

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SUMY STATE UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

Master Work

On the topic:

“Smart Robot Control Information Technology”

Head of Department

Student Group IH.M-05аН

Supervisor

Dovbysh A.S.

Uba B.V.

Oleksiienko G.A.

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TASK

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Student of Master’s Level, group IH.M-05аН specialty "Informatics" Uba
 Bartholomew Vincent

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Contents Explanatory Note: 1) Overview of projects for building a map of the area; 2) selection of methods and tools for developing the smart car robot; 3) The practical implementation of the smart car robot; 4) Analysis of the results.

Date of Task

“ ____ ” _____ 2021.

Mater’s work supervisor

Oleksiienko G.A.

Received task to be performed

Uba B.V.

ABSTRACT

Note: 52 pages, 17 figures, 19 sources literature, 3 app.

Object of study: Smart robot car

Purpose of the work: development of a mapping system prototype

Research methods: implementation of a smart robot using C++ and Arduino IDE. implementation of the server side of building an area map using Telegrams-Bot, Python and PyCharm.

Results: the analysis of literature, methods and tools for development of a mapping system prototype using the Arduino board has been carried out. After getting acquainted with the existing solutions I developed a smart robot. The mapping system prototype use the Pygame for building an area map and the Telegram-bot for show the map.

SMART CAR, MAPPING SYSTEM PROTOTYPE, TELEGRAM-BOT, PYTHON,
PYGAME, ARDUINO, ARDUINO IDE, TERA TERM, PYCHARM,
PYTHONANYWHERE

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INTRODUCTION

Throughout centuries knowledge and technology have offered a huge great impact on civilizations, Without the existence of technology, civilizations would've faced a lot of difficulties in different areas of life. For the past centuries, thousands of civilizations settled on earth spreading out all over the continents, humans had to travel for thousands of miles or engage directly in contact with harmful or dangerous environment based on their lines of work, a lot of them died on the way due to illness of some exposure of certain environment or the danger that they have to face while encountering some challenges due to lack of technologies as of that time. A lot of knowledge and great ideas got lost due to deaths of a person or a group of people because there wasn't any efficient way to conserve and retain energy for more great things.

Robotics is part of today's communication. In today's world, this is fast growing and is becoming an interesting field. It is now becoming the simplest way for the latest technology modification. Communication is part of advancement of technology, so I decided to work in this field, and design something which will make human life simpler in today's aspect, both for the kids and the Adult respectively based on the area in which it will be applied.

This report is based on Arduino Mega2560, which is a smart chip capable of controlling some other external component compatible with the smart chip. This project is a prototype smart car or also called a Robot, the project is made possible using some of the Arduino external hardware components to scan and map it environments, made possible using SLAM(Simultaneous localization and mapping) it detects obstacles in its orbit or path. The smart car uses an IR Sensor that uses light beam for detecting obstacles which may be kept in it way for test purposes or may appear suddenly due to real time predictions

1. INFORMATION REVIEW

1.1. Autonomous UV Robot With SLAM



Fig 1.1 UV Robot [1]

The smart robot has 4 wiper motors, 2 motor drivers, UVsensor, UV light, PIR sensor for sensing motion. The sensors mounted around it which are used for detecting humans and also for avoiding obstacles in its path. It has a charging station which it uses path planning to identify and goes back to every 5 hours to charge up. The robot is equipped with three lamps that emits powerful UV radiation with a wavelength of 240 nm. Because of its mobility and different sensors equipped on it, it can disinfect a variety of nooks and small alleyways, the UV BOT functionality can also be controlled and monitored through an app. The robot was designed and called the UV BOT by the designer of the car, according to the designer the UV BOT's technology and design allows it to operate without exposing workers to either dangerous UV radiation or infected patient rooms[1].

1.1.1 ROS – ROBOT OPERATING SYSTEM

ROS is a set of libraries, plug-ins and tools that aid software developers in the creation of robot applications. Other features include hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more.

You can control and program your robot in three different ways:

- Computer/mouse/keyboard
- Network Cable
- Robot WiFi Access Point
 - Among this three listed above the most preferred and easiest that was used for project UV BOT was to connect the monitor and keyboard to the Raspberry Pi. The robot was set up as a master while the laptop as an observer machine.
 - They three different robot programming ways have quite a few advantages, disadvantages and reliability.

Advantages:

- Computer/mouse/keyboard - Desktop/Laptop are not needed.
- Network Cable - Small number of steps.
- Robot WiFi Access Point – laptop is only required

Disadvantages:

- Computer/mouse/keyboard – Extra keyboard, mouse, and display are required.
- Network Cable – It requires internet cable, desktop/laptop.
- Robot WiFi Access Point – laptop is only required

Reliability:

- Computer/mouse/keyboard –High.
- Network Cable – Medium.
- Robot WiFi Access Point – low.

Key point to note:

While the developer and the programmer were working on the project UV BOT they discovered that RVIZ won't in VNC (Virtual Network Computing), they also made it well known that Virtual Box or VMware is much preferable to work with ROS remotely.

1.2. Route Smart Car Controlled Over Smart Device (Wi-Fi)

This smart robot is a 2-motor wheel bot that can be controlled through a smart phone or any device capable of sending signals to the Arduino robot. The 2WD Car is controlled by an Arduino board programmed to receive information or an instruction through a receiver incorporated into the Robot design. The inventor's core innovative concept is to control a step motor-based robot by sketching a path on a web-based map and having the robot transport its items to their destination by simply moving your finger on a mobile device. The project's designer also did mention that a simple working prototype robot car was built entirely without the use of feedback sensors. As a result, position error builds up over time. This project could very well inspire someone to create the ideal carrier robot by incorporating feedback sensors to correct position errors. If it's integrated with a routing algorithm like the Dijkstra algorithm, it'll be even more convenient.

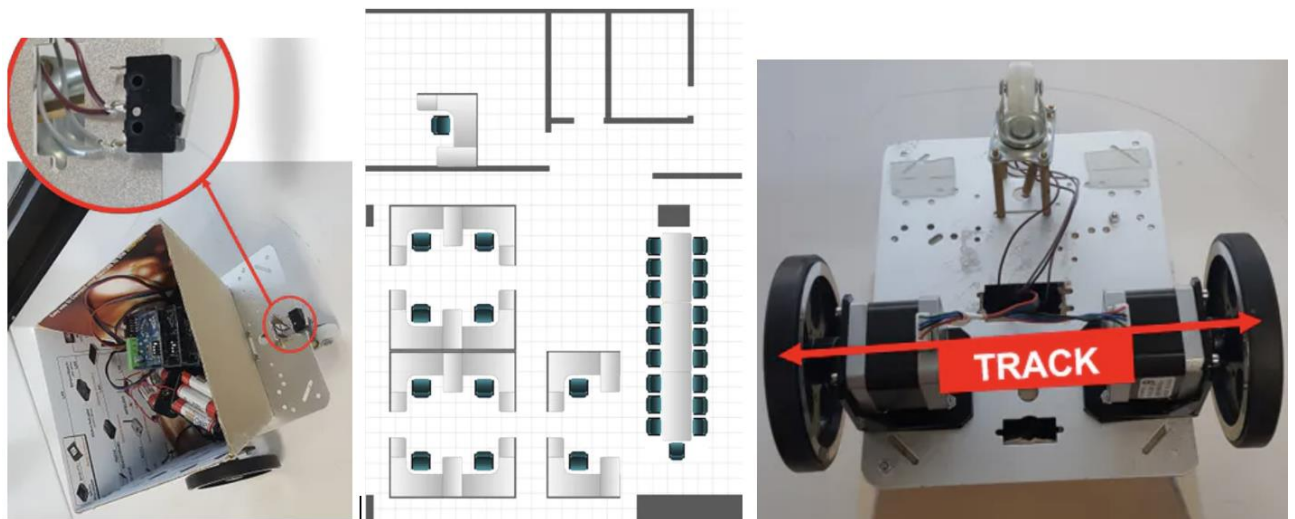


Figure 1.2 Smart car controlled over Bluetooth [3]

The route bot consist of 2 DC motors, PHPoC WiFi shield 2, 2 Stepper motor controllers, OpenBuilds Micro Limit Switch, Arduino Uno and some other unlisted compatible Arduino external components[2].

1.3. Human Navigation Using Indoor Mapping

There are a lot of ways and uses for projects similar to these, this very Human Navigation Indoor Mapping robot project was documented and designed by two authors Christian Roger and SabineTimpf. The goal of their study was to offer a low-cost SLAM implementation that could be used to quickly generate a baseline for navigable maps in indoor, enclosed situations. Non-impaired pedestrians, wheelchair users, and robots are just a few examples of use cases that require various levels of precision when it comes to indoor maps. For their project work, they both chose the non-impaired pedestrians use case as the group with the lowest accuracy requirement which they spent a sum total of 300euros for the construction of their prototype, They chose the lobby of a university building as a test location. For directing the robot's operations and displaying the scans, a program was created. During their test run as they stated, they encountered few errors but wasn't much of a huge problem cause it was not more than 70cm. The study's findings might be applied in a variety of ways, including as the platform for indoor navigation systems in vast, complicated locations like airports or hospitals. It might also be used to map unfamiliar and potentially dangerous interior settings, such as those containing gas or smoke.

This mapping smart robot uses pre-made photo interrupt sensor, infrared sensor, laser sensor, ultrasonic sensor, a Bluetooth module, servo, magnetometer and finally an Arduino uno Rev3 with motor shield with 2 DC motors. This very listed modules of components are so straightforward to use, mounting of it is also not hard to achieve. It's also very cheap to purchase and can be seen and bought online from many sellers selling electronics or Arduino components. this smart car works with three IR sensors which are

separated from each other with about 5mm measurement. Some other hardware's components are not listed. Runt Rover Sprout 2WD chassis is also used to make the body of the car [3].

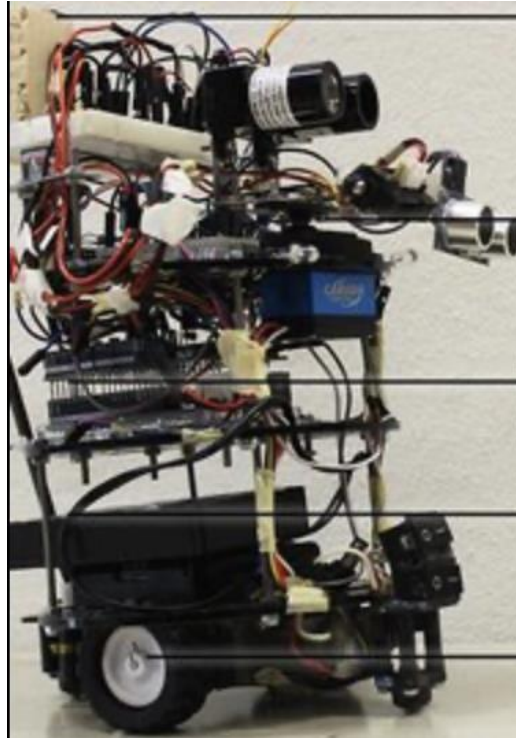


Fig 1.3.1 – Mapping Smart car (side view) [4]

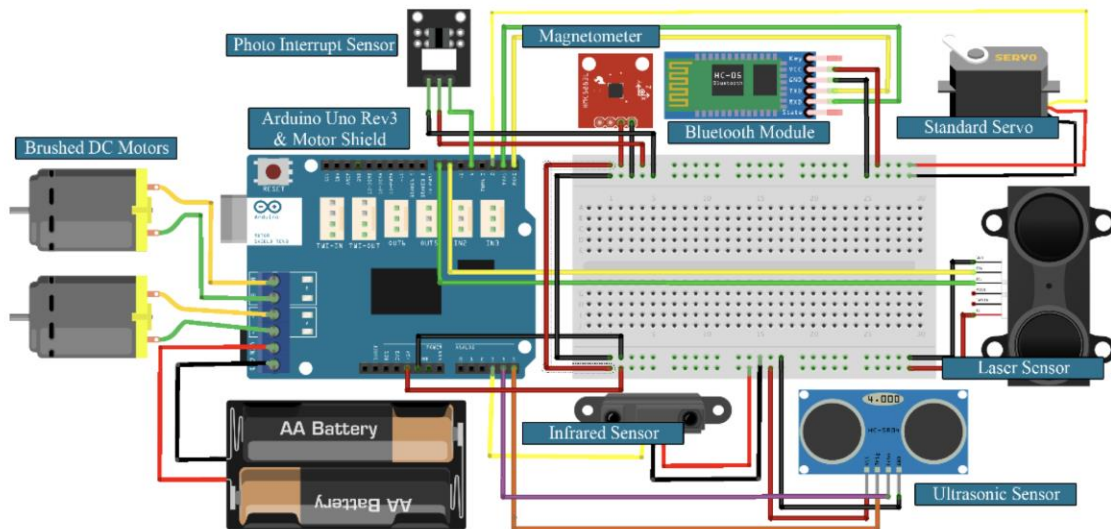


Fig 1.3.2 – Mapping Smart car (Components connections scheme) [4]

1.4. Kalman And Adaptive Filters

ADAPTIVE FILTER

An adaptive filter iteratively simulates the connection between the filter's input and output signals, which is a computational device. The filter values of an adaptive filter are self-adjusted using an adaptive algorithm.

Advantages Of Using Adaptive Filters

- Adaptive filters can be used to eliminate noise with a changing power spectrum which occurs over time, whereas traditional digital filters can't do that.
- While in online mode adaptive filter can handle real-time or online modeling tasks, such as identifying an unknown system.

NOTE: Primarily, Adaptive filters becomes very handy when dealing with real-time and online signal processing applications.

KALMMAN FILTER

A Kalman filter may be used in any situation when you have ambiguous information about a dynamic system and want to make an informed assumption about what the system will do next. Kalman filters are suitable for systems that change often. They have the benefit of being memory efficient, which mean they don't need to retain any record other than the previous state. which makes them very quick, making them ideal for real-time challenges and embedded systems.

Advantages Of Using Kalman Filters

- using the Kalman filter, the steady state error level linked with measurement noise can be greatly reduced.
- The Kalman filter is actually rather simple and straightforward to comprehend.

1.5. Formulation of the problem

The aim of the work is to develop a prototype of a mapping system that will scan the environment and build a map of the area. The prototype will include:

- 1) a data collector based on sensors;
- 2) a data processor that will build a map based on the received data;
- 3) a data transmitter, which will transmit data to the processor and return the map of the area to the client.

To achieve this goal, the following goals were formulated:

- 1) analyze known solutions for building a mapping system prototype;
- 2) choose the appropriate methods and tools to solve the problem;
- 3) design the software and hardware part of the prototype;
- 4) design data transfer between system components;
- 5) develop and test the prototype mapping system.

2. SELECTING OF PROGRAMMING INSTRUMENTS

USED COMPONENTS:

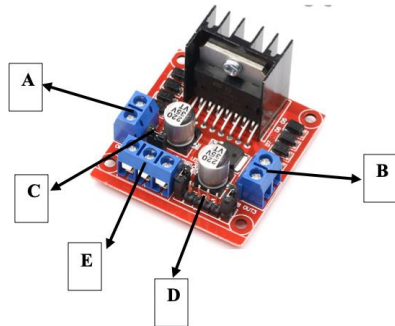
The hardware implementation phase is divided into components listed below.

The components are:

- L298N Motor Driver IC
- Stepper motor 12V 28BYJ-48
- ULN2003 stepper motor driver
- Arduino Mega 2560
- Power Supply
- Left and Right DC Motor
- On/Off switch
- Motor Wheels
- Jumper wires (M – M and F _ M).
- IR distance sensor (10-80 cm) Sharp GP2Y0A21YK0F.
- 4WD smart car chassis.
- HC-06 Bluetooth module

2.1. Components Descriptions

L298N Motor Driver IC

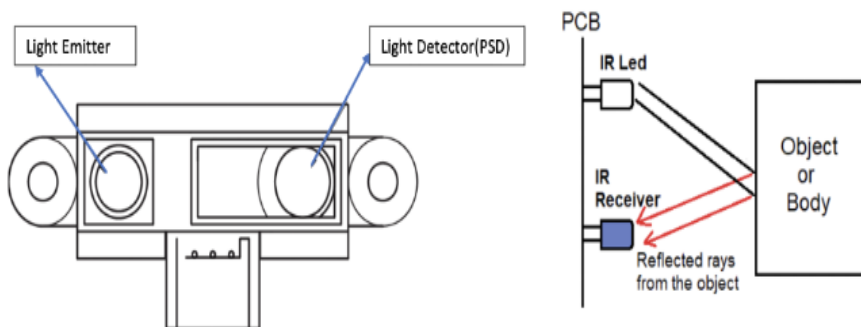


This L298N motor driver module permits the freely and independently control two motors of up to 2A each in both directions, the board can be powered with up to 12V or more and the maximum voltage input is said to be up to 46V – 50V for the L298N motor driver. The DC motors rotating directions can be manipulated by altering the input voltage on different connecting ends of the DC motors. An H-Bridge is use for motor rotation(direction) and PWM used for motor speed control, combing all these is used to manipulate both the direction and speed movements of the DC motor. The motor driver module consist of two screw terminal blocks for the A and B motor connection, and another terminal block labelled D which contains of eight pins for different connection purposes, some of the pins are used as Ground pin, 5V pin for forward and backward rotating movement, while the other pins(ENA, ENB pins) are used for speed control. The part labeled E is a screw terminal used for power supply which can either be an input or output(5V), while the part labeled C is a 5V EN jumper [5].

Sharp GP2Y0A21YK0F IR distance sensor



The ultrasonic IR distance sensor is a sensor and it is extremely popular among Arduino users for detecting of objects. The Sharp IR distance sensor is usually used with a microcontroller and microprocessor platforms just like the Arduino, the Raspberry Pi platforms and a few other compatible platforms. The sensor has a total of 3 pins for controlling the sensor, with a 10 cm to 80 cm (4" to 32") measurement range. This infrared sensor is less expensive than the sonar rangefinders, yet it performs far better than other IR options.



A Diagram illustration of how IR distance sensor works

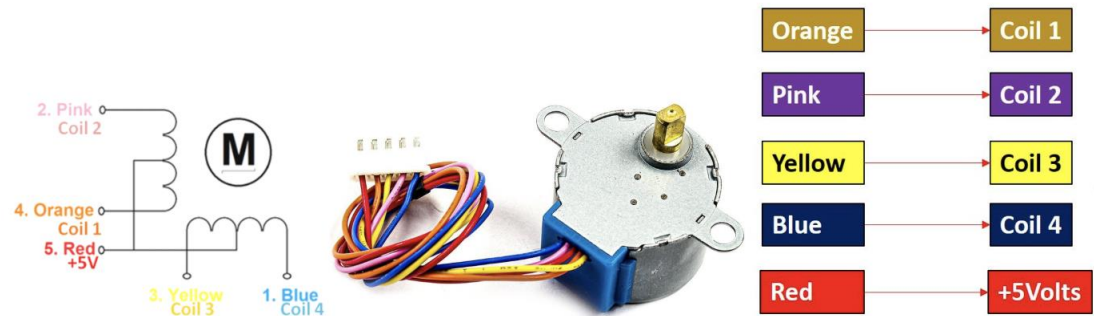
To detect the distance between objects, an IR distance sensor employs a beam of infrared light that reflects off them. The distance is estimated by triangulating the light beam. An IR LED and a light detector, also known as Position Sensing Device, make up the IR sensor. Whenever a light beam is reflected by an object or an obstacle, the reflected beam reaches the light detector, where it forms a "optical spot" on the PSD. The three pins, yellow, black and red,

Yellow – The yellow wire or the V0 pin should be linked to the A0(analog) port on the Arduino board.

Black – The wire should be attached to Arduino on port GND.

Red – This pin port should be connected to 5v on the Arduino uno board[10].

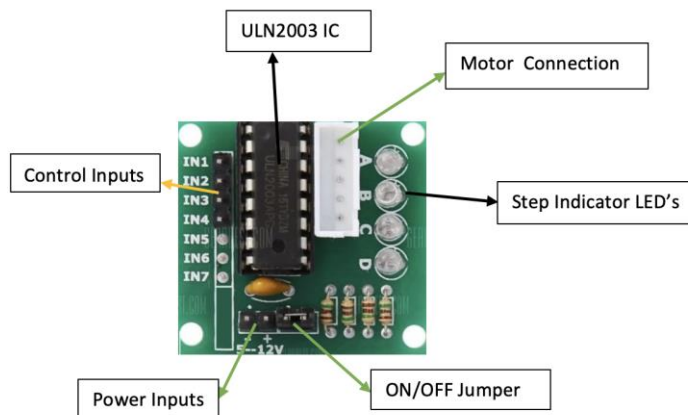
Stepper Motor 12V 28BYJ-48



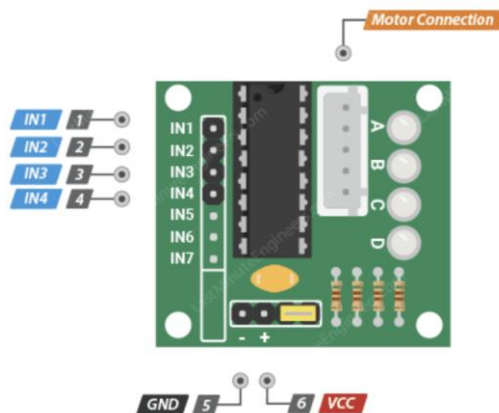
The Stepper motor 12V 28BYJ-48 is a 11.25° degrees, When the 28BYJ-48 motor is in full step mode, each step translates to a rotation of 11.25 degrees, based on the data sheet. That implies each cycle has 32 stages ($360^\circ/11.25^\circ = 32$). This is the most prevalent stepper motor in low-power industrial applications, as well as in popular hobbyist projects. The 28BYJ-48 is a five-coil unipolar stepper motor with a 5V working voltage, The motor's current usage is roughly 240mA. That implies the 28BYJ-48 contains four coil patterns, each of which can be driven with 5 volts. Because of the 5 volt working voltage, any microcontroller, such as the TM4C123 Tiva Launchpad, may simply operate this motor.

As can be seen from the picture description above, the motor has four coils, one of which is connected to +5V (Red) while the others Orange, Pink, Yellow, and Blue are pulled out as wires which supply the coils with sequence logic[9].

ULN2003 stepper motor driver



The board features a connection that properly matches the motor wires, making it very simple to attach the motor to the board. There are four control inputs (IN1-IN4) as well as power supply connections that are designed specially on the board. The ULN2003 driver board is a popular motor driver IC that consists of an arrangement of seven Darlington transistor pairs. Four of the seven pairs are employed on this board, and each pair can drive loads up to 500mA and 50V. On the PCB, four LEDs display activity on the four control input lines, which signify the stepping state, which are labelled from A - D on the board. When stepping, they offer a lovely view because of the activity on them.



NOTE:

- The IN1–IN4 pins control the motor functionalities. by Connecting them to Arduino's digital output pins.

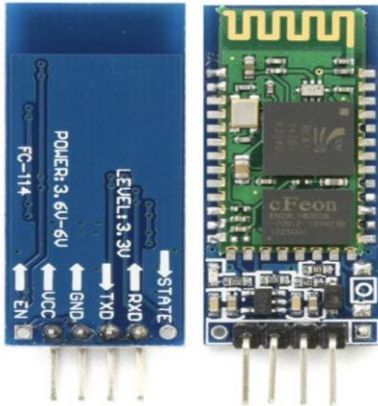
- GND is ground pin or the negative connection pin port to the driver.
- The motor is powered by the VDD pin, which provides 5 volts. It is suggested that you use a 5V external power supply with it. Using the 5V voltage supply from your Arduino board to drive this stepper motor is not a good idea since it consumes and requires much power.
- Motor Connector pin ports, this is where the motor connects to the rest of the system which has a unique ports design than the others. Because the connection is keyed, it can only be used in one direction.

On/Off switch



Switch are among electrical component that can break or stop an electrical circuit flow due to their different and unique designs, interrupting it current or diverting it from one conductor to another determines whether a switch is ON or OFF. The switch used for the very design of this project is called a toggle switch, which is used to control the flow of current of the smart car, this switch has two basic operations, which are ON and OFF. When the switch is on the current from the battery pack flow to the motor shield and then from the motor shield 5V is passed into the Arduino Uno R3 board, when the switch is off the current can no longer flow out of the battery pack [4].

HC-06 Bluetooth module



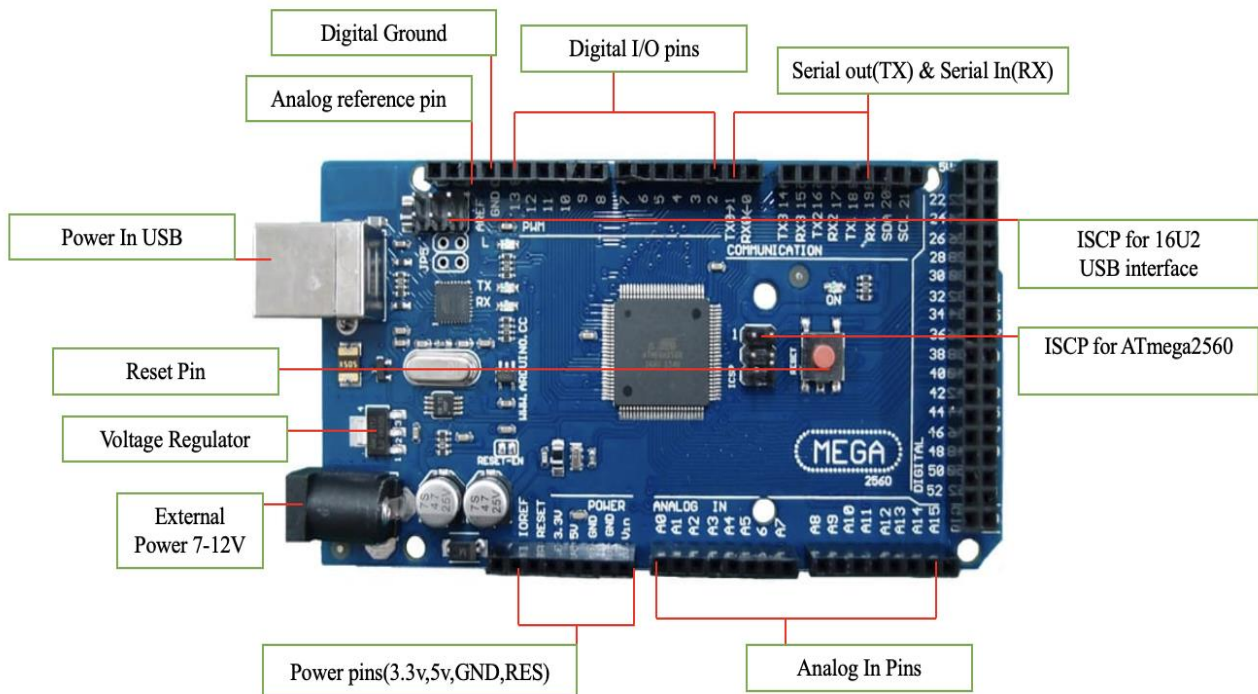
HC-06 model for Arduino has 4pins or 6pins depending on it design, the HC-06 4pins can be powered with 3.6V – 6V, the ground pin is connected to the ground in the Arduino, while the RXD and TXD pins are connected to different compatible ports in the Arduino depending on the designer programming style. The Arduino Bluetooth model HC-06 can be paired to a mater Bluetooth device like the smart phones, pc, and also a tablet. The RXD pin is 3.3V and is recommended to be connected to the Arduino Uno and Mega to protect it from reaching up to 5V which can damage the model[4].

Motor wheels



The smart car has four wheels in total, two on the left side and two on the right. Because the wheel cannot move on its own, it need the assistance of a DC Motor; similarly, the Dc motor cannot drive the smart vehicle without the assistance of the wheels. The whole weight of the vehicle is supported by the wheels, which are designed in such a way that the entire weight of the car may be moved.

Arduino Mega2560



The Arduino mega2560 board is most likely the most popular among the fundamental components of an Arduino project design used by different developers of electronic products based on Arduino. Arduino mega2560 is ideal for debugging software and testing hardware parts of devices during the development phase of a project. This is due to the presence of some special features embedded in the board, the features and ability of the Arduino mega2560 are [4]:

The interface converter, it a special port with allows you to connect the card directly to the USB ports of the computer the port designs can be different depending on it design models.

3.3 and 5 V powerful stabilizers ports or pins, which allows you to power your devices from the board.

The board can also be powered from the computer through different designed special port via USB.

During the development and debugging phase, connection of external devices takes place through the connectors which are programmed to turn on or off depending on its program.

The board also contains some LEDs indicators like the RXD, TXD and the ON led indicators, as the name implies it is used to know when the board is switched on for the ON led indicator, and when the TX and RX is in used the RXD and TXD LEDs also indicates when it is being used.

Arduino mega uses the microcontroller ATmega328, and it very design contains:

54 digital input / output ports.

16 analog inputs.

clock frequency 16 MHz

USB port.

power connector.

In-circuit programming connector.

Reset button.

Voltage regulator.

LEDs indicators.

NOTE: When the reset button is pressed, the reset button will make contact with the ground pin for a temporary time causing the board to reset any code present on the board, the voltage regulator on the Arduino board controls the amperes of current flowing into the board. Voltage regulator should be present in the Arduino board for proper functionality not so as to be interacted with on our Arduino board, but to assist the board in controlling the voltage coming into the board. It is not advisable to attach 20V power supply to Arduino board to avoiding damaging the board completely[6]

Power Supply Pack



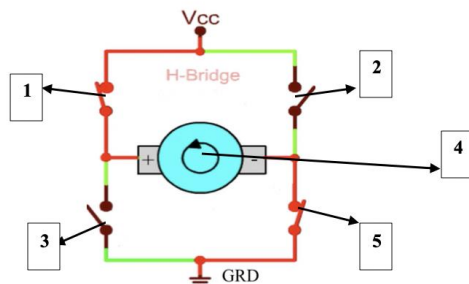
This Arduino battery pack used for the design of the smart car can only accommodate maximum of only two batteries, the total output of the battery pack when inserted with a battery is determined by the sum total of the two-battery voltage. The Arduino board can operate and function fully with a power supply between 6v to 20 volts. If sending more than 12 volts directly on the Arduino board, the voltage regulator on the board may heat up and cause little or serious damages to the board. During the design of the smart car. I figured out that using 7 volts to 9 volts works very well in perfectly powering and distributing accurate power to the board and also to the external components connected to the Arduino board. You can simply connect the “+” end of your battery to Arduino board and “-” end to Arduino ground you ought to see the orange light or red light on the Arduino board which indicate that the board is on.

DC Motors



An Arduino analog output can be used to manipulate the speed of the motor by posting or sending number between 0 to 255 from the motor shield speed control pins.

Depending on the size and voltage capacity of the DC motor, the DC motor can easily be linked and connected to a PWM output base of transistor which is used to regulate the speed of the motor, which is done by altering the PWM. For controlling the rotation direction of the DC motor, the current flowing through the motor is altered depending on the direction you choose. The most common method used in making this change is done by an H-Bridge. Four switching element makes up the H-bridge circuit, to form the H-like configuration structure on motor, the motor has to be positioned at the center. When two particular switches are activated at the same time, we can reverse the current flow direction, thus changing the rotating direction of the motor either by moving or spinning forward or backward [4].



Pictorial illustration of H-bridge connection.

From the picture on H-bridge connection illustration:

- When 1 and 5 are on HIGH, while 2 and 3 are set to LOW the motor spins in a certain direction.
- When 1 and 5 are on LOW, while 2 and 3 are set to HIGH the motor spins in an opposite direction from the first point.
- The part labelled 4 represent the DC motor.

Arduino IDE



Arduino was first launched in 2005 by students at the Interaction Design Institute Ivrea (IDII) as a simple programming software (IDE) or tool for Mac and Windows users. Since the release of Arduino, it has been able to establish, decorating or building prototypes for development phase at the electronics industry. The microcontroller hardware is an open source designed and created in a manner in which it can easily be incorporated with different numerous sensors for controlling the performance and responses of other components connected to the board, like the speakers, LCDs display, DC motors, servo, led, etc. And some other compatible external models, like the Bluetooth model used in this project and other models. The best amazing thought of Arduino is the effortlessness of users with slight or very small experience to write simple codes and also able to understand the IDE and use it without little or no difficulties. Arduino is among the best well-known and widespread tools of choice for engineers and inventor in building and designing interactive objects or electronics because of this features and capability. Arduino was founded by Massimo Benzi and David Cuartielles in 2005, based on wiring platform dated 2003[8].

One can easily write and upload machine codes to Arduino board Due to its open-source environment. It is best to have in mind that Arduino is compatible on Linux, Mac and Windows operating systems. The Arduino environment is also programmed in Java language. Programs are compiled into c/c++, as the code execution can be either c, c++,

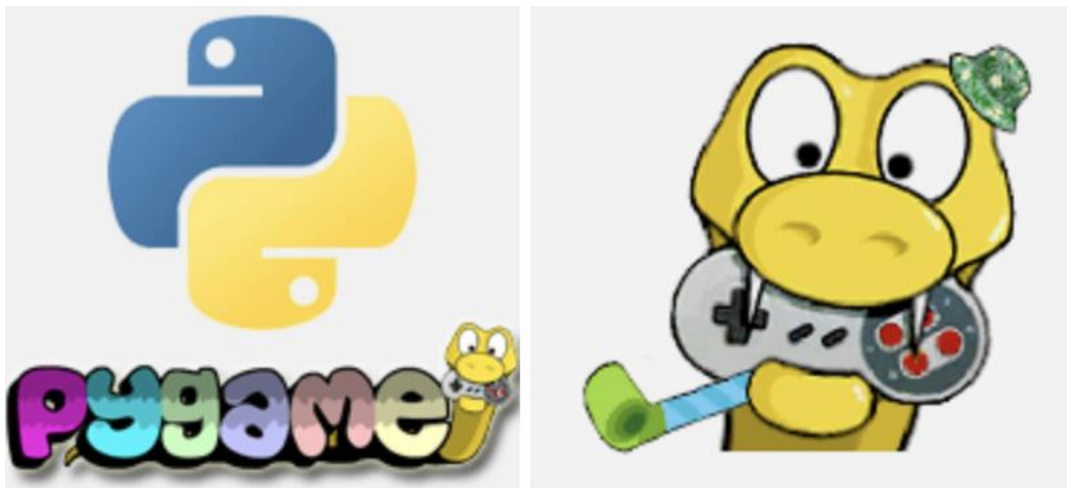
java, or python. Arduino programming language have some limitations like having all your files on the same folder.

Running java directly on Arduino is a little bit stiff, java can be used to communicate and control Arduino from another computer running java with the help of serial port communication software.

The Arduino IDE has specific code structure guidelines to support the languages C and C++. User requires only two functions, the `setup()` function and the `loop()` function, both functions must be included in the sketch even if it is not used for anything on the code. The code on the Arduino IDE are called sketch, It's important to note that C and C++ being a standard programming language is significant slightly different in the concept or view of OOP(Object Oriented Programming), in the sense that C++ programming language support OO features while C programming language does not support OO features. But Arduino IDE/compiler accept C and C++ language in it form, C++ language are also used in writing a lot of libraries which are used in Arduino, but also know that C++ is not garbage collected. The memory has to be explicitly managed by you.

2.2. Pygame

Pygame is among the major fields in python for enormous libraries for Game development. Pygame is a cross-platform collection of Python modules for making video games, which contains a collection of computer graphics and sound libraries for the Python programming language. Pete Shinnars created Pygame to take the role of PySDL, his innovation, the Pygame is well suited to the development of client-side applications that may be packaged as a standalone executable.[11]



Pygame may be installed in a variety of methods, including using the pip tool and the command "py -m pip install -U pygame --user." The alternative option is to install through IDE; to do so, follow the steps below:

- From your file tab navigate to settings,
- From the settings select project interpreter and on the right side click on the "+" icon,
- Type Pygame into the search field after clicking the "+" icon, next hint on the install package button to download and install. [11]

Note: Enter the command "import pygame" to see if pygame was installed entirely and correctly.

2.3. Telegram-bot. BotFather

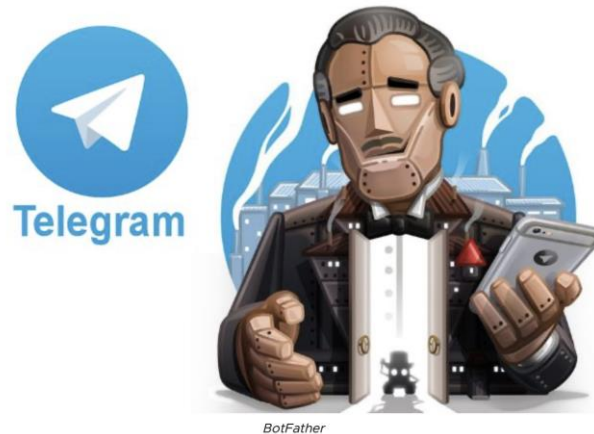


Figure – 2.4 Telegram BotFather

BotFather is the master of all bots cause of Its abilities that allows you to create new bot accounts as well as manage the ones you already have. The bot comes with pre-programmed bot commands that allow users to perform a variety of tasks and commands on it. These are a handful of few of some command line options: `"/deletebot"` from the name, this command line lets users delete newly generated bots, `"/mybot"` lets users edit newly created bots, `"/revoke"` lets users revoke access tokens for newly created telegram custom bot, and `"/newbot"` – this command grant one the access to create and customize his/her bot with a unique name, unique HTTP API token, this token makes it possible for the user to build a python code for the different functionality of choice to permit the user of the newly created telegram bot. Bot can be used for other features like to Receive targeted news and updates, It can add material from other services like Gmailbot, Googlebot, and YouTubebot to Telegram chats. Bots do not have an online status or a last seen timestamp; instead, the interface displays the label 'bot.' Bots are unable to start communication dialog with users.

NOTE: For the project a telegram bot “[@Mappingcarbot](#)” is created for communication and interaction purposes for my smart car.

2.4. Tera Term Software



Figure 2.4 – Tera Team Software

Tera Term which is most of the time also known as TeraTerm, this software application is an open source software which is also free at the same time. this software also mimics variety of computer terminals, ranging from DEC VT100 to DEC VT382. Telnet, SSH 1 & 2, and serial port connections are all supported. It also includes a macro programming language as well as a few other handy plugins.

- The software application connects to the Arduino smart car via Bluetooth connection and wait to receive IR distance reading from the sensor, when the sensor completes its 360° rotation with the help of the stepper the programming saves it as a txt file.
- When the file is saved, the file is sent from the pc to telegram bot, the file is then saved by the sever and is then ready for mapping.
- The user of the telegram bot have to initiate a dialog for the bot to reply or carry on command instructions.

3. APPLICATION REALIZATION

3.1. Structure Diagrams

Diagram Illustration of the used component:

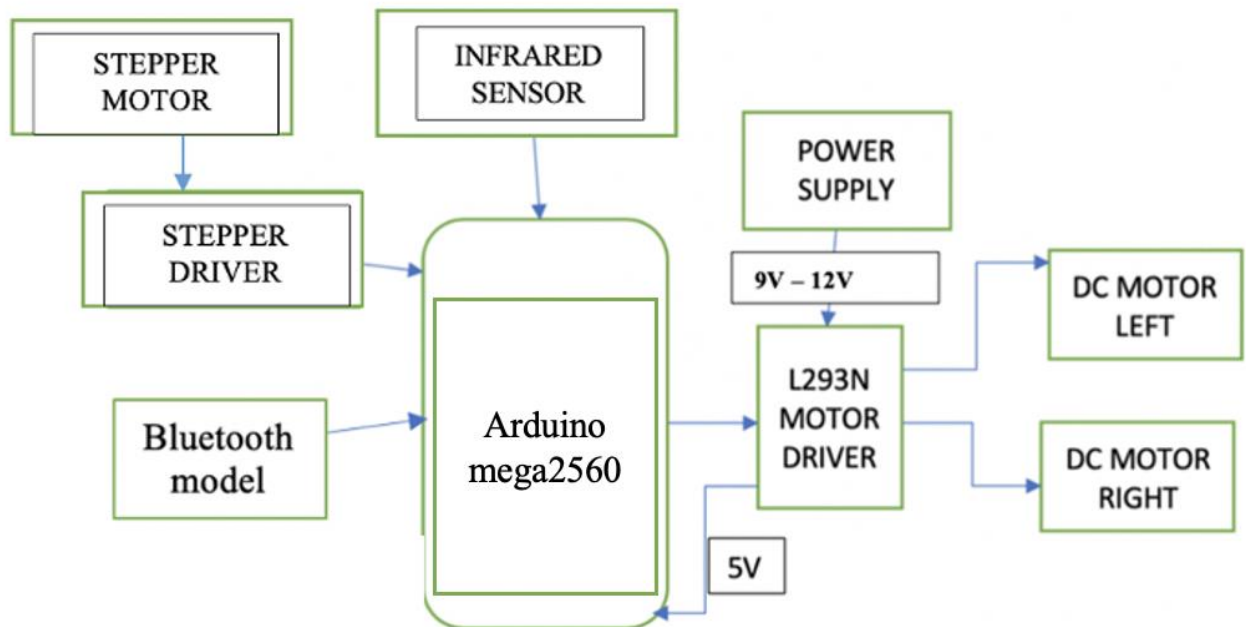


Figure 3.1.1 - Diagram of robot used component

All connections for my robot hardware are illustrated and expressed in the form of mathematical shapes for hardware components in the figure above, while the lines with arrows represent wire connections. The diagram illustration above shows how external power between 9voltage – 12voltage is being distributed from the source into the L293N motor driver, this motor driver then regulated 5voltage into the Arduino Mega2560. The Arduino Mega2560 is then capable of distributing 5v or 3.3v to any external components which are connected to it for proper and stable voltage supply.

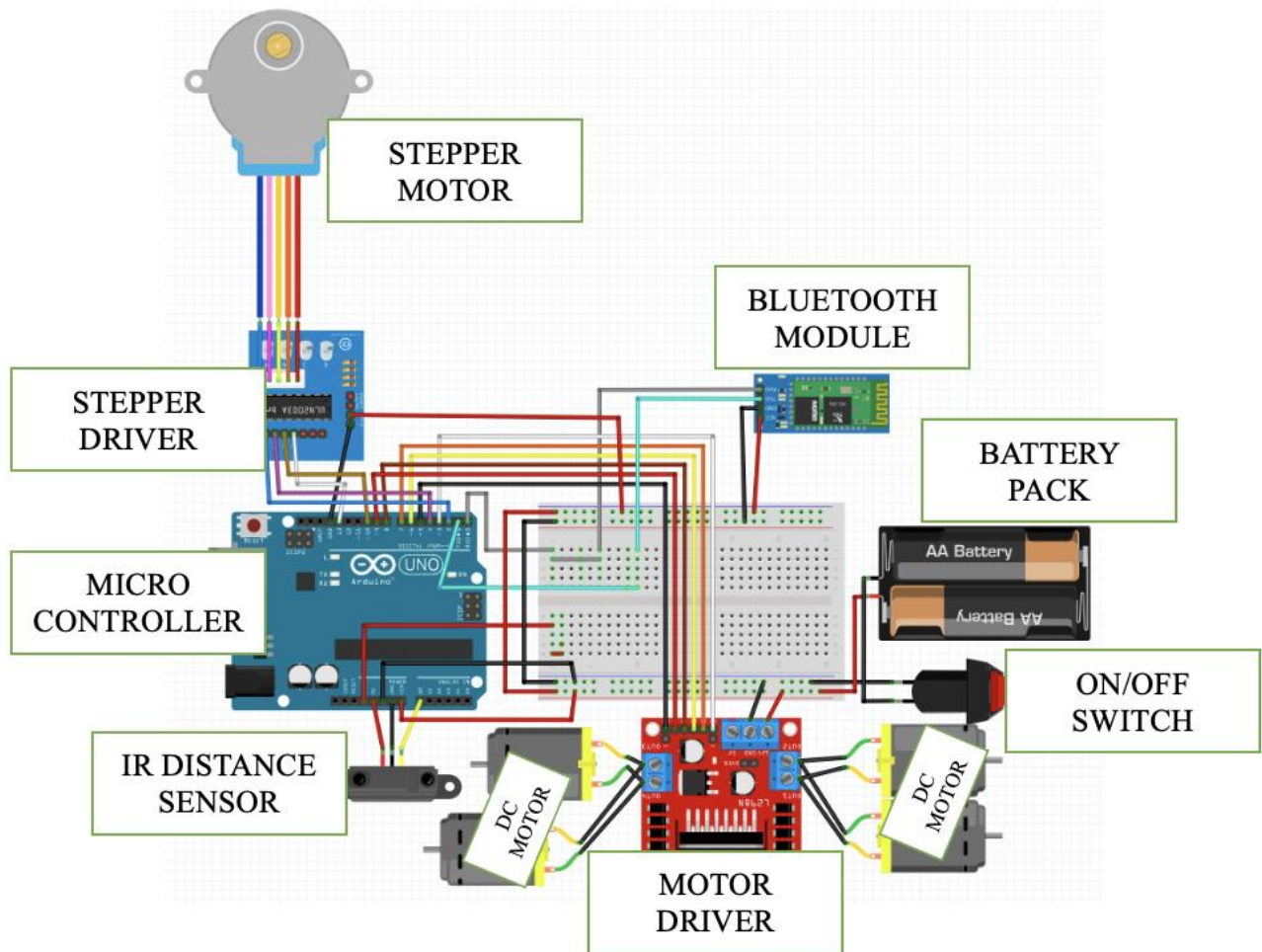


Figure 3.1.2 - Robot Scheme

This diagram above is designed using Fritzing IDE by using the inbuilt component parts on the IDE to represent a well-connected connections of the robot design components and how there interact with one another (power input 8V – 12Voltage goes in to the motor driver). The switch on the diagram is used to stop the entire distribution supply of power to the smart car, while the IR distance sensor is mounted on the stepper motor to enable smooth 360 degrees movement. When the Smart car is switched on from the power switch, the car stays on delay for 20ms and rotate the IR distance sensor(car movement from point A to point B is controller from smart phone) which is mounted on the stepper motor for 360 degrees taking 2159 measurement at it complete rotation(360°), once the rotation is complete the stepper rotates back to starting point.

3.2. Smart Control Car Scheme

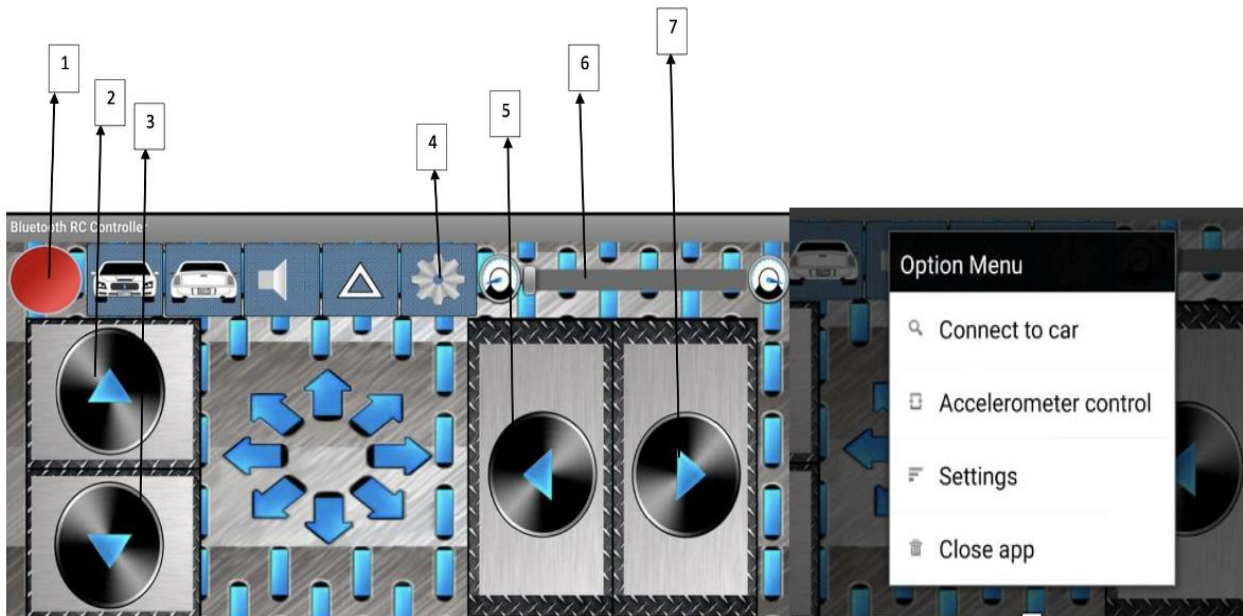


Fig 3.2.1 Bluetooth rc controller (android app)

This software is presently only accessible for Android users; however, the Bluetooth rc controlling app has yet to be uploaded to the Apple App Store for Apple or Mac users.

The marked buttons are used to connect to the smart car or to control its movement.

- "1" section is a signal indication that changes color to RED or GREEN depending on whether or not the device is connected.

GREEN – connected; RED – not connected

- 2 – This button is for forward or up direction movement.

- 3 – This button is used to move backwards or down.

- 4 – When this button is pressed, a drop menu appears, as seen in Fig 3.3.1

The drop-down menu on the left includes a number of options, including connecting the device to your smart car, accelerometer control, app settings, and closing the app entirely.

- 5 – This button controls the car's left turn direction.

- 6 – This button is used to boost the car's acceleration.
- 7 – This button controls the car's right turn direction.

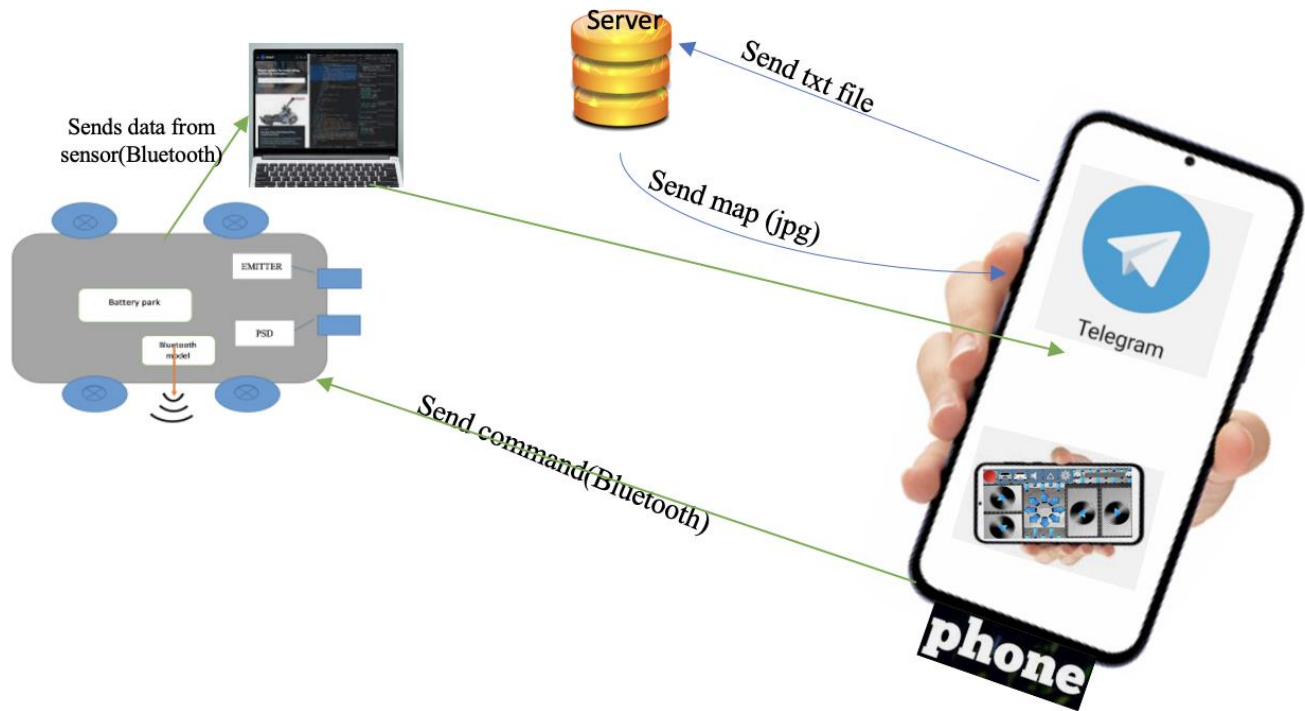


Figure 3.2.2 - Scheme of data transfer between system components

The diagram above is a pictorial full representation of the complete working principle of my smart car. It shows various communication between the smart car, mobile smartphone, telegram, and the server. The Arduino smart car sends txt data to the server through telegram and also it can be controlled from the mobile smartphone using Bluetooth. The IR distance sensor readings is sent to the pc over Bluetooth connection and the readings are saved in txt file format and the file is then sent to telegram from the pc. The txt file is sent to the telegram bot, the bot saves the txt file and the user inputs a “/map” command for the bot to send the file for analysis. The server reads the file and uses the values on the txt file to plot a map and sends back a plotted map back to the telegram bot in jpg file format.

3.3. Creating a Telegram-bot

To make a new bot, use the “/newbot” command will have to be typed by the user into the BotFather chat cause BotFather will not start a dialog with its user. Before generating an authentication token for your new bot, the BotFather will request the user to input your name and username.

- Your bot's name appears in contact information and other places.
- The Username is a unique name that can be used in links or in chat to mention. When Creating a username is must finish with 'bot,' e.g.'smartcar bot' or 'SmartCarBot.' Usernames that the user creates must be between the range of 5-32 characters long which are also very much case insensitive.
- The token is a string that looks like this: 110xx1543:AAHdqTxxxxxxGWJxfSeofSAsxxxxxLDsaw, and it's needed to authorize the bot and submit queries to the Bot API.

NOTE: Keep your token private and protected; it may be used to operate your bot by anybody.

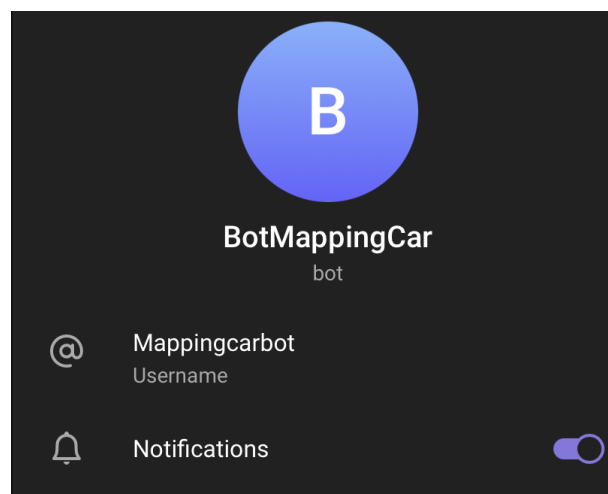


Figure 3.3 Telegram Bot for Smart Car Control

When working with the “[@Mappingcarbot](#)” telegram bot created for the smart car control, the list down instructions should be followed accordingly:

- Firstly, a txt file is sent from the IR distance sensor on our Arduino smart car to the telegram bot created, just as seen on figure 3.3 a txt file is being sent to the bot(the file must be in txt format) “AdaptationAngle.txt”. The file is saved and recorded by the bot.
- After the txt file is saved by the bot, the user have to pass in a command to the telegram bot for the bot to initiate mapping using the values on the saved txt file. The user have to send “/map” command message to the telegram bot to draw map. Once the map is complete, the server sends back the plotted map to the telegram in jpg format.

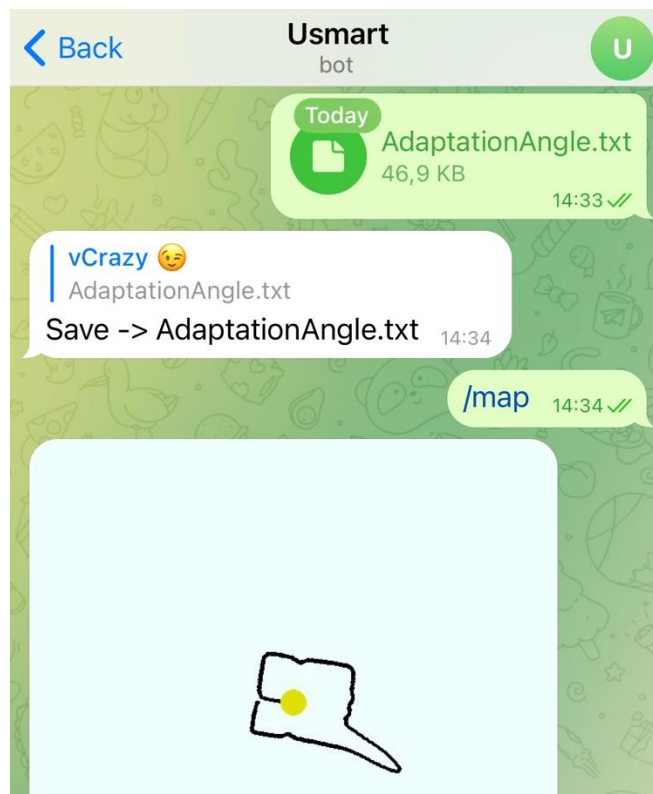


Figure – 3.3 TelegramBot Chat for Smart Car

3.4. Server implementation

Building and working with server I made use of an online platform called the “Pythonanywhere.com”, which is based on the Python programming language for web hosting service and online integrated development environment. It allows you to access server-based Python and Bash command-line interface from within your browser. A code editor with syntax highlighting is also included.

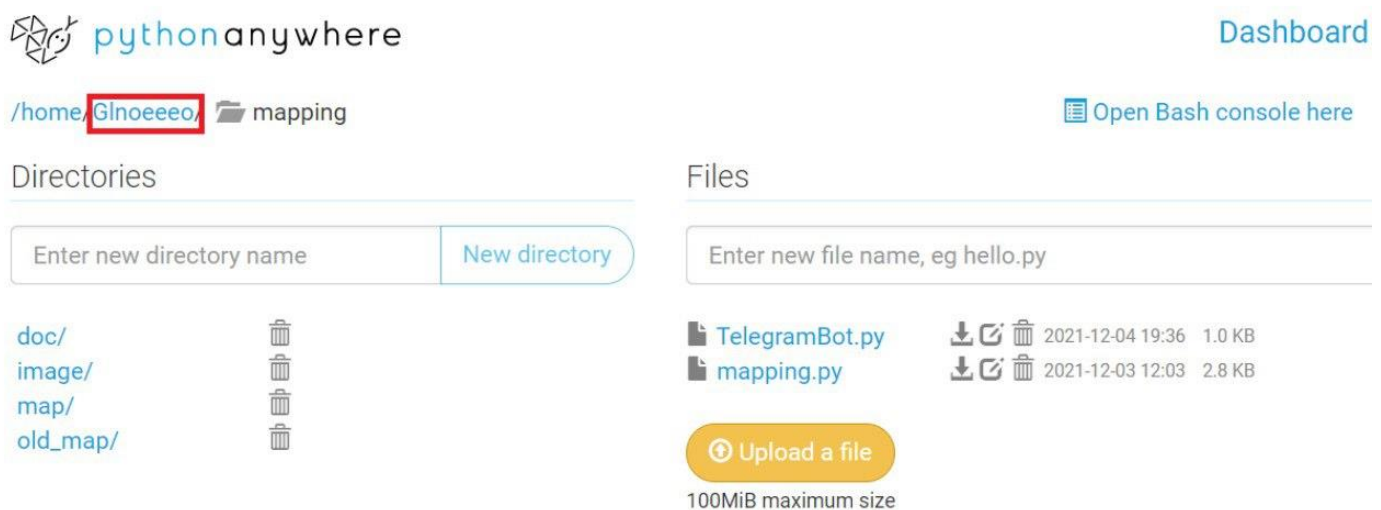


Figure – 3.4.1 - Files Directory Folder on Server(online)

- The Pythonanywhere online server holds two main python code files for the smart car control project which are the TelegramBot file and mapping file, it also holds four sub files in side our main folder created on the server. The four sub files are “/doc” folder, “/image” folder, “/map” folder and “/old_map” folder. On the server folder “Glnoeeeo” we created, all the four sub folder is created inside the main folder. The “TelegramBot.py” file and the “mapping.py” file is also uploaded directly into “Glnoeeeo” Server main folder.

Dashboard

Welcome, [Glnoe](#)CPU Usage: 5% used – 5.94s of 100s. Resets in 9 hours, 22 minutes [More Info](#)File storage: 11% full – 57.6 MB of your 512.0 MB quota [More Info](#)[Upgrade Acc](#)Recent
Consoles

+ 5 -

[Bash console 22478719](#)[Bash console 22479030](#)Recent
Files

+ 5 -

[/home/Glnoeeee/mapping/mapping.py](#)[/home/Glnoeeee/mapping/
TelegramBot.py](#)Recent
Notebooks

+ 5 -

Your account does not support
Jupyter Notebooks. [Upgrade your
account](#) to get access!All
Web apps[Glnoeeee.pythonanywhere.com](#)[Open Web tab](#)

Figure – 3.4.2 – Bash Console on Server (online)

Using the pythonanywhere online server is provides you with free 2 server bash console access for your project work, two bash console is created for our two main python files, the TelegramBot.py and the mapping.py. The TelegramBot.py runs the start-up server for or telegram app for the bot to be functional to perform it task, while the second bash console runs the mapping.py which initiate the mapping code for txt file received from the Arduino IR distance sensor.

[/home/Glnoeeee/mapping/](#)  doc[Open Bash console here](#)

Directories

[New directory](#)

Files







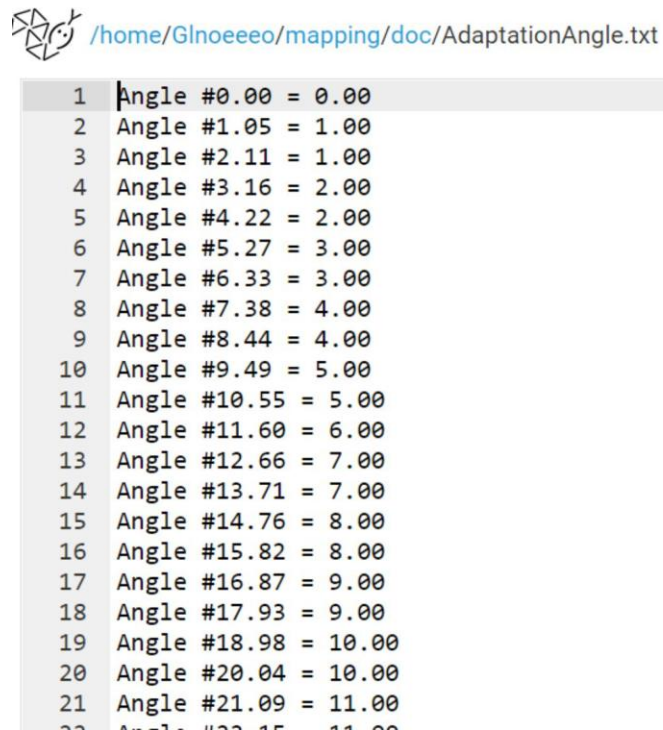
 01.12.txt	  	2021-12-07 08:14	236.9 KB
 3cvad.txt	  	2021-12-01 01:11	47.0 KB
 AdaptationAngle.txt	  	2021-12-07 08:13	47.0 KB
 AlfaBetaAngles.txt	  	2021-12-01 01:14	47.0 KB
 alfa.txt	  	2021-11-30 22:22	47.0 KB
 calm.txt	  	2021-12-01 01:01	47.0 KB
 leastSquaresAngle.txt	  	2021-12-01 01:36	47.0 KB
 name.txt	  	2021-12-07 08:14	10 bytes
 test2.txt	  	2021-12-07 08:13	47.3 KB
 test23.txt	  	2021-12-01 10:26	47.3 KB
 test3_OK.txt	  	2021-12-01 01:12	236.7 KB
 test45.txt	  	2021-12-01 10:27	46.4 KB
 without.txt	  	2021-12-01 01:12	47.0 KB
 CalmanAngle.txt	  	2021-12-01 01:16	47.0 KB

Figure – 3.4.3 – Directory for Saved Files on Server

The “/doc” sub folder is located inside our main folder(“Glnoeeco”), this folder holds all the txt files sent to the telegram bot, the telegram bot receives the txt file and saves it to the “/doc” folder created on the pythonanywhere sub folder of “Glnoeeco” main folder on the online server. Figure 3.4.3 is a screenshot of all the sent sample files sent to the telegram bot during our smart car test run.



```

/home/Glnoeeco/mapping/doc/AdaptationAngle.txt
1 Angle #0.00 = 0.00
2 Angle #1.05 = 1.00
3 Angle #2.11 = 1.00
4 Angle #3.16 = 2.00
5 Angle #4.22 = 2.00
6 Angle #5.27 = 3.00
7 Angle #6.33 = 3.00
8 Angle #7.38 = 4.00
9 Angle #8.44 = 4.00
10 Angle #9.49 = 5.00
11 Angle #10.55 = 5.00
12 Angle #11.60 = 6.00
13 Angle #12.66 = 7.00
14 Angle #13.71 = 7.00
15 Angle #14.76 = 8.00
16 Angle #15.82 = 8.00
17 Angle #16.87 = 9.00
18 Angle #17.93 = 9.00
19 Angle #18.98 = 10.00
20 Angle #20.04 = 10.00
21 Angle #21.09 = 11.00

```

Figure – 3.4.4 – txt File From IR sensor

The txt files sent from our Arduino IR distance sensor of the smart car holds two important values for our mapping.py to correctly plot our mapping graph. The values hold are the angle value and the distance value, from Figure 3.4.4, the first values are the angle values while the second values are the distance values.

NOTE: The program code to pythonanywhere.com online server is added to the “ADDITION” section of the project report. The codes for the TelegramBot.py and code for mapping.py, both codes will be included to the section.

3.5. Choice of Filters

Fig. 3.5.1 – This diagram above is the initial setup used during mapping test stages, the robot is being boxed in which represents obstacles or objects in this case. The smart Arduino robot is connected to the PC and the angles with readings(Stepper and IR sensor) is being calculated using the Arduino uno IDE, when it is done, the readings which were recorded is being sent to PyCharm IDE for map plotting.

- five filter samples where used, Alpha Beta, Average, Adaptive, Least mean square, Simple Kalman filters, all this filters listed will be tested individually with my robot to best pick the filter that will work better for the smart robot[14].



Figure 3.5.1 – Environment Mapping Setup

1) WITHOUT FILTER CASE

Figure 3.5.2 from the diagram above, is representation of when filter is not used during reading from the IR sensor for mapping, the corners are not a well-defined in a way in shows the initial diagram of the test environment in Figure 3.5.1.

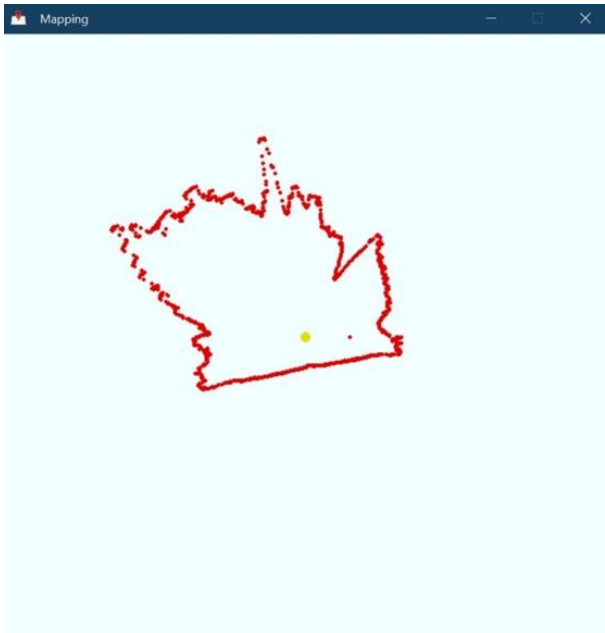


Figure – 3.5.2 Diagram for Without Filter

2) ALPHA BETA FILTER CASE



Figure 3.5.3 – Alpha Beta Filter

Code sample for Alpha Beta Filter:


```

float dt = 0.02;
float sigma_process = 3.0;
float sigma_noise = 0.7;

float ABfilter(float newVal) {
    static float xk_1, vk_1, a, b;
    static float xk, vk, rk;
    static float xm;

    float lambda = (float)sigma_process * dt * dt / sigma_noise;
    float r = (4 + lambda - (float)sqrt(8 * lambda + lambda * lambda)) / 4;
    a = (float)1 - r * r;
    b = (float)2 * (2 - a) - 4 * (float)sqrt(1 - a);

    xm = newVal;
    xk = xk_1 + ((float) vk_1 * dt );
    vk = vk_1;
    rk = xm - xk;
    xk += (float)a * rk;
    vk += (float)( b * rk ) / dt;
    xk_1 = xk;
    vk_1 = vk;
    return xk_1;
}

```

A simple kind of observer for estimating, data smoothing, and control applications is when an alpha beta filter comes in handy. It has similarities with Kalman filters and linear state observers, all of which are essential for control theory. Its main benefit is that it does not need a comprehensive system model.

3) AVERAGE FILTER CASE

Code sample for Avarage Filter:

```
const int NUM_READ = 30;

float midArifm() {
    float sum = 0;
    for (int i = 0; i < NUM_READ; i++)
        sum += значение;
    return (sum / NUM_READ);
}
```

The arithmetic average is computed by adding the total of the values and then dividing by the number of them. The first approach works precisely as described in the code diagram above: using a loop, everything is summed into a variable, then divided by the number of measurements.

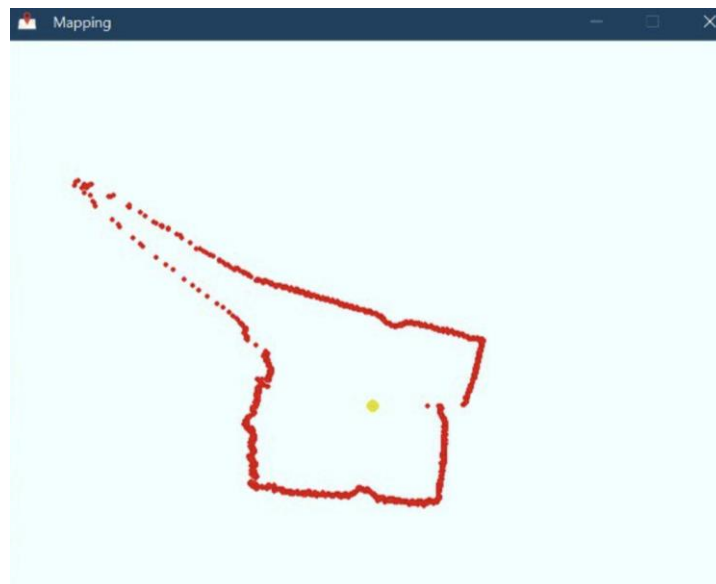


Figure 3.5.4 – Average Filter

4) ADAPTIVE FILTER CASE



Figure 3.5.5 – Adaptive Filter

Code sample for Adaptive Filter:

```
float expRunningAverageAdaptive(float newVal) {  
    static float filVal = 0;  
    float k;  
  
    if (abs(newVal - filVal) > 1.5) k = 0.9;  
    else k = 0.03;  
  
    filVal += (newVal - filVal) * k;  
    return filVal;  
}
```

The coefficient could be made adaptive such that it responds to rapid changes in the value to function appropriately with abruptly changing signals. When the filtered value is "far", from the real one, for an instance, the coefficient rises dramatically, allowing you to swiftly reduce the "gap" between the two values. If the value is "near," the coefficient is set low to effectively filter noise.

5) LEAST MEAN SQUARE FILTER CASE



Figure 3.5.6 – Least Mean Square Filter

Code sample for Least mean square Filter:

```
float a, b, delta;

void minQuad(int *x_array, int *y_array, int arrSize) {
    int32_t sumX = 0, sumY = 0, sumX2 = 0, sumXY = 0;
    arrSize /= sizeof(int);
    for (int i = 0; i < arrSize; i++) {
        sumX += x_array[i];
        sumY += (long)y_array[i];
        sumX2 += x_array[i] * x_array[i];
        sumXY += (long)y_array[i] * x_array[i];
    }
    a = (long)arrSize * sumXY;
    a = a - (long)sumX * sumY;
    a = (float)a / (arrSize * sumX2 - sumX * sumX);
    b = (float)(sumY - (float)a * sumX) / arrSize;
    delta = a * (x_array[arrSize-1] - x_array[0]);
}
```

The technique of least squares is the next filter that permits users to examine a noisy process and anticipate its behavior.

6) SIMPLE KALMAN FILTER CASE

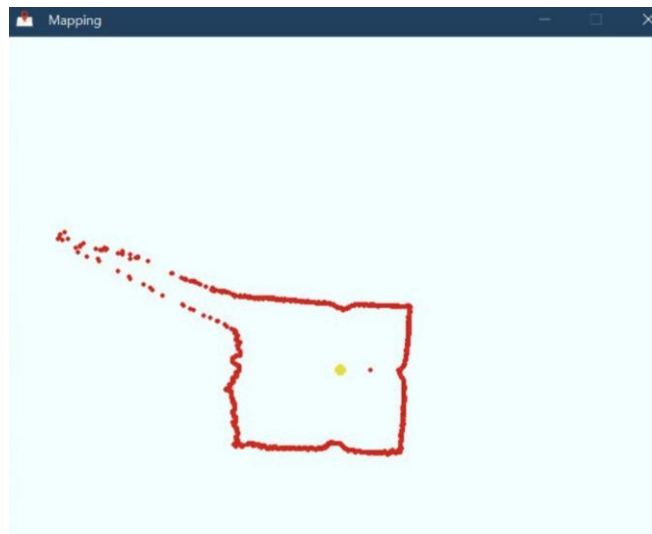


Figure 3.5.7 – Simple Kalman Filter

Code sample for Simple kalman Filter:

```
float _err_measure = 0.8;
float _q = 0.1;

float simpleKalman(float newVal) {
    float _kalman_gain, _current_estimate;
    static float _err_estimate = _err_measure;
    static float _last_estimate;

    _kalman_gain = (float)_err_estimate / (_err_estimate + _err_measure);
    _current_estimate = _last_estimate + (float)_kalman_gain * (newVal - _last_estimate);
    _err_estimate = (1.0 - _kalman_gain) * _err_estimate + fabs(_last_estimate - _current_estimate) * _q;
    _last_estimate = _current_estimate;
    return _current_estimate;
}
```

The filter controls the anticipated measurement noise, the estimate spread (which can be set the same as the measurement noise, but can also adjust itself during the Simple kalman filter operation), and the rate of change of values (0.001-1, this can be altered by choice), are all adjusted by the filter.

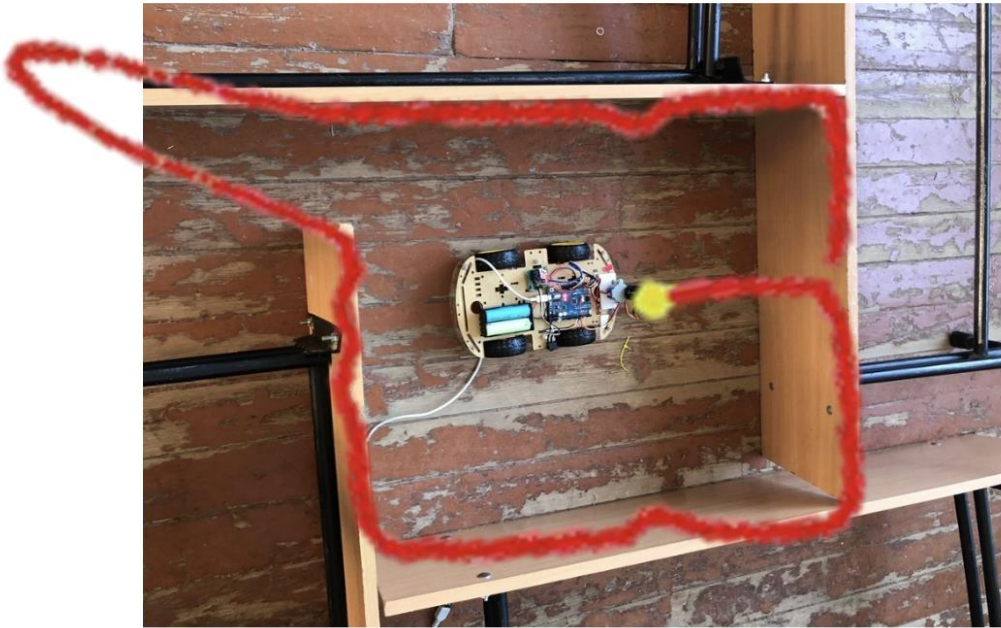


Figure 3.5.8 – Overlapping filter map with real image

For This project the Adaptive filter will be used, from it diagram in Fig 3.5.5 we can see during the test check it completely shows a well-defined picture of the robot and the object surrounding it. Figure 3.5.8 shows the actual instance of when the selected chosen(Adaptive Filter) choice of filter is placed over on the actual environment used for the project test purposes. The Red drawn along the real image of the test environment shown on Figure 3.5.1 is over lapped by Arduino IR distance scanned map which is implemented by using the adaptive filter. The Yellow dot on the picture is the position of the sensor placed Infront of the smart robot.

3.6. BUILDING AN AREA MAP

The smart car from it starting position will take 5 position reading, all the position readings from the map will be overlapped with their actual images respectively. The

Pictures below represent all the positions taken by the smart car during its prototype test drive.

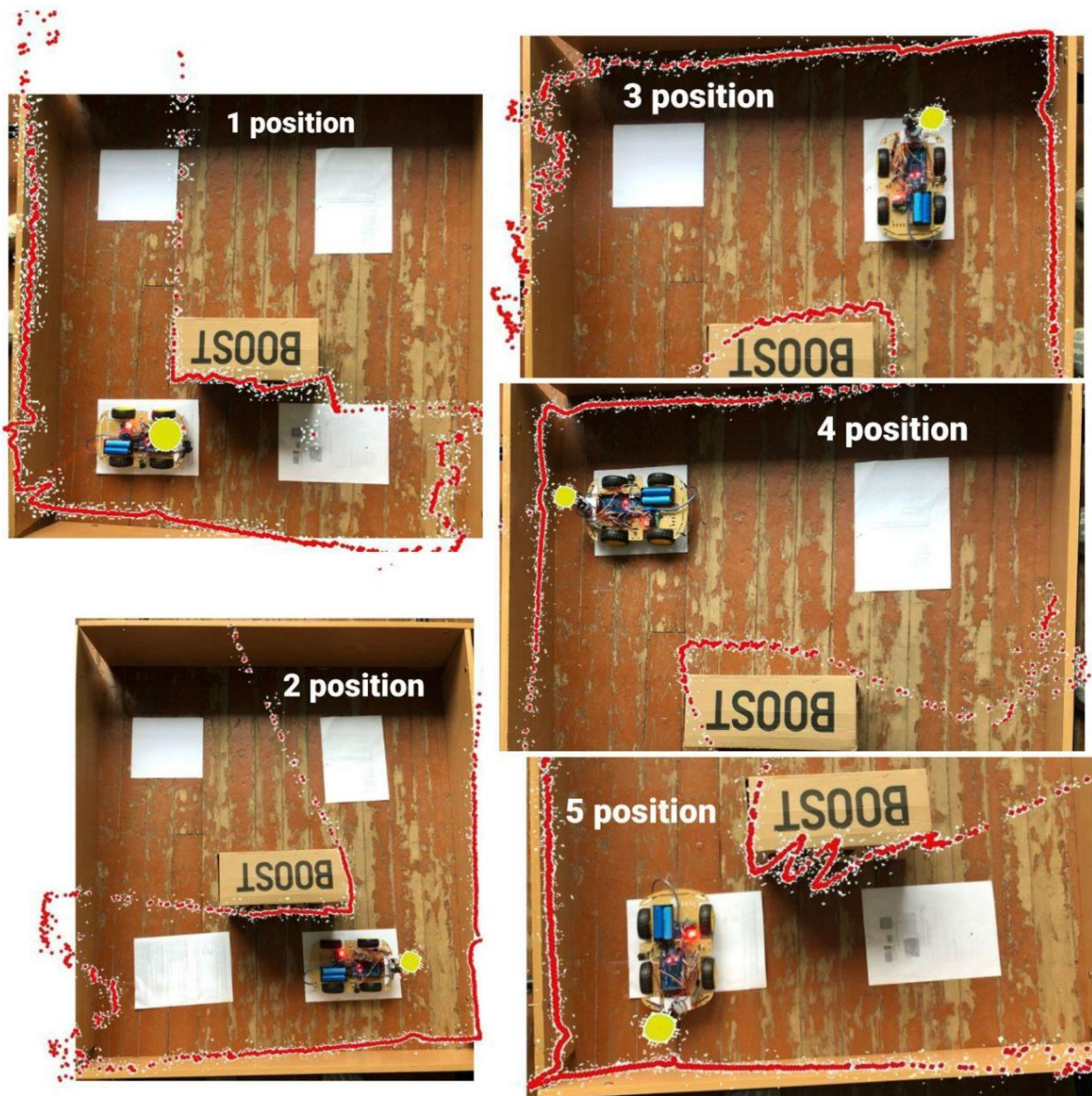


Figure – 3.6.1 Overlapping all position map with real image

- Position 1 – starting position of the smart car.
 - Position 2, 3, 4, 5 – movement is made before taking next position for reading,
- NOTE: From all the position pictures above, the red outlines the surrounding borders of the test environment while the yellow dots indicate the position of the smart

car control. The dimensions of the box are $1.07\text{ m} \times 1.07\text{ m}$, and also IR distance sensor can only read up to 0.7m .

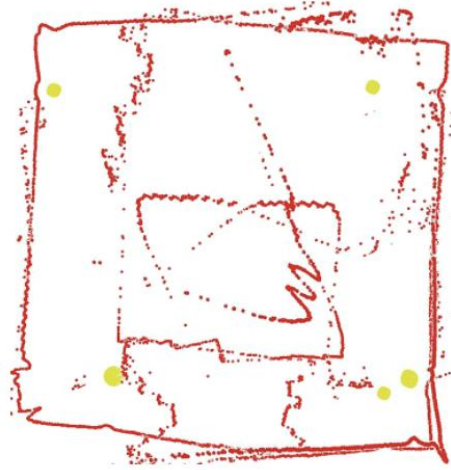


Figure – 3.6.2 Combining all position map

This diagram is a combination of all the 5 positions taken by the smart car during its movement to different points(position 1, 2, 3, 4, and 5).

CONCLUSION

Based on the results of the analysis of existing prototypes for building a terrain map based on Arduino, I identified problems in their functionality and accuracy of construction. Therefore, it was decided to create an alternative mapping system.

After analyzing the methods and tools, I designed a prototype of a mapping system and a system for transferring data between the elements of the system. C++ was used to collect data and control a smart robot. The components of the system interact with each other under the means of Bluetooth, Tera Term, Telegram-bot. To send data to the server and display a map of the area, a telegram bot was developed and launched on the server. A Pygame to build the map was used. The Python codes on a free host pythonanywhere.com was run.

As a result, all the tasks were achieved. A prototype of a mapping system has been developed, which creates a map of the area with good accuracy. In the future, it is possible to make improvements to the system when deciding an algorithm for simultaneous localization and mapping (SLAM), to that already for detailing objects in 3-D space.

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ADDITION