments of robot design using a slightly different infrastructure than traditional LEGO Mindstroms NXT or VEX. Thus, using Arduino the aim of the thesis is to introduce the new students to more economical and robust robotics.

2. Assembling the Chassis

The chassis used for this thesis is known as Magician Chassis, which is widely used for robotics project. It is a very simple robot platform which consists of two gear motors and wheels and many constructing elements like screws, chassis plates and tools. The chassis is available on many online stores. sparkfun.com is one renowned website which sells the product .The full description of the chassis can be found on their webpage.

Figure 1. Magician Chassis parts

2.1 Assembling process

Assembling the chassis may take some time but it comes with detailed information so it is not difficult to assemble the parts. There are numbered screws and the plates have numbered mounting holes for the equivalent screws. The figures below show the process of assembling.

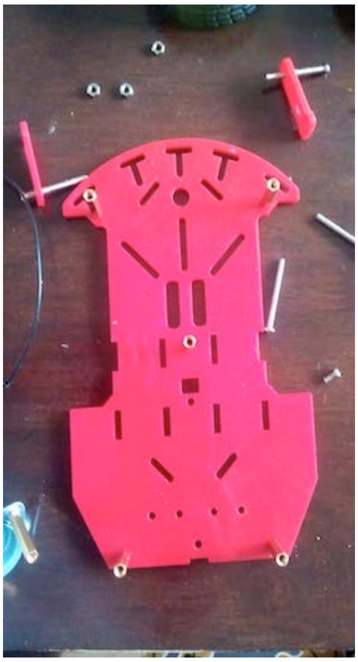


Figure 2. Lower panel of chassis

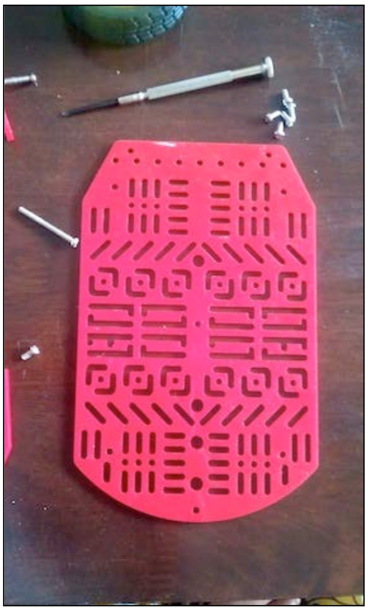
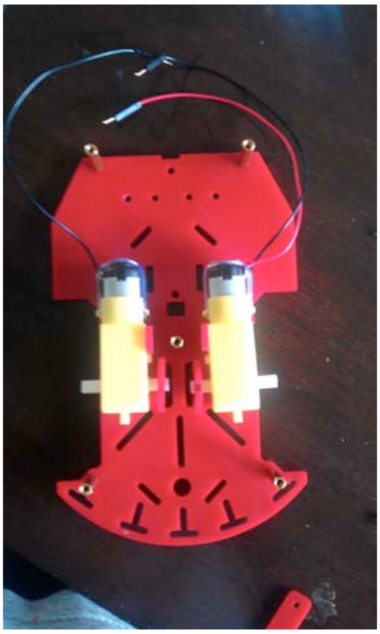


Figure 3. Upper panel of chassis

Figure 4. Two gear motors

Figure 5. Two wheels



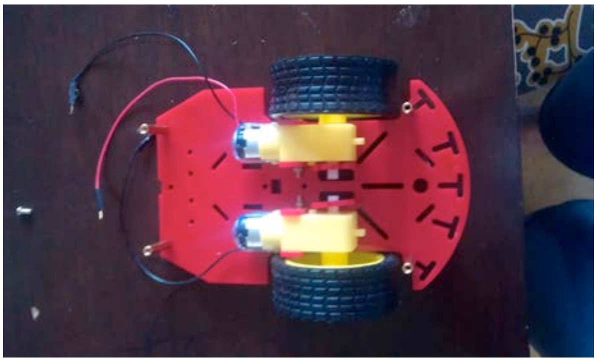


Figure 6. Connecting gear motors motor

Figure 7. Connecting wheels to the

to lower panel chassis

Figure 8. Side view of the chassis

Figure 9. Ariel view of the completed chassis

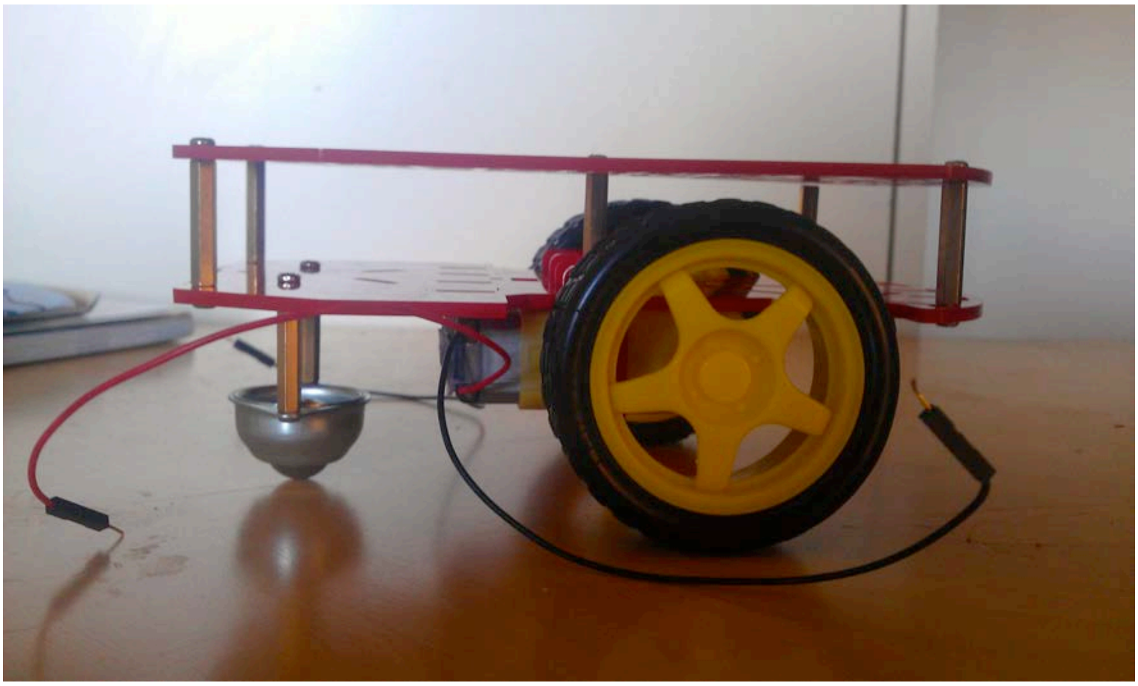


Figure 10. Final product

2.1.1 Completion of assembling process

The final product on the picture above is the framework for the robot movement which can gain the momentum if connected to the power source. But for certain control of the momentum it needs different elements. Thus, the elements required for the control are explained in part two.

3 Arduino, Ardumoto, Bluetooth modem and Circuit Design

This chapter of the thesis concentrates on the use of Arduino as the brain of the project which controls the action of the robot through signals sent from it. Ardumoto is a motor driver shield which can control two DC motors and drive up to 2 A per channel. A Bluetooth modem is a medium that enables Arduino to connect to the android device or smartphone. Thus, the modem is the bridge for the commands sent from a smartphone to the Arduino. In addition, to power up the gear motors with appropriate signals, there is a need for a circuit to be designed.

3.1 Arduino

“Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.” (Arduino 2012)

An Arduino microcontroller is a simple yet sophisticated device, which has taken the world of electronics by storm. Because of its versatility in innovation, the product has gained several accolades from the electronics professionals. Further, it has made the newbies in electronics very enthusiastic about their possible future in electronics computing. The product’s simplicity has allowed even the novel users to innovate different objects. (Robin Sandhu 2012)

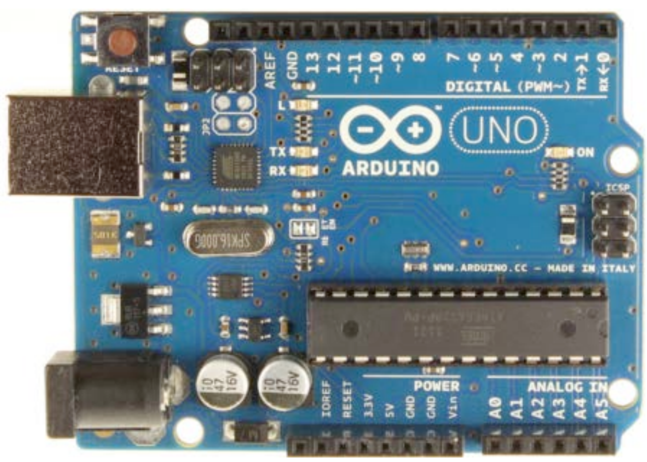


Figure 11. Arduino Uno R3 (Arduino board used for project)

3.1.1 Arduino History

The project Arduino first began in 2005 at Interaction Design Institute Ivrea (IDII) but the dawn of Arduino began in year 2002 when Massimo Banzi (Massimo Banzi 2012) co-founder of Arduino was appointed as an associate professor to teach the students of IDII to promote modern ways of interactive design. (David Kushner 2011)

Banzi wanted to offer his students something modern and inexpensive so everybody could carry their works without many obstacles. By then, the most used tool in the market was BASIC Stamp (Parallax 2012), which was expensive. So as an alternative Banzi wanted to develop something better. Banzi was also involved in processing (Processing 2012), the processing language. So with the help of a Colombian student Hernando Barragán (Barragan Studio 2012) who was working on a wiring (Wiring 2012) platform, they tried to make processing for hardware and make it simpler and easier to use. After working on the project. They came up with a prototype, which was the birth of Arduino.

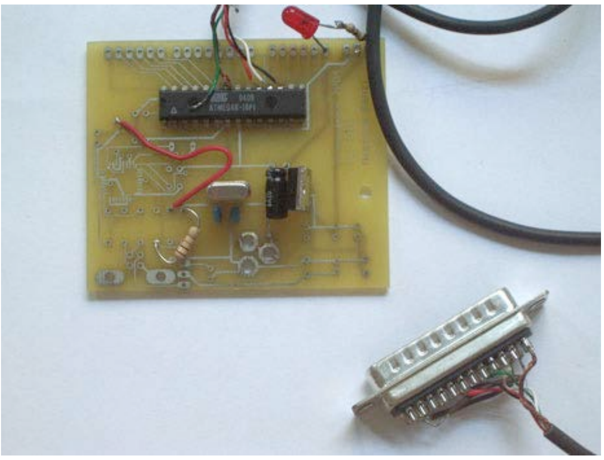


Figure 12. First prototype board

With issues in IDII funding running out, Banzi and the co-founders decided the project to be open source(Open Source 2012), so that the product would be better. The hardware was then complete and only the remaining part was software, which was later built with collaboration of other team members.

3.1.2 Arduino Hardware

The hardware used for the thesis is Arduino Uno R3. Arduino Uno is a microcontroller based on ATmega328 (Arduino Uno R3 2012). It uses 5V of power to operate .The recommended input voltage is 7-12 V and the limits is 6-20 V. It consists of 14 digital input/output of which 6 provide PWM output and 6 analog input pins. It comes with a USB connector, a power jack, an ICSP (In-Circuit Serial Programming) header and a reset button.

The hardware is the latest to the ArduinoUno hierarchy and comes with various modifications to its predecessors. It has a flash memory of 32 KB (ATmega328) of which 0.5 KB used by boot loader. SRAM is of 2 KB and EEPROM of 1 KB. The clock speed has been set to 16 MHz. (Arduino Uno R3 2012)

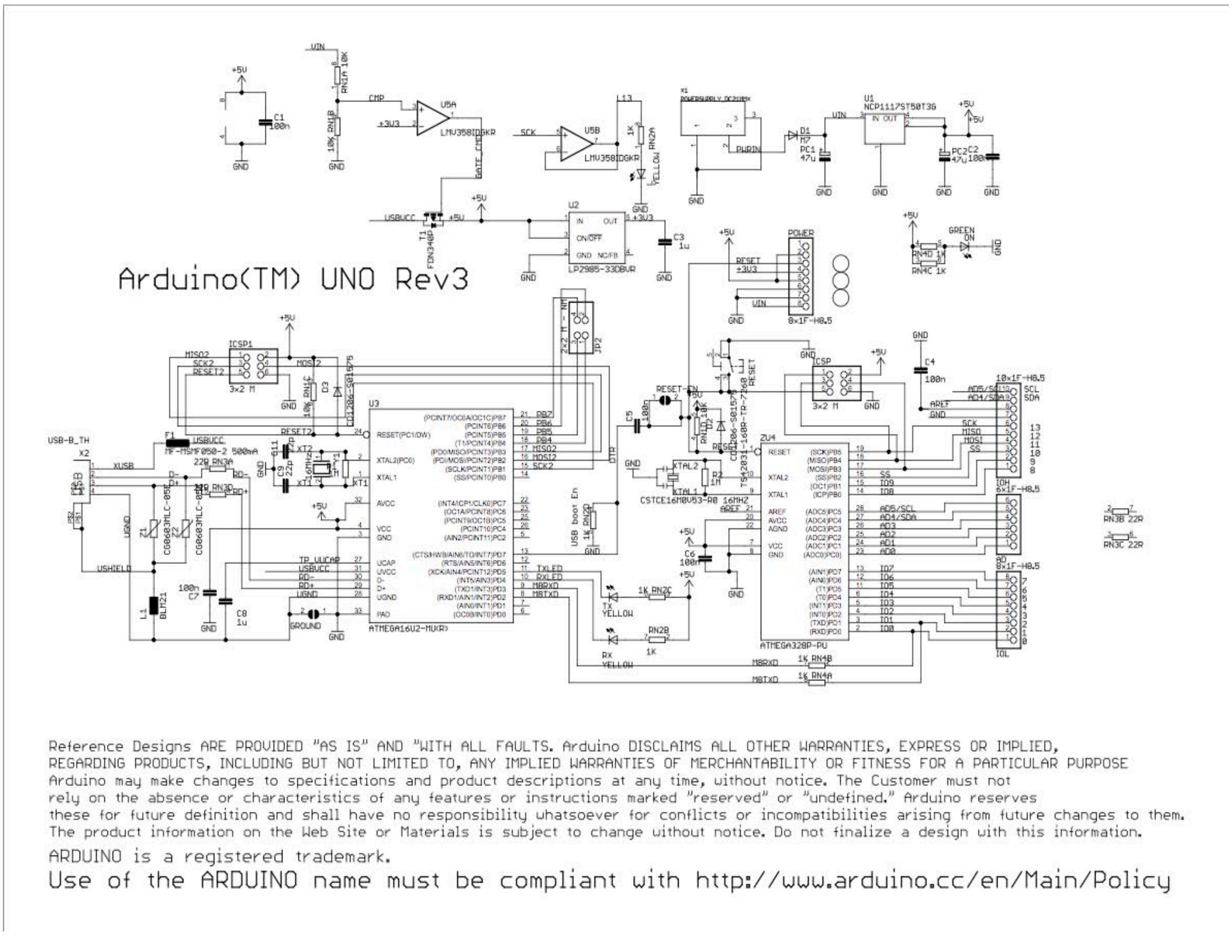


Figure 13. Arduino Uno R3 Schematics

3.1.3 Arduino Software

The board can be programmed from the Arduino software, which is available for different platforms such as Windows, Mac OSX and Linux. It is open source software, which is designed using a Java environment and is also based on processing and avr-gcc.

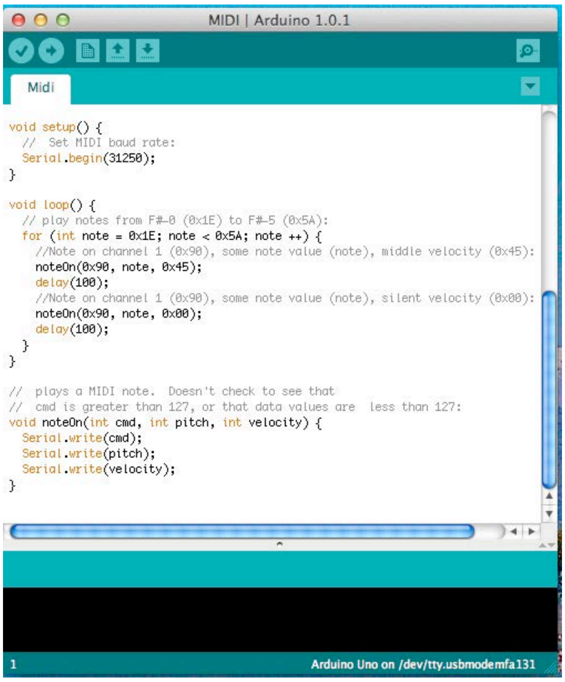


Figure 14. Arduino Software

The software allows users to write their code in C and upload to the board. The boot loader allows the uploading without the need of external hardware programmer. Thus the software is very easy to use and efficient. (Arduino Software 2012)

3.2 Ardumoto (Motor Driver Shield)

Ardumoto is the motor driver shield which is designed to drive small DC motors. As the motors draw a large quantity current, driving motors without the shield may cause instability and may be unhealthy for the motors and Arduino in long run. So, the shield is good in controlling the current to the motors and helps the performance.

Figure 15. Ardumoto (Motor Driver Shield)

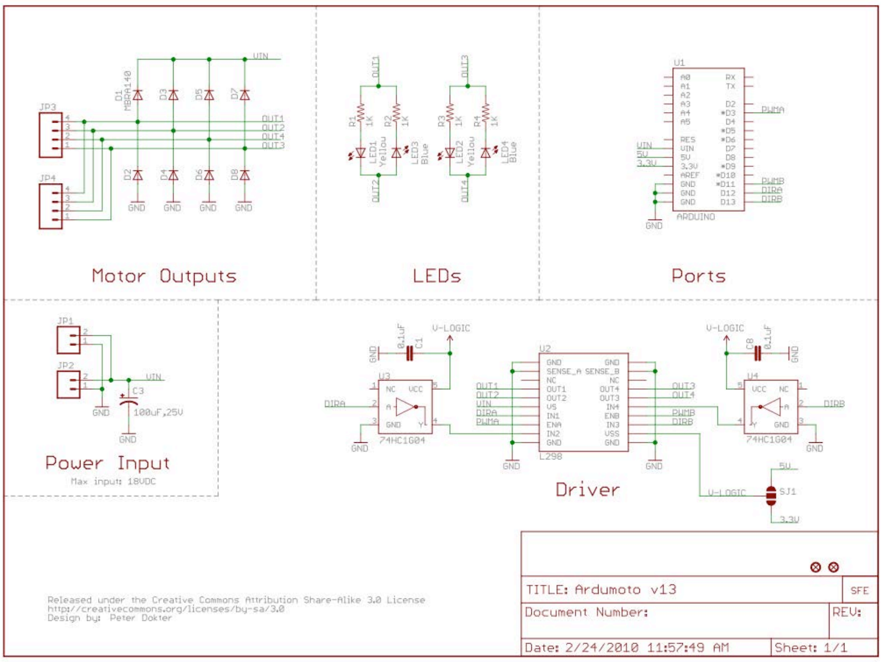


Figure 16. Ardumoto Schematics

3.3 BlueSMiRF (Bluetooth modem)

Bluetooth is a technology developed to eradicate the need of wires to communicate among different devices. Bluetooth is a wireless technology which has been a major innovation in world of technology as it has made the communication robust, easy, and low cost and energy. Most of the devices today have adopted this technology, thus resulting in various innovations daily. (Bluetooth 2012)

This technology stands out among the top in front of other wireless technology because it accedes the developers both link layer and application layer definitions allowing the support of both data and voice communications. It is a technology operating at industrial, scientific and medical (ISM) unlicensed band of 2.4 to 2.485 GHz. It uses spread spectrum, frequency hopping and full duplex signal at a nominal rate of 1600 hops/sec. Bluetooth can operate at the range between 10 to 100 m. (Bluetooth 2012)

The Bluetooth modem used in this thesis is Bluetooth Serial Miniature RF (BlueSMiRF). This device is capable of establishing connection with any Bluetooth device and can connect to any microcontroller for the exchange of serial data. It has a range of 18 meters and is capable of transferring data at the rate of 2400 bps to 115200 bps. The operating voltage range is 3.3 V to 6 V and the temperature range is -40 ~ +70C. It has an encrypted connection; a built-in antenna and can operate under harsh RF environments like Wi-Fi, 802.11g and Zigbee. (BlueSMiRF 2012)

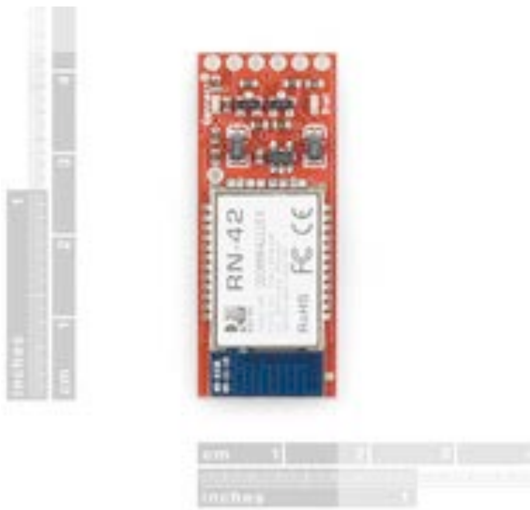


Figure 17. BlueSMiRF Silver

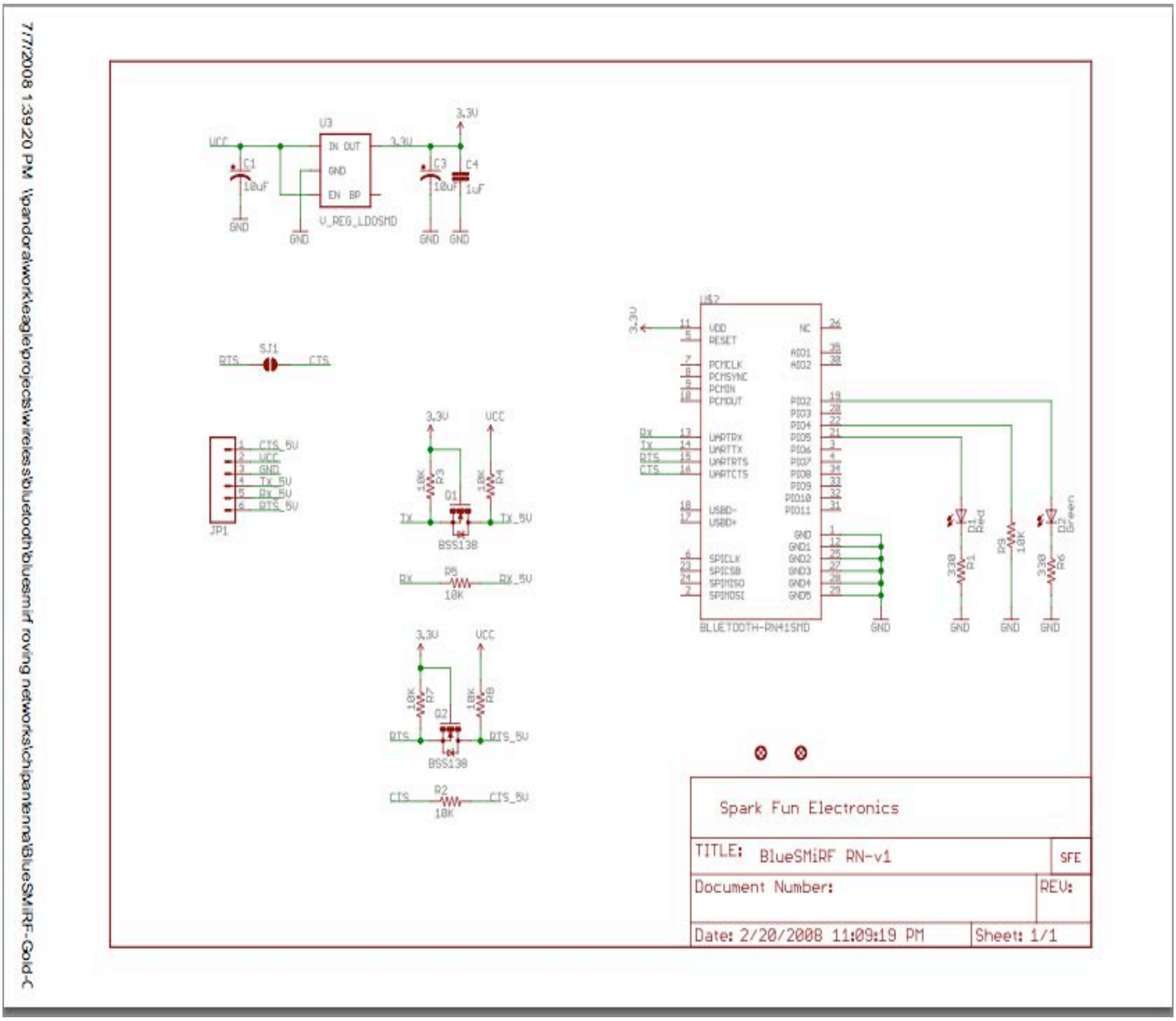


Figure 18. BlueSMiRF Schematics

3.4 Circuit Design

The final part of the hardware design is the formation of a circuit which would enable the communication among different hardware used for this thesis. The process of building the circuit involves the alignment of Arduino, Ardumoto and BlueSMiRF together.

The Arduino board comes with an inbuilt female pin header which has connections to its input/output pins, TX (transmit signal), RX (receive signal), ground pins and voltage pins. And with the help of soldering iron, a male pin header can be mounted on Ardumoto. The Ardumoto comes with the same alignment of pins so it can be overlaid on the Arduino, so there is no need for wires to join the Ardumoto and Arduino.

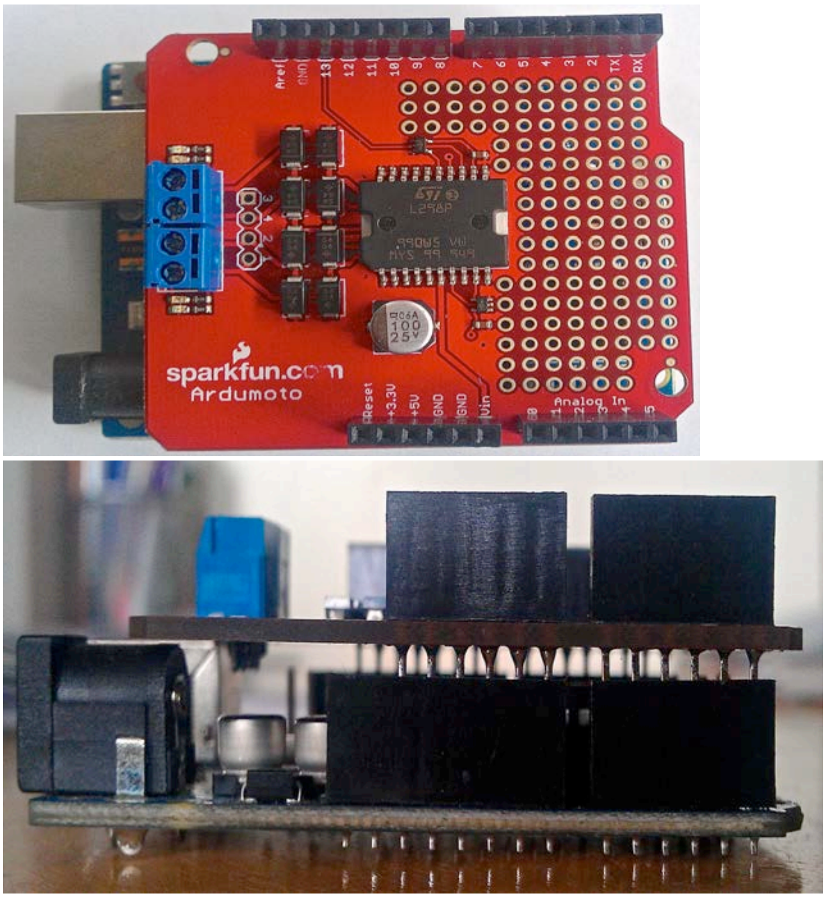


Figure 19. Ardumoto overlaid on Arduino

3.4.1 Wire Connections and Bluetooth placement

After the ardumoto is overlaid over Arduino, there is a need for the connection of Bluetooth to the appropriate pins and power source. Thus, for the convenience, in this thesis a breadboard is used for mounting a Bluetooth and then the wires are connected. TX and RX pins from Bluetooth are connected to their opposite pins from Arduino and power pin of Bluetooth is connected to 5V pin of Arduino and the ground pin is connected to the Arduino ground pin.

All the connections are made with the wires from the breadboard to Arduino.

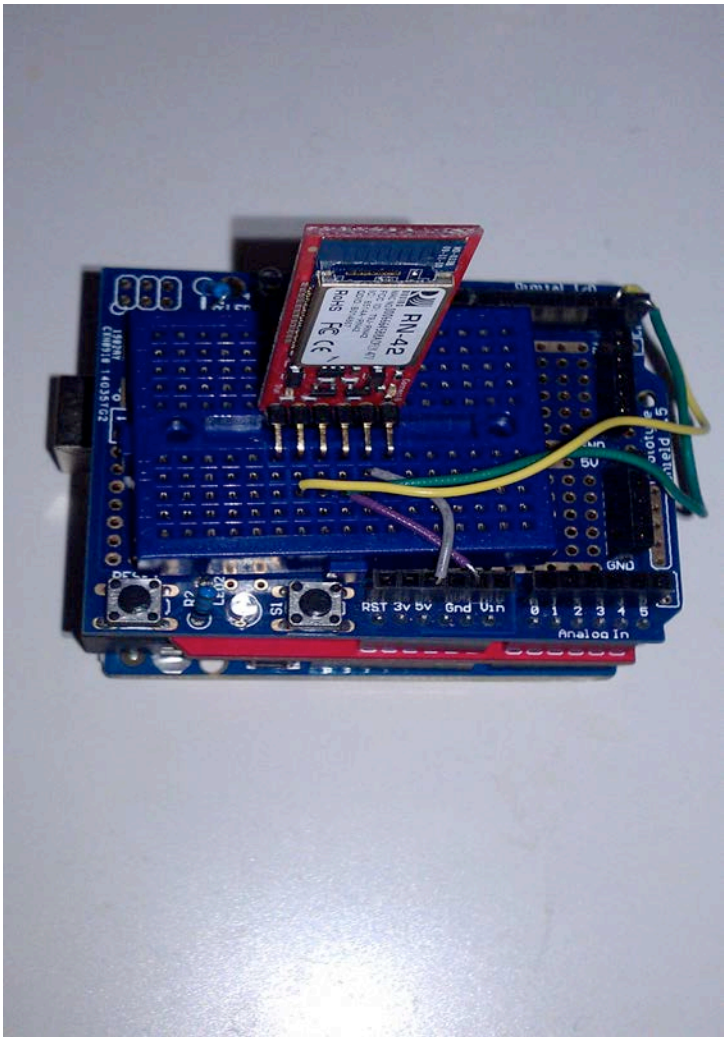


Figure 28. Bluetooth placement

4. SOFTWARE DESING (ANDROID APP DESING)

The software or the android application for the thesis was designed using a very innovative product initially provided by Google but now under the maintenance of the Massachusetts Institute of Technology (MIT) known as MIT app Inventor (App Inventor 2012). The software was previously called Google App Inventor and was released publicly on December 15,2010 only to be terminated one year later on December 31,2011. However, the product is now under MIT Centre for mobile learning and by the name MIT App Inventor. (Larry 2010)

Technology is all about efficiency. As technology has advanced things have become simpler. So application development is no longer limited to the fierce programmers, now users with very limited programming knowledge are able to develop applications. Thus, the product is a simple yet effective way in Android application development. The App Inventor allows its users to develop different kinds of Android apps just over a web browser. A user needs a Google account to get started with and the app inventor's servers stores and keep tracks of all the work user uploads. The application building process in App Inventor involves three aspects:

(i) App inventor designer,

(ii) App Inventor Blocks editor, and

(iii) An emulator or Android Phone.

The set-up process for the software is very easy. The system requirements are very basic and it is compatible with Mac OSX, Windows and Linux Operating systems. Browsers required for the software are Mozilla Firefox 3.6 or higher, Apple Safari 5.0 or higher, Google Chrome 4.0 or higher and Microsoft Internet Explorer 7.0 or higher. (App Inventor 2012)

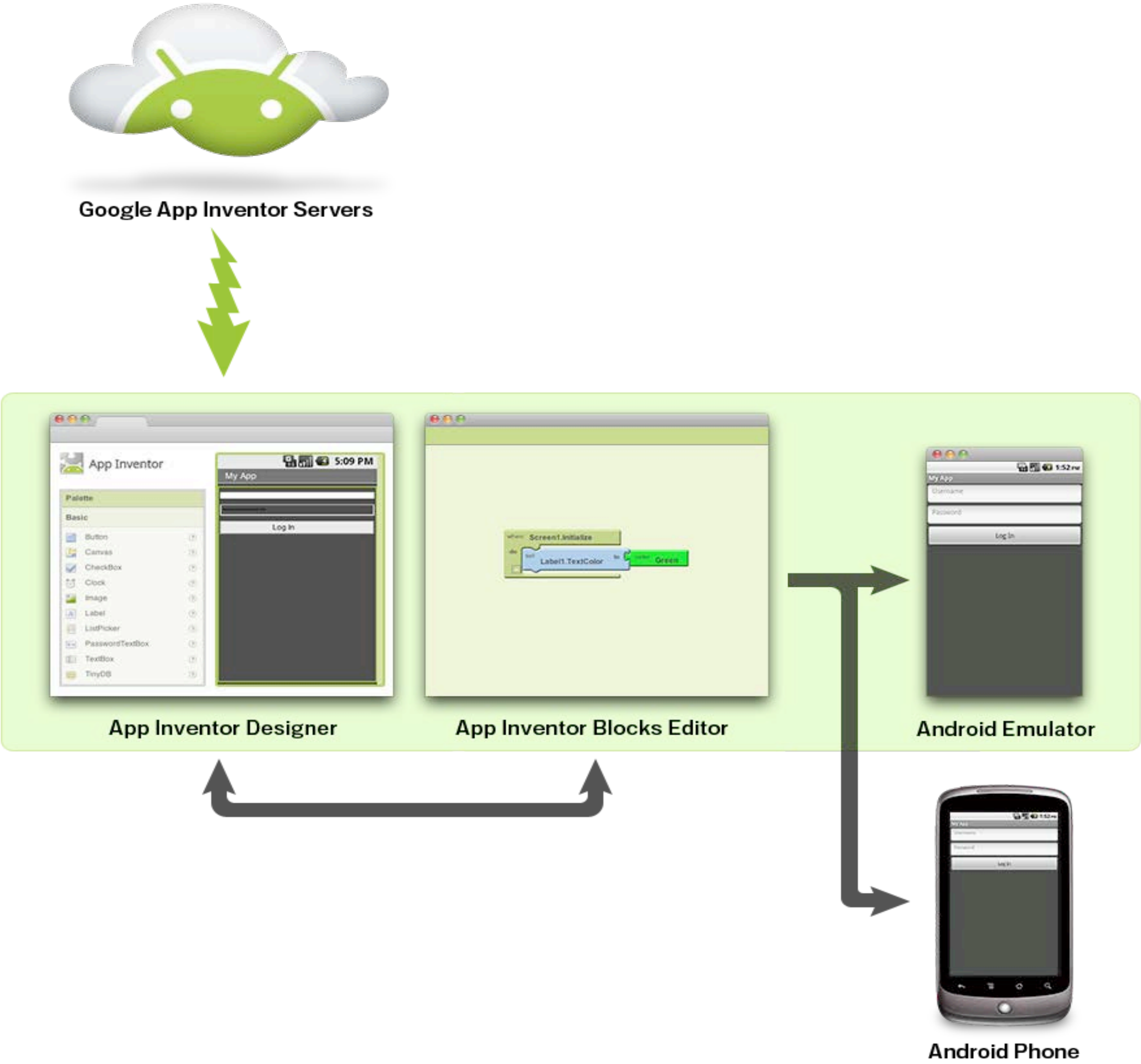


Figure 20. MIT App Inventor

4.1 App Inventor Designer

The first phase of application design goes through App Inventor Designer. Designer is accessible through the web page and all the ingredients for the app are available on the left side of the window. The ingredients include elements like a screen for the app, buttons for tapping, text boxes, images, labels, animations and many more. The right side of the designer allows users to view the screen and components added to the screen. Additionally, the properties section of the window allows users to modify the properties of components.

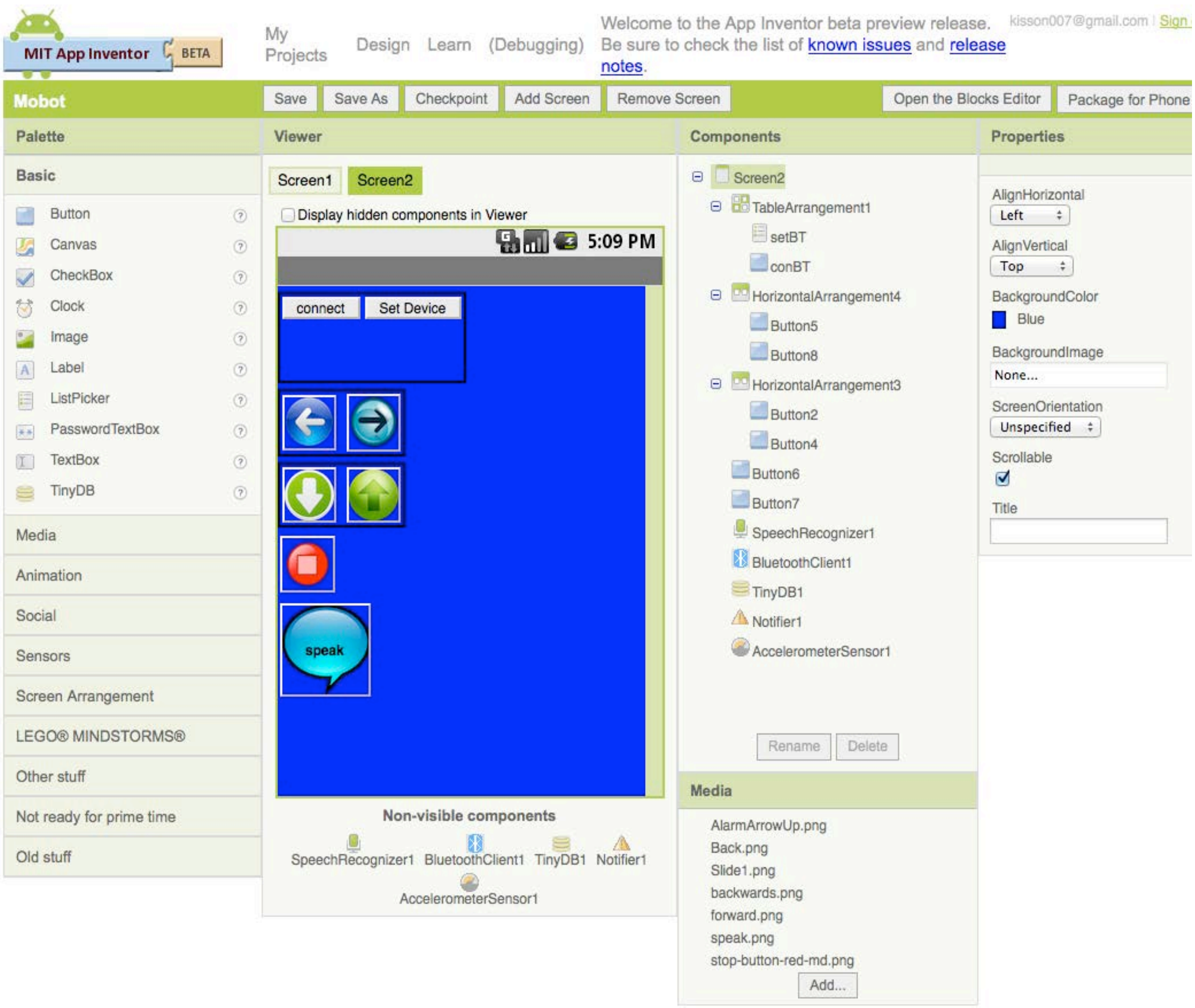


Figure 21. App Inventor Designer

Adding the components to the screen is a simple drag-and-drop process. Then the alignment of the components can be managed through alignment options on the left side of the window. The figure above shows the features added to the application for this thesis. Several non-visible components are also added to the screen, which are explored later in the blocks editor.

4.2 App Inventor Blocks Editor

After the completion of design process, for the app to function as desired, users should go through the blocks editor. App Inventor Blocks Editor uses open blocks java library. Those open blocks integrate to create visual blocks of programming language. Hence, the blocks are the programming codes which can be dragged and cemented with other blocks to create a desired functional program. The Editor can be opened from the options available in the App Inventor Designer which launches a Java applet for Blocks Editor. With a little logic in programming any user can combine the blocks and make the components added in Designer to function as required.

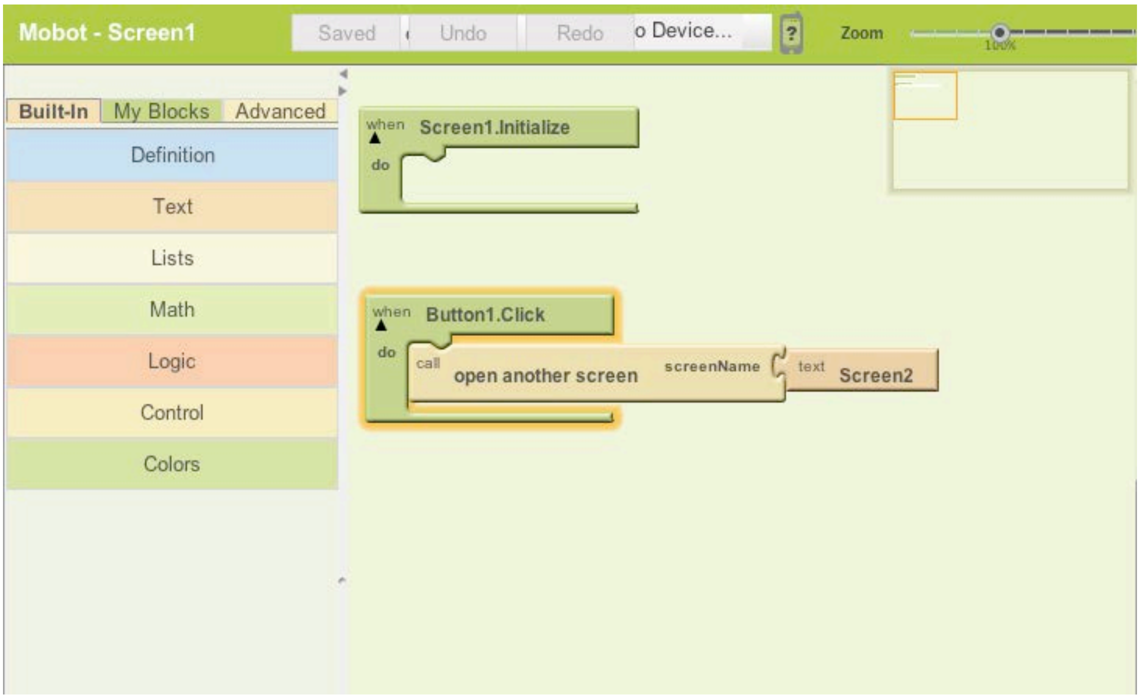


Figure 22. App Inventor Blocks Editor

4.3 An emulator or Android phone

The final part of the application design is testing the application. Thus, for the users without the android handsets. App Inventor gives the option of testing the application in an emulator which is very similar to the real device but with some limitations. From the Blocks Editor, the user can connect the application to the emulator available via the connect option and test how the application functions in real world. Apart from the emulator, the user can also directly connect the android phone to the computer via USB connecter and test the application. Real time testing is definitely the best option for monitoring the application function.

Figure 23. Android Emulator

5 MOBOT APPLICATION

Mobot is the name of the android application designed for this thesis. It was designed through App Inventor. The basic function of the application is to control the robot (created with Arduino and Magician Chassis). Mobot has different buttons integrated to it and each button has different functions.

Figure 24. Mobot Application Layout

5.1 Buttons

There is a total of eight buttons in the application. Two of them are for preparing the device to communicate with the robot. Four of them are for commanding the directions. One is for stopping the motion of robot and the last one for controlling the robot with the voice of the user.

5.1.1 Set Device and Connect Buttons

The first button is the set device button. When the button is tapped the application takes the user to a window with the list of Bluetooth devices available. Tapping the right device allows the user to come back to the main window which awaits the user with the activated connect button which when clicked connects the application to the robot allowing the user to use other buttons available.

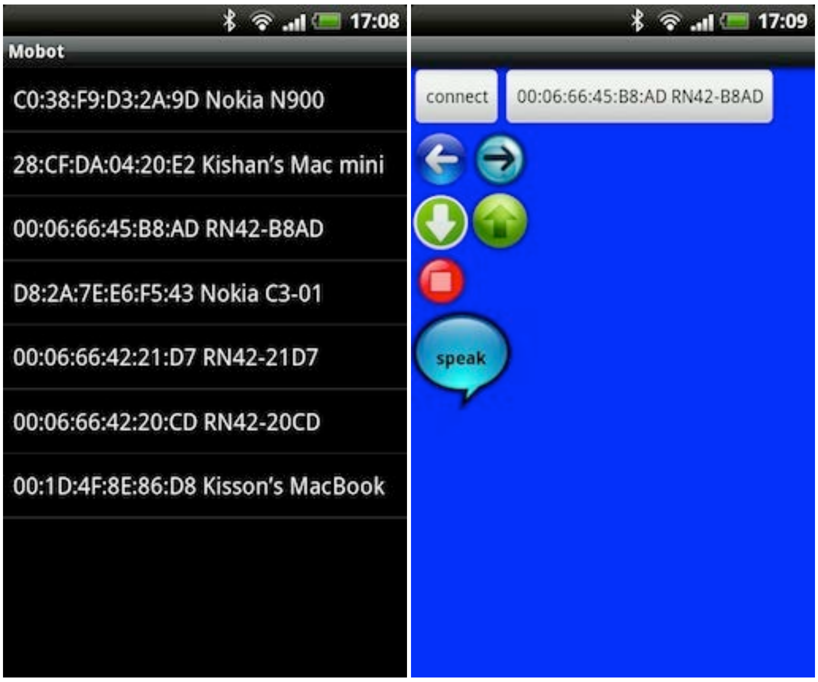


Figure 25. Set Device and Connect Button

5.1.2 Direction and Stop Buttons

There are four direction buttons in the application. Tapping each button allows the user to direct the robot to the respective direction. The directions available are left, right, front, and back. There is also a stop button available to stop the motion of the robot. Tapping the stop button stops the motion of robot irrespective of the direction it is heading towards. The buttons also have pictures integrated to them for the purpose of convenience to the users.

Figure 26. Direction and stop Buttons

5.1.3 Speak Button

The last button is the speak button. This button allows users to control the robot with voice commands. When the speak button is tapped, it initiates the Google speech to text function which is integrated in most of the android devices today. After the function is initiated, users are asked to give some commands which will decide the direction of the robot.

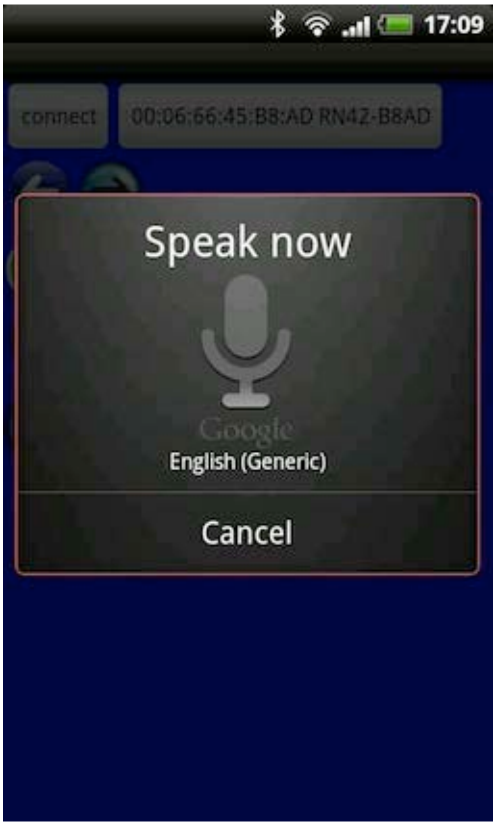


Figure 27. Speak Function

6. ROBOT'S WORKING MECHANISM

The working mechanism of the robot is based on the information passed from the phone via Bluetooth connection to the robot using a Bluetooth modem and vice versa.

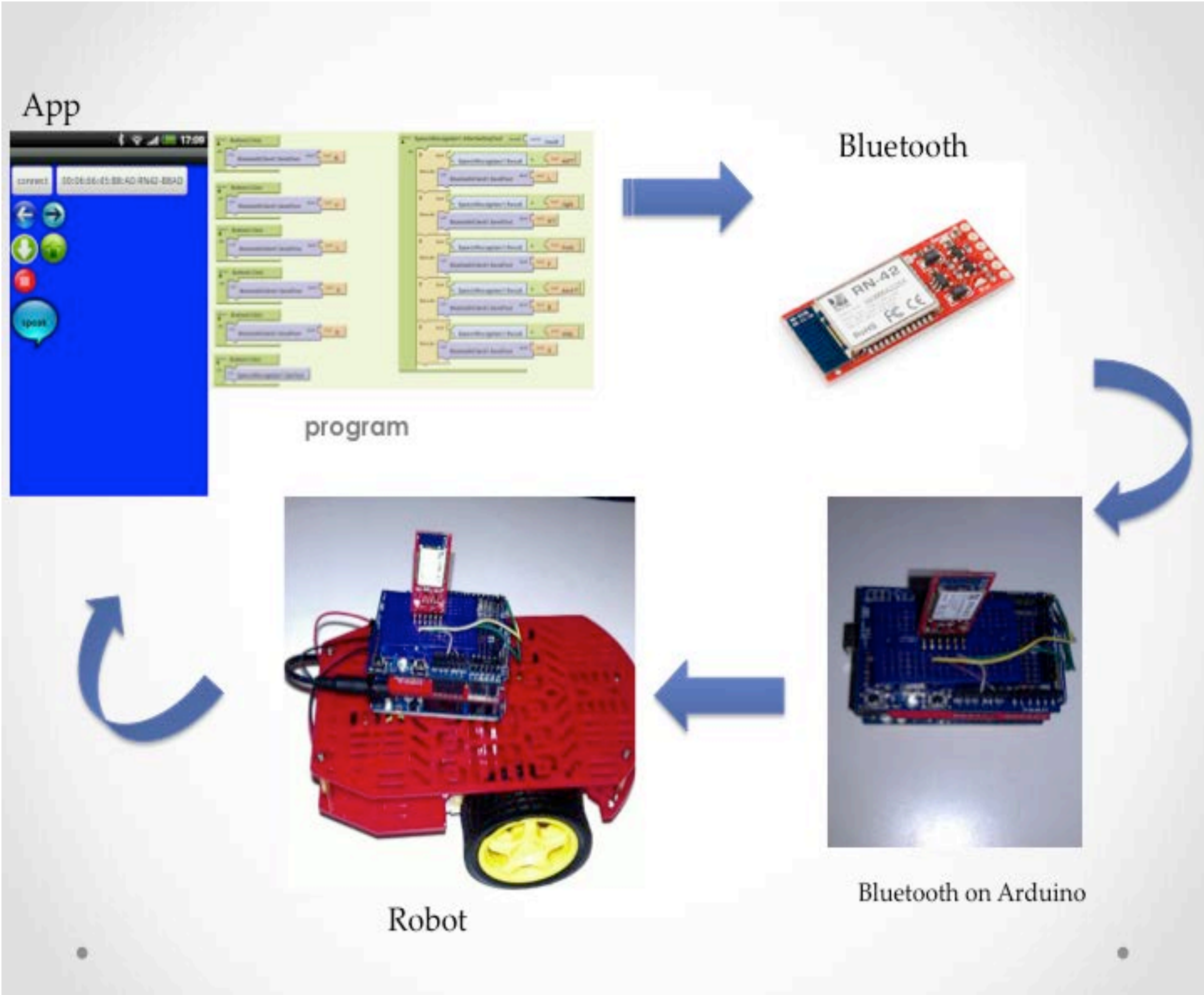


Figure 29. Robot's Working Mechanism

7. CONCLUSION

The outcome of the thesis is a simple robot which is controlled by a smart phone and also receives the voice commands. This thesis aims to provide simple guidelines for people interested in building robots. As mentioned earlier, the project has been carried out several times and the aim of this thesis is to familiarize the students with fundamentals of Arduino and Android to build anything possible. Although the thesis projects very little about the robot's use in real world, but with the help of guidelines and the abundance of resources the outcome could be very beneficial for many people in the world. People with physical limitations such as handicapped people could use the feature from this thesis to compensate their abilities.

Additionally, as the Design Build Project is under the CDIO initiative, the guidelines provided in this thesis could be very useful for the new students or the students taking an initiative in Robotics. The thesis gives detailed information about Arduino and the use of App Inventor for android application design. The guidelines provided are very simple to use and understand thus, making it very easy for the new students to build a foundation in their Robotics learning as well as app design.

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APPENDIX

Application download link:

http://www.4shared.com/android/go24ERGx/Mobot.html

App Inventor Source File download link:

http://www.4shared.com/zip/tFIHh0uH/Mobot.html

Instruction:

Download the zip file, open MIT app inventor and under my project, upload the source as a ZIP file

Source code for Arduino:

```
//Mobot code for arduino


#define serialSignal 57600


int receivingByte;


int pinF = 10; //PWM control at pin 10

int pinB = 11; //PWM control at pin 11

int pinL = 12;  //direction control at pin 12

int pinR = 13;  //direction control at pin 13



void setup() {


  pinMode(pinF, OUTPUT);
```

```
  pinMode(pinB, OUTPUT);
  pinMode(pinL, OUTPUT);
  pinMode(pinR, OUTPUT);



  Serial.begin(serialSignal);


}

void loop() {

  if(Serial.available()) {

    receivingByte = Serial.read();

  if (receivingByte == 'B') { //backward

    digitalWrite(pinF, HIGH);
     digitalWrite(pinB, HIGH);
      digitalWrite(pinL, LOW);
      digitalWrite(pinR, LOW);

      analogWrite(pinF, 255);

      analogWrite(pinB, 255);
      delay(1000);

  }
```

```
 if (receivingByte == 'F') { //forward

  digitalWrite(pinB, LOW);
   digitalWrite(pinF, LOW);
    digitalWrite(pinR, HIGH);
    digitalWrite(pinL, HIGH);
    analogWrite(pinF, 255);

    analogWrite(pinB, 255);
    delay(1000);
}

 if (receivingByte == 'S') { //stop

  digitalWrite(pinF, LOW);
   digitalWrite(pinB, LOW);
    digitalWrite(pinL, LOW);
    digitalWrite(pinR, LOW);

}

 if (receivingByte == 'R') { //right

  digitalWrite(pinL, HIGH);
    digitalWrite(pinR, LOW);

  digitalWrite(pinB, HIGH);
   digitalWrite(pinF, LOW);
   delay(1000);
}
```

```
  if (receivingByte == 'L') { //left

   digitalWrite(pinF, HIGH);
    digitalWrite(pinB, LOW);
   digitalWrite(pinR, HIGH);
     digitalWrite(pinL, LOW);
     delay(1000);
 }

 }
}
```