Chapter 1

Introduction

CHAPTER 1: INTRODUCTION

1.1 Problem Statement

Water pollution has increased beyond its limits in recent times. Water forms an important resource for almost every strata of the society. Illegal dumping of debris and other waste in water bodies Dumping of solid waste like plastics, demolition and construction wastes, garbage (animal and vegetable wastes), rubbish, yard debris, ashes, wood waste and so on leads to water pollution.

Many religious offerings are also dumped into the holding ponds and lakes adding to water pollution. Various forms of water bodies like lakes, lakes, streams, etc. are getting deteriorated day by day. Plastic waste being a major water pollutant, is causing huge destruction of marine life and is believed to be responsible for deaths of various types of fishes. To cite an example, 90 percent of the lakes in Bangalore city are polluted. Also, a 2017 survey by the environmental ministry revealed that the pollution level at Mumbai's Powai lake was about 8 times above the safe limit[10]. That being said, it is of utmost importance now to care about this problem before it gets even further out of hand. Humanity as a whole needs to make a collective effort to secure and maintain our lakes which are not only sources of potable water, but also serve as important biological habitats for a multitude of flora and fauna.

Figure 1.1 : Current conditions of lakes in India

Conventional methods for lake cleaning include intensive labour and continuous human involvement. This innovative project aims to create an ‘Internet of Things’ (IoT) based Semi-autonomous lake cleaning robot which will prove to be an effective solution to reduce the human interaction to a minimum level. To add to that, this project on lake cleaning robot has a vision of contributing to the ambitious mission of **Swachh Bharat Abhiyan** by monitoring and removing floating garbage in the lakes.

1.2 Objective

This project aims to create an ‘Internet of Things’ (IoT) based Semi-autonomous lake cleaning robot. The existing technologies for cleaning water bodies include specialized equipments and intensive human labour. This projects provides an effective solution to reduce the human interaction to a minimum level. The project contains camera placed on the robot to navigate around in an efficient manner. The live video transmission from the camera can be viewed remotely.

A conveyor belt is used for collecting the floating garbage and transferring it in the bin which will be placed on the robot. The bin is be equipped with loading and unloading mechanisms. The robot will traverse through the still waters using paddle wheels. The Raspberry Pi is used for aiding the live video transmission from the robot. The bot will be guided using IoT. The robot and the floating garbage would be visible on a terminal using IP camera installed on the bank of the water body. The robot uses several onboard sensors for battery level indication, GPS to indicate location and load level indication. We wish to implement the robot for social and environmental cause and thus support the government’s ‘Swatchh Bharat’ mission. The proposed system has tremendous potential for cleaning the floating garbage in still waters such as lakes and swimming pools as it provides a simple and cost effective solution for the problem at hand.

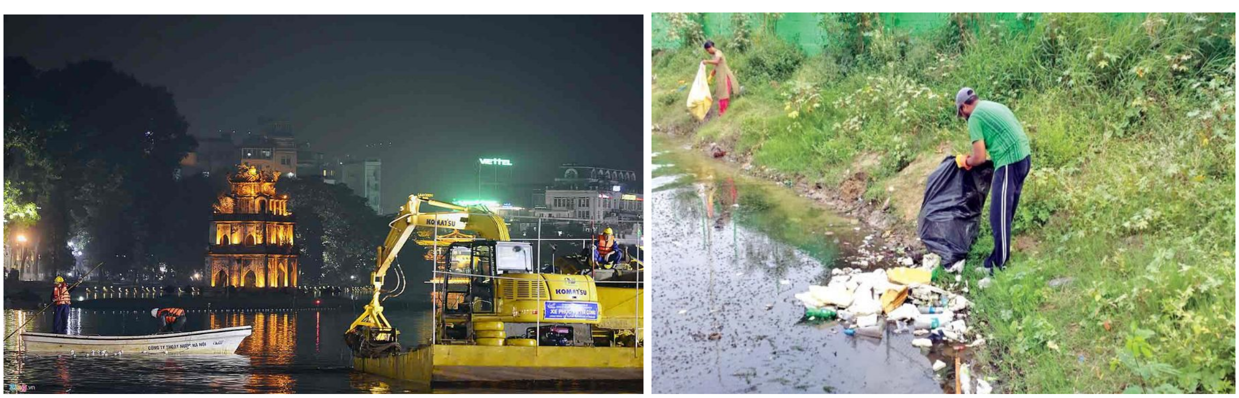

Fig 1.2 : Existing solutions giving lower results.

1.3 Organization of the report

- **Chapter 1** states the problem and basic introductory idea of the project.
- **Chapter 2** presents the literature survey. In this chapter, we discuss about the papers we referred for the selection of our topic in brief. Here, the papers that we referred to, gave us an idea of the existing models, and helped us to come up with a more efficient solution
- **Chapter 3** describes the methodology of the project. It gives the block diagram and the description of the use or importance of each component being used in this project
- **Chapter 4** shows how to use the Raspberry Pi for remotely using the VNC server
- **Chapter 5** deals with the conclusion and future scope.
- **Chapter 6** gives the description of the components used.
- **Chapter 7** states the references.

Chapter 2

Literature Survey

CHAPTER 2: LITERATURE SURVEY

The pollution of lakes has been a huge concern since many years. As explained earlier, lakes form a precious resource for humans as well as for other flora and fauna to flourish. This need engendered various efforts from the governments as well as the citizens to take a step in the direction of cleanliness of the water bodies, with varying results. To cite an example, the Brihanmumbai Municipal Corporation recently took an initiative to start cleaning some of the lakes in Mumbai [1]. It appointed an agency to carry out bioremediation of five small lakes including the Bandra lake. Also, a few months ago, citizens, living near the Powai lake area, came out on a weekend to clean the lake. In the latter example, there was no use of technology to much extent. This intrigued us to create the idea of using current technology to advance the cleanliness mission in a sophisticated manner. To start off with, various papers and algorithms were researched upon to come out with a unique solution to tackle the problem.

Justin E. Manley, to celebrate the 40th anniversary of the Oceanic Engineering Society (OES), combined many research papers to review the field of unmanned surface vehicles (USVs) and autonomous surface craft (ASCs) [2]. The paper discusses the enabling technologies that have allowed USVs to emerge as a viable platform for marine operations as well as the application areas where they offer value. The paper tracks developments in technology from early systems developed by the author in 1993 through the latest developments and demonstration programs. At the MIT Sea Grant College Program, Autonomous Surface Craft (ASCs) were first developed in 1993 and were designed for various missions. The first ASC produced at MIT Sea Grant was named ARTEMIS. This vessel was a scale replica of a fishing trawler used as a platform capable of testing the navigation and control systems required by an ASC. This ASC was then used to collect simple bathymetry data in the Charles river in Boston, MA

Sheikh Md Shahid Md Rafique and Dr. Akash Langde had proposed a mechanism in 2017 titled ‘Design And Fabrication Of River Cleaning Machine’ [3]. This research paper suggested the construction of the robot. The project consisted of two main shafts balancing and hoisting the sprocket of chain drive. They rested all the components on a frame serving as the main body of the project. The hollow PVC pipes on the either side of the robot, generate pressure head to run the project on water surface. The fabricated storage tank was used to store the waste fulfilling the purpose of the project.

Prof. N.G.Jogi et al developed a system similar to that we have undertaken [4]. They created a boat-like structure in which two people could sit and which also had a conveyor belt in the front. The boat would be deployed in the lake and the people sitting in the boat would have the control to navigate the boat through the lake to clean up the floating waste. It operated only on the basis of the mechanical and the physical structure. There was no electronics involved there. Using the pedals, the persons sitting in the boat, were capable of controlling the boat. Still, it was an innovative idea which received positive response.

Niramon Ruangpayoongsak et al developed a 'A Floating Waste Scooper Robot On Water Surface' in 2017 [5]. They proposed a water cleaning robot for calm water surfaces. In this work, they have focused on collecting plastic bottles floating on water surface. The main contribution as follows: First challenge to collect round shape and slippery plastic bottles which usually flow away from the robot due to drag force. Scooper system was used with the conveyor belt and a track belt system was used for removing weeds. This will help is making further additions in the robot.

Zhongli Wang and Yunhui Liu have researched on 'Estimating Hydrodynamic Parameters of a Lake Surface Cleaning Robot Using Numerical Methods' in 2009 [6]. In this paper a detailed research on the maneuverability performance prediction is important in design and control of a lake surface cleaning robot has been done. This paper proposes a new method based on numerical simulations to estimate the velocity hydrodynamic derivatives of the dynamic model. The forces and momentums of the LSCR under different velocity and drifting angle conditions were obtained from the simulations. This will help us for minimizing the drifting and doing other necessary calculation for still water surface.

The conventional methods of lake cleaning did not prove to be as effective as they should. The need for incorporating the essence of technology began to be felt. The Internet of Things has been a growing field now. Its applications knows no bounds. Our use of this technology stems from the fact this very fact that usage of IoT would prove to be the most effective. Various researches have been conducted on the technology that prove its mettle. To further explore or check the viability of IoT in our project, we looked up on the different applications of IoT and how those would have an impact on the usage of IoT in our project. The use of IoT to control things remotely is a thing now. Home automation would not have been possible had it not been for IoT.

Mohamed Hisham Moubarak used IoT to implement home automation [7]. He first used AutoCad in designing the separate parts of the home model. Then, using laser, the actual 3D model was prepared using cardboard. Using Raspberry Pi, servo motors, web camera, IR sensor as the hardware along with concepts related to web server and OpenCV and Python as the programming language, he implemented home automation. An app was also created using Ionic framework for mobile application. Using this application, to illustrate the capability of the project, some LEDs were turned on and off using the internet to represent the switching on and off of the lights in the room. Thus, this encouraged us to implement our project using IoT.

The usage of the Raspberry Pi camera for video surveillance was found out to be a perfect match for our project idea. Chinmaya Kundaya et al proposed the use of the Raspberry Pi camera system for video surveillance [8]. They used the camera for getting the view of the environment and image processing for detection and recognition of the faces. This proved to be a great idea for us to incorporate in the project as we have planned to put on the camera on the robot to collect live camera feed from the robot as it views its surroundings. This will help us in navigating the robot remotely without any distance limitations.

Vaibhav A.Vyavahare published a paper titled ‘Live Audio and Video Transmission System Using Raspberry Pi’ in 2016 [9]. Live audio and video transmission was done using raspberry pi over Wifi. Live video streaming was done by connecting webcam to both the system & audio transmission by connecting headphone or the microphone to the system. Along with one keyboard & one mouse to both the system.It acted as the standalone system for the live audio & video data transmission without PC. Transmission of Audio and Video was carried out with the help of VOIP and SIP Protocol in real time from one raspberry pi module to another raspberry pi module. This will help us for the live video feed transmission from the robot over wifi.

CHAPTER 3
SYSTEM IMPLEMENTATION

CHAPTER 3 : SYSTEM IMPLEMENTATION

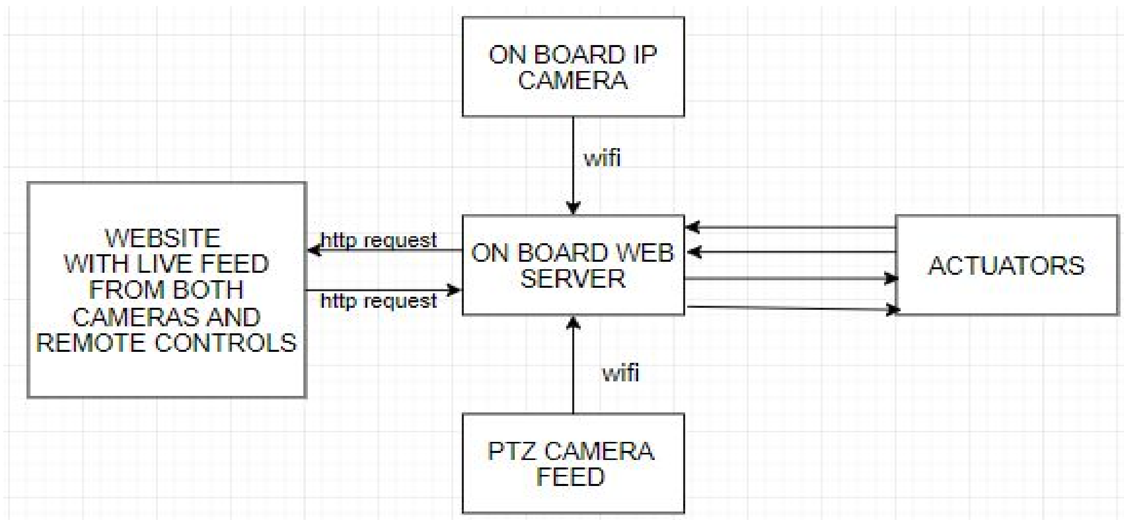

Figure 3.1 IoT architecture of the project

Figure 3.1 describes the Internet of Things (IoT) structure of the project. IoT is basically interconnection of things via the Internet. In this project, we have incorporated IoT in order to control the robot. As the above block diagram suggests, the on board web server that is created using the Flask framework is the main station for the control. All the commands that the user will be entering on the website will be transported to the controller to perform further corresponding actions. The screenshot of the website is attached further.

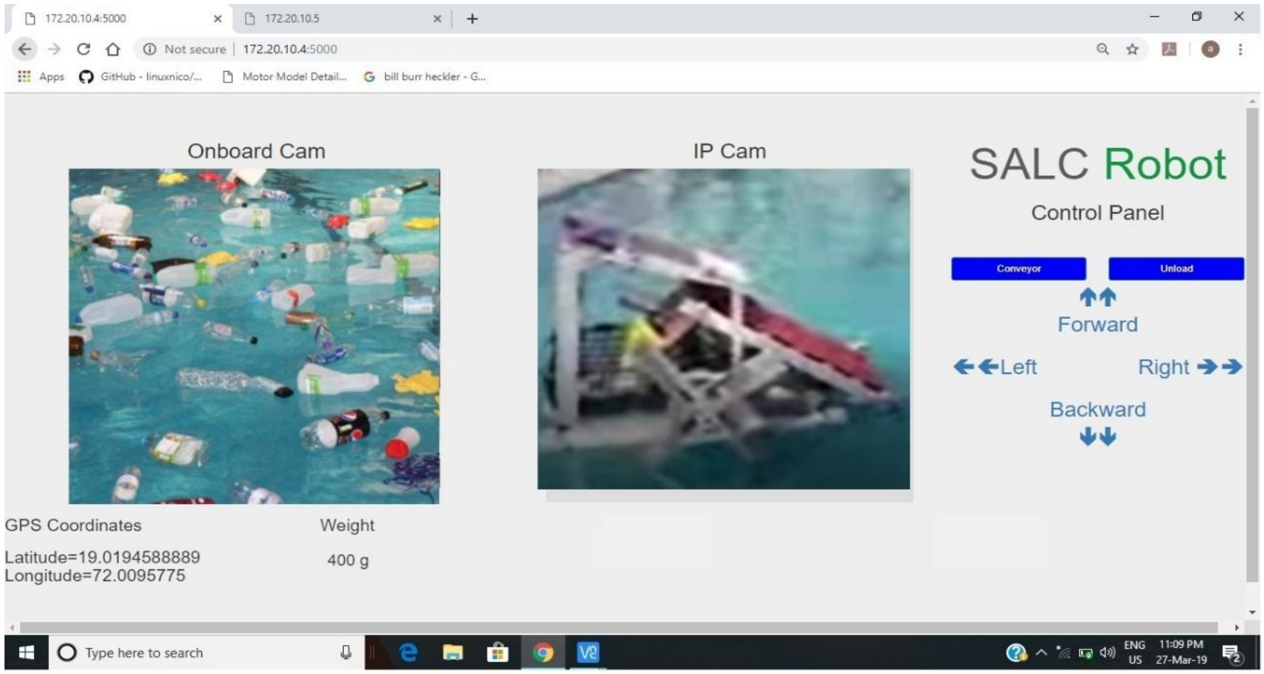

Figure 3.2 Web Interface

The website is constructed using HTML and the aesthetics is taken care of by using CSS. The web server is built using the Flask microframework of Python. This server handles all the commands or operations or functions and forms the bridge between the website and the central control unit which is the Raspberry Pi computer in this case. If a button is pressed on the website, a corresponding page is opened in the background which sends JSON files specific to the button pressed from the client side to the server side using AJAX (Asynchronous JavaScript and XML). This JSON file is basically a packet of data containing some information. This JSON file is given to the Raspberry Pi.

Depending on the command from the user i.e. depending on the web page opened in the background, a certain function is executed which is written in the Python code in the Pi and the Python file is running at the time. Raspberry Pi then sends corresponding serial data to the Arduino which commands the motors to run depending on the code embedded in it.

For example when the 'Forward' button is pressed by the user on the website, a page defined as '/up_side' is opened by the server in the background which is not visible to us. When this page gets opened in the background, corresponding JSON file is sent from the client side to the server side.

The information contained in the JSON file is used to execute a specific function in the Python script, for example, ‘onup’ in this case when ‘Forward’ is pressed. In the ‘onup’ function, serial communication from the Raspberry Pi to the Arduino takes place. ‘f’ is sent by the Raspberry Pi to the Arduino. When the Arduino receives ‘f’, according to the code in the Arduino, it sends appropriate signals to the motor drivers to rotate the propellers in the forward direction. In this way, the operation of the robot takes place.

Using stepper motor, its driver, and a thread/string, a mechanism has been devised in order to facilitate the unloading mechanism. The bin is hinged on one side. Thus if an upward force is applied on the other end, it gets lifted up. The thread is connected to the free end of the bin and the stepper motor system acts like a pulley mechanism. When the motor is switched on, the motor’s shaft rotates, the thread gets wound on the it and the bin When the user clicks on the ‘Unload’ button on the interface, the procedure explained in the previous paragraph is carried about. To be more precise technically, when the ‘Unload’ button is pressed by the user on the web interface, a page defined as ‘/unload’ is opened by the server in the background which is not visible to us. When this page gets opened in the background, corresponding JSON file is sent from the client side to the server side.

The information contained in the JSON file is used to execute a specific function in the Python script, for example, ‘unload’ in this case. In the function, serial communication from the Raspberry Pi to the Arduino takes place. ‘u’ is sent by the Raspberry Pi to the Arduino. When the Arduino receives ‘u’, according to the code in the Arduino, it sends appropriate signals to the motor drivers to start the stepper motor and thus the unloading mechanism.

Sensor Data Acquisition

GPS Module:

The connections of the Pi Board to the GPS Module is as shown in figure below:

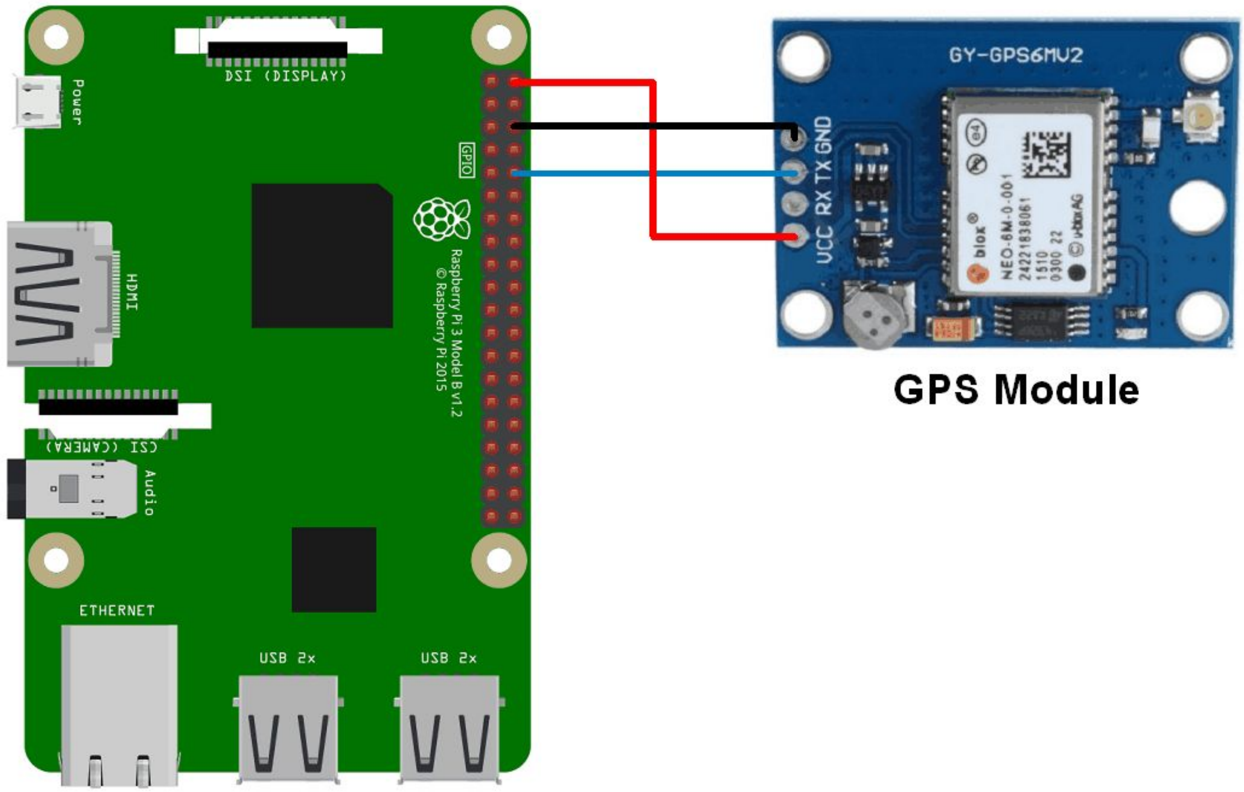

Figure 3.3 Interfacing of RPi with GPS module

The first step is to connect the GPS module to the Raspberry PI. There are only 4 wires (F to F), so it's a simple connection.

Neo-6M RPI
VCC to Pin 1, which is 3.3v
TX to Pin 10, which is RX (GPIO15)
RX to Pin 8, Which is TX (GPIO14)
Gnd to Pin 6, which is Gnd
The GPS module needs to be out in the open for it to receive signals from GPS satellites. The GPS module output is obtained via a Python script in the form of latitude and longitude coordinates which when entered into Google Maps, give the the location on the map. Using the flash() module in the Flask microframework, the Python script output is displayed on the webpage.

Weight sensor:

The connections of the Pi Board to the weight sensor system is as shown in figure below:

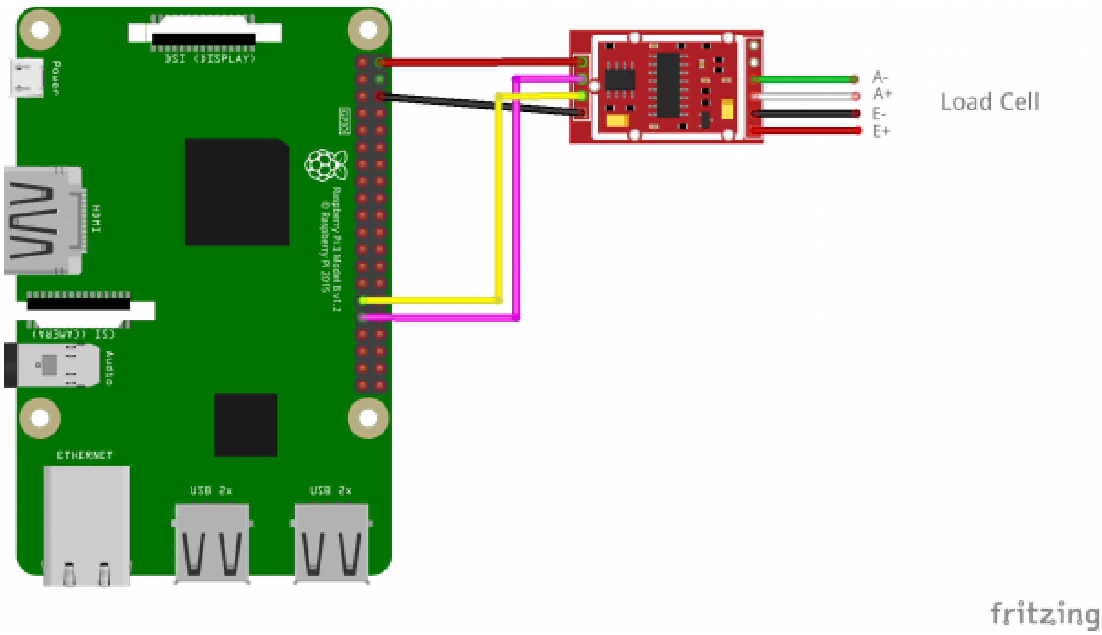

Figure 3.4 Interfacing of Rpi with load cell

Figure 3.5 Load cell

The most important thing to build a weighing scale is a "load cell", which is a metal bar with a hole in the center as shown above. This is available for different weight classes (up to 1kg, up to 5kg, up to 50kg, etc.). Even though some have a different form, all are provided with four cables. To read out the values, the HX711 weight sensor is also required. A Python script is required to print the values on the web page.

The sensor information like the location in terms of GPS coordinates and the weight of the bin behind is displayed on the interface. Thus, live monitoring of these parameters is made possible.

Following is the block diagram for the sensor and actuator control interface of the project:

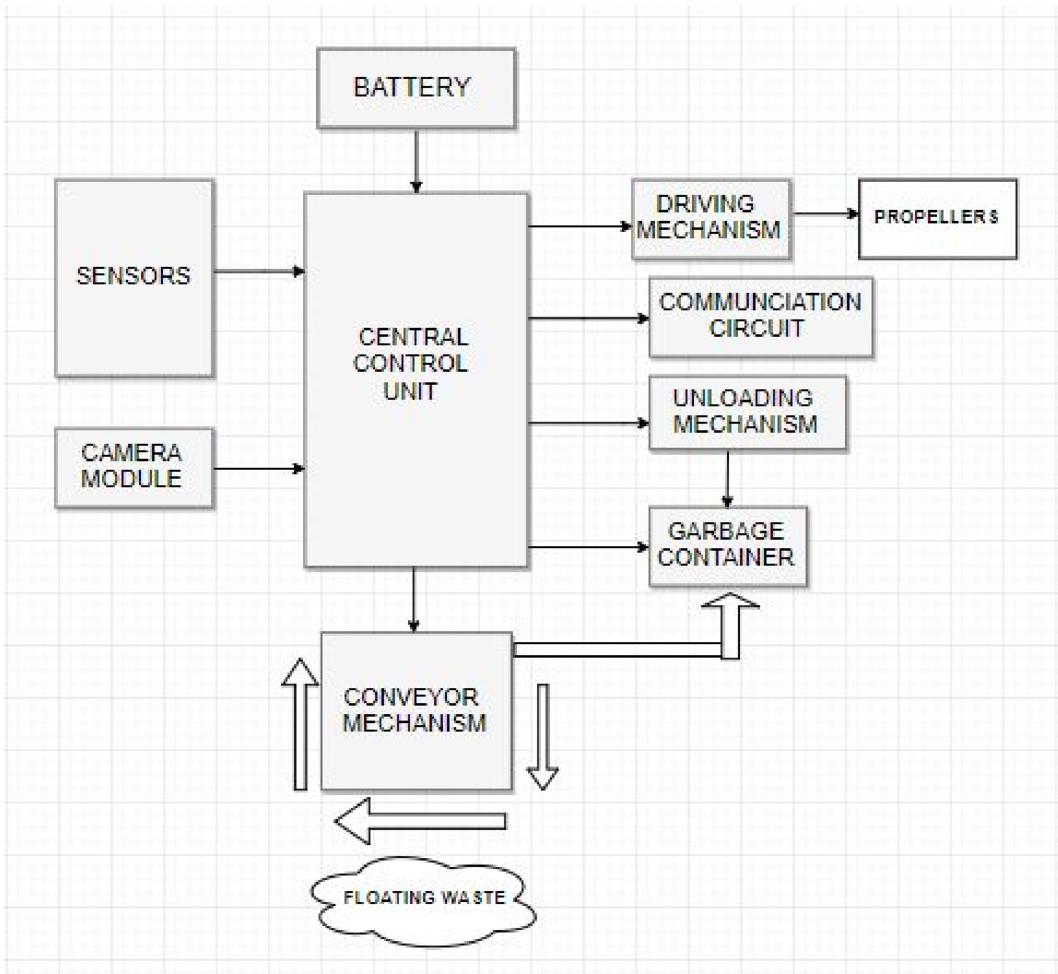

Figure 3.6 Sensor and actuator control interface

The central control unit is the Raspberry Pi. It is the main part of the entire system that handles all the functions. It is connected to various devices and sensors. Currently the entire driving mechanism which consists of the Arduino UNO.

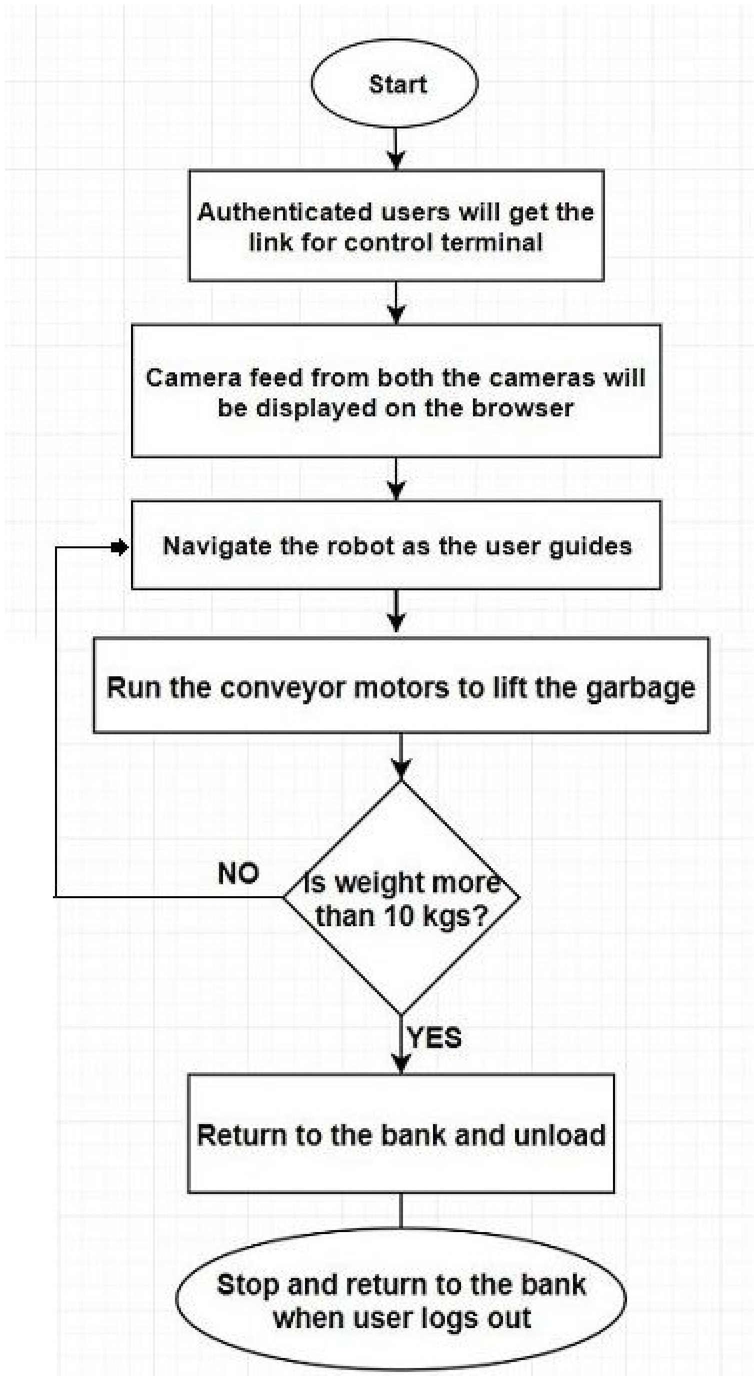

Figure 3.7: Flowchart for navigation process

- Start the robot.
- When the power is on and the Raspberry Pi is connected to the internet, a link for the control terminal will be generated and given to an authentic user.
- The control Terminal will have all the controls for navigation, Conveyor belt and unloading mechanism.
- The camera feed from the 2 cameras, one of which is placed on the robot for the view from the robots perspective and the other camera will be placed on the bank of the river for the viewer's perspective, will be shown to the user for maneuvering the robot with ease.
- When the user presses any navigation button from the control terminal, the robot will receive the commands via the internet and the respective propellers will be rotated by the motors to navigate the robot as the user guides it. For obstacle detection ultrasonic sensors will be attached to various spots on the robot.
- When the user see the garbage through the live feed from any of the cameras, the conveyor belt can be switched on so that the garbage can be picked up and dumped in the bin placed in the back of the back of the robot.
- A maximum weight of 10 Kilograms can be sustained but the robot, a load sensor will always calculate the load in the bin if the load is less than 10 kg the robot can continue to maneuver freely in the water and if the load is to the point of 10 kg or more then the unloading of the robot can be initiated. The robot will return to the bank and unload the garbage.
- This process will continue till the user is online or the alloted time to the user is over.
- When any of the situation is satisfied the robot will return to the bank and stop.
- If the user tries to maneuver the robot outside of the boundary that has been set then again the robot will return to the bank of the lake.

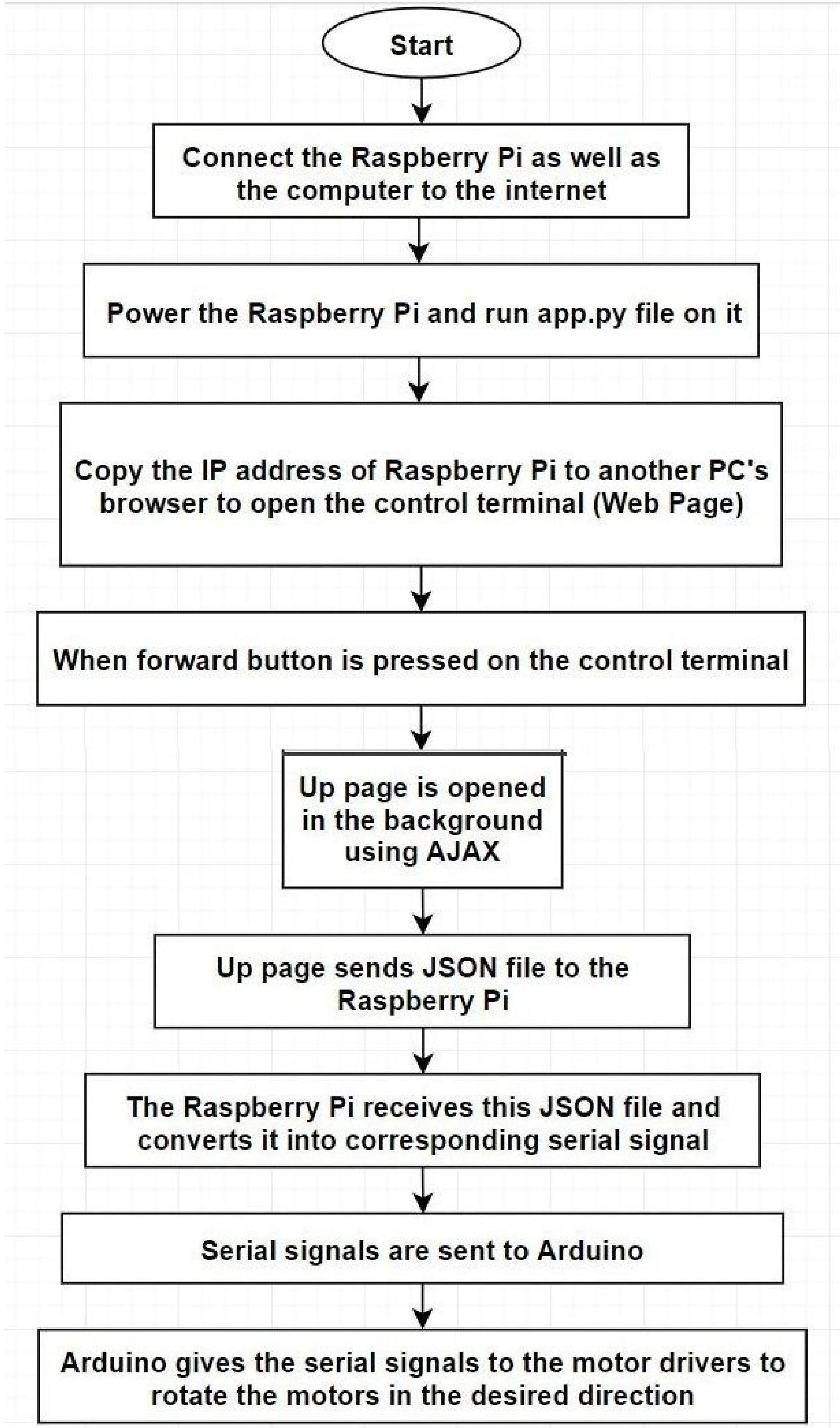

Figure 3.8 :Flowchart for entire working of the robot

1) The computer through which the controlling is to be done as well as the raspberry pi mounted on the lake cleaning robot should be connected to a good internet connection
2) Run the app.py which is a python file on the command prompt on the raspberry pi.
3) An IP address of the raspberry pi will be generated, copy the ip address on the browser on the PC and load the page. If internet connection is proper then main.html page will open on the browser. This is the control terminal through which all the maneuvering of the robot will be done
4) The control terminal will have 4 navigation buttons, a button for conveyor belt to start and stop and one button for unloading mechanism.
5) When the forward button is pressed on the control terminal a \up page is opened in the background using AJAX (Asynchronous JavaScript and XML).
6) The new page that is opened in the background sends JSON (Java Script Object Notation) files to the raspberry pi via the internet.
7) The raspberry pi receives the JSON files and converts them into serial signals which will be sent to the arduino.
8) The arduino receives the serial inputs from the raspberry pi and gives them for motor drivers
9) The motor drivers rotate the motors which are connected to the paddle wheels as per the given commands from the control terminal.
10) Similarly the process is repeated when back, left and right buttons are pressed on the control terminals.

The Schematic diagram for the project is as follows:

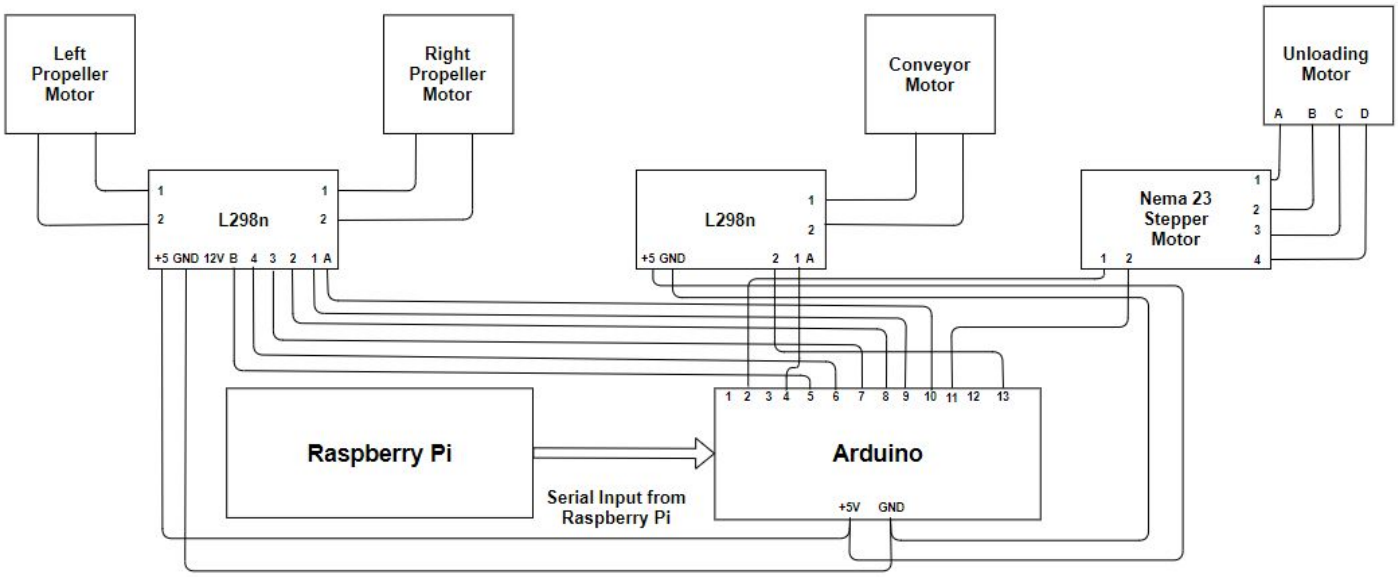

Figure 3.9. Schematic

The Schematic diagram is as shown in the diagram above, Raspberry pi receives JSON files through the internet from the control terminal and forwards it to the arduino, the arduino is connected to 2 L298n motor drivers. L298n is a dual motor driver, one of the motor driver is used for the propeller mechanism, one output goes to the left propeller motor and the other to the right propeller motor. The enable pins are used for giving the pwm inputs to the motors. The other motor driver is used for conveyor mechanism and unloading mechanism. The stepper motor is used here to support the unloading mechanism.

Chapter 4
Remote Monitoring using Raspberry Pi

Chapter 4: Remote monitoring of Raspberry-Pi

1)VNC

VNC stands for Virtual Network Computing. It is a graphical desktop sharing system that uses the Remote Framebuffer protocol (RFB) to remotely control another computer. It transmits the keyboard and mouse events from one computer to another, relaying the graphical screen updates back in the other direction, over a network. Since Raspberry-Pi is a computer in itself and supports VNC, we use VNC for remote access

VNC was originally developed at the Olivetti and Oracle Research Lab in Cambridge, United Kingdom. The original VNC source code and many modern derivatives are open source under the GNU General Public License

Basic operation of VNC

1. The VNC server is the program on the machine that shares its screen. The server passively allows the client to take control of it
2. The VNC client (or viewer) is the program that watches, controls, and interacts with the server. The client controls the server

The VNC protocol (RFB protocol) is very simple, based on one graphic primitive from server to client (Put a rectangle of pixel data at the specified) and event messages from client to server.

Note that the machine which is the VNC server is running on does not need to have physical display. In the normal method of operation a viewer connects to a port on the server the server (default port 5900). Alternatively a browser can connect to the server on the implementation) (default port 5800). And a server can connect to a viewer in "listening mode" on port 5500. One advantage of listening mode the server site does not have to configure its firewall to allow access on 5900 (or 5800); the onus is on the viewer, which is useful if the server site no computer expertise, while the viewer user would be expected to be more knowledgeable

VNC by default uses TCP port 5900+N, where N is the display number (usually physical display). Using VNC over the Internet works well if the user a broadband connection at both ends. However, it may require advanced NAT, firewall and router configuration such as port forwarding in order for the connection to go through. Alternatively, a VNC connection can be established as has a LAN connection if VPN is used as a proxy.

Security of VNC

By default, RFB is not a secure protocol. While passwords are not sent in plain-text (as in telnet), cracking could prove successful if both the encryption key and encoded password are sniffed from a network. For this reason it is recommended that a password of at least 8 characters be used. On the other hand, there is also an 8-character limit on some versions of VNC; if a password is sent exceeding 8 characters, the excess characters are removed and the truncated string is compared to the password

TightVNC is a version of VNC and is not secure as picture data is transmitted without encryption. To circumvent this, it should be tunnelled through a SSH connection.

VNC may be tunnelled over an SSH or VPN connection which would add an extra security layer with stronger encryption. SSH clients are available for most platforms; SSH tunnels can be created from UNIX clients, Microsoft Windows others. Clients, Macintosh clients (including Mac OS X and System 7 and up) and many others.There are also freeware applications that create instant VPN tunnels between computers.

An additional security concern for the use of VNC is to check whether the version used requires authorization from the remote computer owner before some- control of her device. This will avoid the situation where the owner of accessed realizes there is someone in control of her device without previous notice.

By comparing all parameters for all versions of VNC, we used RealVNC for which was tunnelled with SSH and for physical display, use use port 500x For Raspberry pi. The detailed steps are given below

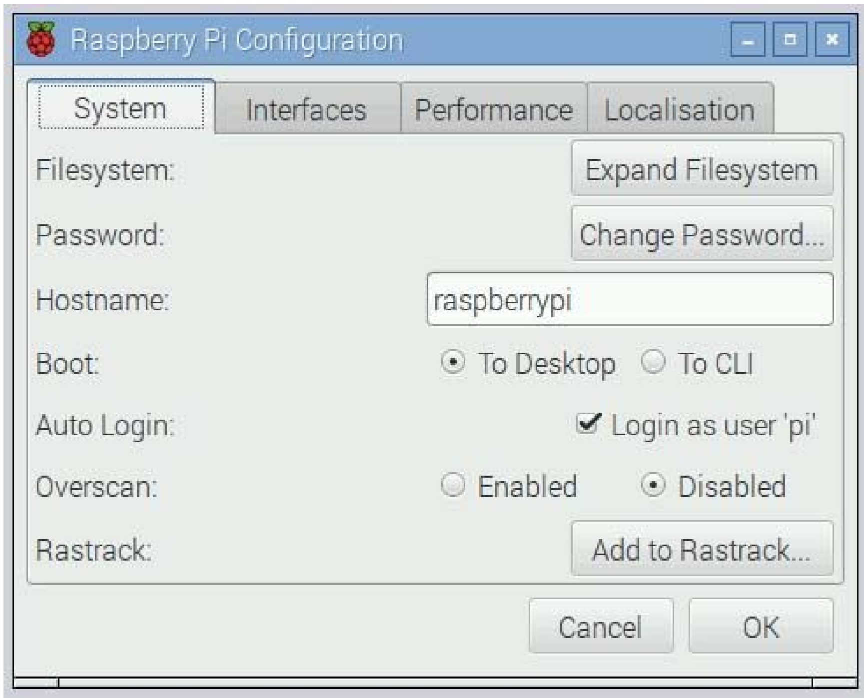

Figure 4.1 Rpi configuration window

Remember the username and the password of the Raspberry Pi. It is needed to take control of the Pi remotely using Putty or VNC.

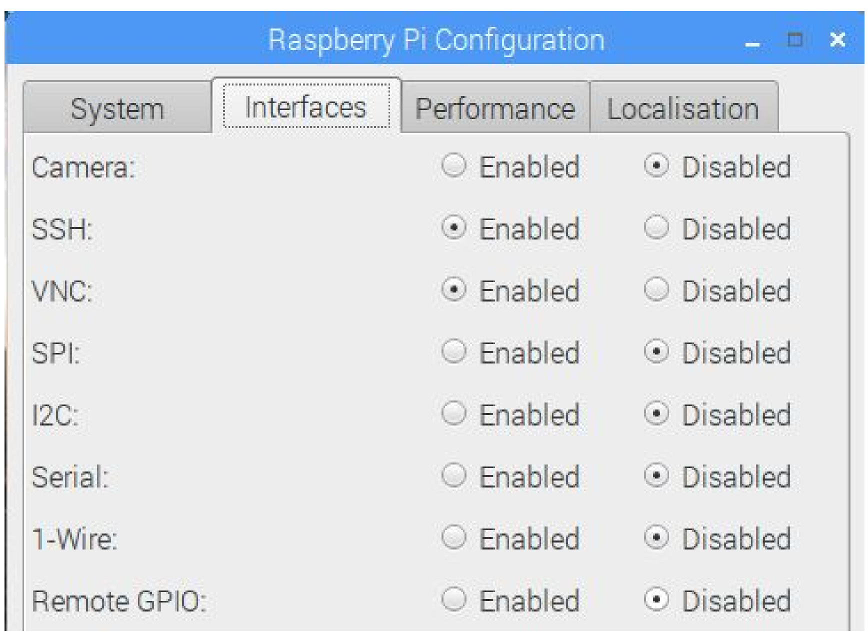

Figure 4.2 Rpi interface window

Enable SSH and VNC interface to enable remote access via secure shell and VNC server

How to: Set up VNC in Raspbian

STEP-01 Enable VNC

Click the Raspberry Pi icon at the top-left of the screen and select Preferences > Raspberry Pi Configuration. Click the Interfaces tab, followed by the Enabled radio button beside VNC.

STEP-02 Check your credentials

Click the VNC button that appears at the end of the menu bar and note down the four numbers that appear below Connectivity. These are your computer’s IP address on the network.

STEP-03 Open VNC Viewer

If you’re connecting from another Raspberry Pi, switch to it, click the Raspberry Pi icon, and select VNC Viewer from the Internet submenu. Enter the IP address of your original machine. Otherwise, open it on your OS/computer of choice and enter the IP address there.

STEP-04 Optimise performance

If your remote Pi feels sluggish, hover at the top of the VNC Viewer window and click the cog on the menu that appears, then reduce the picture quality on the Options tab

Chapter 5
Conclusion and
Future Scope

Chapter 5: Conclusion and Future Scope

5.1 Conclusion

In India the condition of our lakes is in dire state. The people and governments are aware of this situation, but due to shoddy planning and implementation, many of these efforts fall flat. Thus, the proposed project aims to alleviate the efforts already being made in this regard and ensure increased efforts to tackle this profound and deep-rooted problem. Conventional methods for lake cleaning include intensive human labour and specialized equipment such as boats, nets, etc. which result in excessive time consumption and cost escalation.

Currently, the movement of the robot using IoT is accomplished. Also, the conveyor mechanism and the unloading mechanism is completed. The two live feeds from the camera also can be seen on the web interface for smooth and seamless maneuvering. Other sensors like the GPS sensor for the live location of the robot and the load cell for the knowledge of total weight the robot is carrying in the bin has been integrated in the web interface.

The Semi Autonomous Lake Cleaning Robot has tremendous potential as a product as it provides a simple and cost-effective solution for the problem at hand. This robot is unique as no other lake cleaning solution offers such smooth operation and navigation capabilities. Thus, this work will contribute to the ongoing Swachh Bharat Abhiyan. Reducing human efforts is a major step in making the cleaning process more efficient and cost efficient. The success of the project shall benefit the society and the environment in a broader sense.

5.2 Future Work

The boat is not fully autonomous because of IoT control from the user using the web interface, but partially autonomous. It autonomously updates sensor readings and can come back on its own to dump the collected garbage.

This project can be scaled up to produce a large sized model of the robot in order to aid the cleaning of bigger rivers and lakes. The same algorithms can be used with a more hydrodynamic structure made from better, sturdier materials and improved performance metrics to impact the cleaning of major rivers. A more detailed study regarding the structural aspects of the robot can be conducted to further improve the design process and streamline it. The full-scale version can be fully autonomous by GPS path planning, garbage detection will be used to control conveyor to utilize power whenever there is no garbage.

Using image processing techniques, this robot can be made fully autonomous in which case the robot will be able to automatically detect garbage and do the appropriate tasks on its own. Currently, garbage detection is not possible at night as image processing techniques are used to detect garbage. Multiple robots can be used (swarm robotics). Accurate GPS path planning can be performed. Along with garbage, oil spills can also be mitigated. With additional net under boat and it's lifting mechanism, underwater garbage can be picked.

Chapter 6

APPENDIX

APPENDIX

A) Hardware Specifications

Raspberry Pi 3 b+:

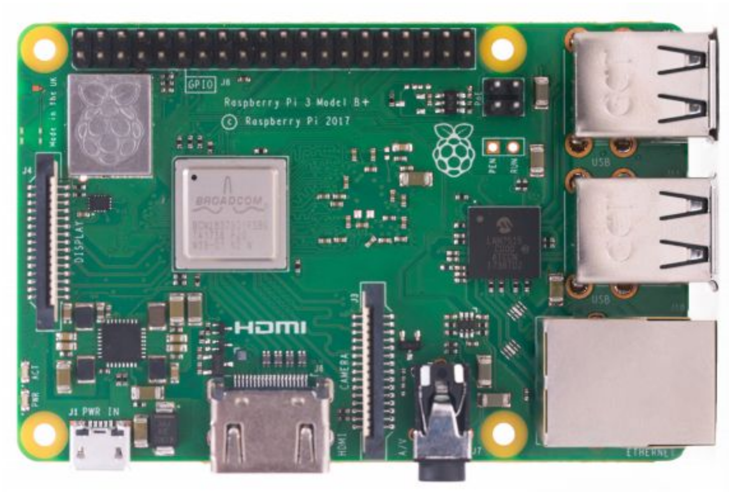

Figure 6.1 Raspberry Pi 3B+

The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market. The Raspberry Pi 3 Model B+ maintains the same mechanical footprint as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.

Processor :- Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz

Memory :- 1GB LPDDR2 SDRAM

Connectivity :- a)2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless
b)LAN, Bluetooth 4.2, BLE
c)Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps)

d)4 × USB 2.0 ports

Access :- Extended 40-pin GPIO header

Multimedia :- H.264, MPEG-4 decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1

Environment :- Operating temperature, 0–50°C

Input power :- 5V/2.5A DC via micro USB connector

5V DC via GPIO header

Power over Ethernet (PoE)–enabled (requires separate PoE HAT)

Arduino Uno:

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes. Stronger RESET circuit. Atmega 16U2 replace the 8U2.

Figure 6.2 Arduino UNO

Parameter Values:

CPU type :- 8-bit AVR

Performance :- 20 MIPS at 20 MHz

Flash memory :- 32 kB

SRAM :- 2 kB

EEPROM 1 kB

Pin count :- 28-pin PDIP, MLF, 32-pin TQFP, MLF[2]

Maximum operating frequency :- 20 MHz

Number of touch channels :- 16

Hardware QTouch Acquisition :- No

Maximum I/O pins :- 23

External interrupts :- 2

USB Interface :- No

L298n:

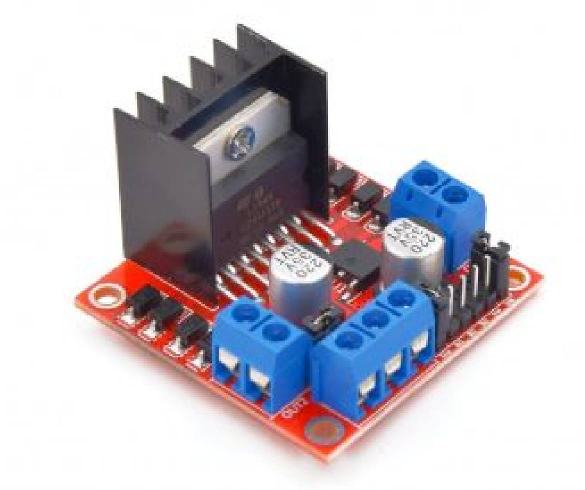

Figure 6.3 L298N Motor driver

This motor driver IC is popular for stepper motor or dual DC brushed motor control projects. The interface is the same as that of the L293 and the TI SN754410, so this IC can also be used with our dual serial motor controller PIC to make a higher-power dual serial motor controller. We have this chip in the L298N version, which is staggered-lead, through-hole package that can be used with breadboards and other prototyping boards.

NEMA23:

Figure 6.4 Nema 23 Stepper Motor

Stepper motors work on the principle of electromagnetism. There is a soft iron or magnetic rotor shaft surrounded by the electromagnetic stators. The rotor and stator have poles which may be teethed or not depending upon the type of stepper. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of a variable reluctance stepper). This way the stators are energized in a sequence to rotate the stepper motor. We have used a 10kg-cm torque stepper motor.

LITHIUM POLYMER BATTERY:

Figure 6.5 Lithium Polymer Battery

A lithium-polymer (LiPo, LIP or Li-Poly) battery is a type of rechargeable battery that uses a soft polymer casing so that the lithium-ion battery inside it rests in a soft external “pouch.” It may also refer to a lithium-ion battery that uses a gelled polymer as an electrolyte. However, the term commonly refers to a type of lithium-ion battery in a pouch format.Lithium-polymer batteries are lighter and more flexible than other kinds of lithium-ion batteries because of their soft shells, allowing them to be used in mobile and other electronic devices, as well as in remote control vehicles.

Long lifespan. In the common working condition, the cycle times of charging and discharging is more than 500. Charging quickly. 0.5 to 1 time of current can be applied to the charging process, and the charging time can be shortened to 1-2 hours. It can be used in parallel. It is the most advanced “green” battery of the world, because it does not threaten the environment and does not have the heavy metal element like cadmium, lead or mercury.

TB6560 Driver Board:

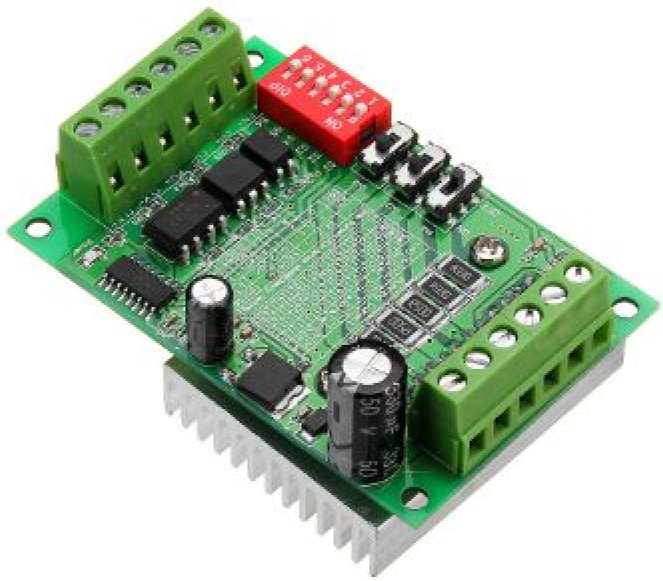

Figure 6.6 TB6560 driver board

The TB6560-3 Axis Stepper Motor Driver is a excellent microstepping driver that use TOSHIBA TB6560 Chip,based on pure-sine current control technology.Owing to the above technology and the self-adjustment technology (self-adjust current control parameters) according to different motors, the driven motors can run with smaller noise, lower heating, smoother movement and have better performances at higher speed than most of the drives in the markets. It is suitable for driving 2-phase and 4-phase hybrid stepping motors.

Suitable for a wide range of stepping motors from NEMA size 17 to 23. It can be used in various kinds of machines, such as X-Y-Z tables, labeling machines, laser cutters, engraving machines,pick-place devices, and so on. Particularly adapt to the applications desired with low vibration,high speed and high precision.

Raspberry Pi Camera:

Figure 6.7 Raspberry Pi camera module

The Camera v2 is the new official camera board released by the Raspberry Pi foundation. The Raspberry Pi Camera Module v2 is a high quality 8 megapixel Sony IMX219 image sensor custom designed add-on board for Raspberry Pi, featuring a fixed focus lens. It's capable of 3280 x 2464 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video. It attaches to Pi by way of one of the small sockets on the board upper surface and uses the dedicated CSi interface, designed especially for interfacing to cameras. 8 megapixel native resolution sensor-capable of 3280 x 2464 pixel static images Supports 1080p30, 720p60 and 640x480p90 video Camera is supported in the latest version of Raspbian, Raspberry Pi's preferred operating system The board itself is tiny, at around 25mm x 23mm x 9mm. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. It connects to Raspberry Pi by way of a short ribbon cable. The high quality Sony IMX219 image sensor itself has a native resolution of 8 megapixel, and has a fixed focus lens on-board. In terms of still images, the camera is capable of 3280 x 2464 pixel static images, and also supports 1080p30, 720p60 and 640x480p90 video

NEO M8:

Figure 6.8 Neo M8 GPS module

The NEO-M8 series of standalone concurrent GNSS modules is built on the exceptional performance of the u-blox M8 GNSS (GPS, GLONASS, BeiDou, QZSS, SBAS and Galileo-ready1) engine in the industry proven NEO form factor. The NEO-M8 series provides high sensitivity and minimal acquisition times while maintaining low system power. The NEO-M8M is optimized for cost sensitive applications, while NEO-M8N/M8Q provides best performance and easier RF integration. The NEO form factor allows easy migration from previous NEO generations. Sophisticated RF-architecture and interference suppression ensure maximum performance even in GNSS-hostile environments. The NEO-M8 series combines a high level of robustness and integration capability with flexible connectivity options. The future-proof NEO-M8N includes an internal Flash that allows simple firmware upgrades for supporting additional GNSS systems. This makes NEO-M8 perfectly suited to industrial and automotive applications.

LOAD CELL:

Figure 6.9 Load cell

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various load cell types include hydraulic, pneumatic, and strain gauge.

A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (quarter bridge) or two strain gauges (half bridge) are also available.The electrical signal output is typically in the order of a few millivolts (mV) and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer. Sometimes a high resolution ADC, typically 24-bit, can be used directly.

The gauges themselves are bonded onto a beam or structural member that deforms when weight is applied. In most cases, four strain gauges are used to obtain maximum sensitivity and temperature compensation. Two of the gauges are usually in tension can be represented as T1 and T2,and two in compression can be represented as C1 and C2, and are wired with compensation adjustments. The strain gauge load cell is fundamentally a spring optimized for strain measurement. Gauges are mounted in areas that exhibit strain in compression or tension. When weight is applied to the load cell, gauges C1 and C2 compress decreasing their resistances.

HX711:

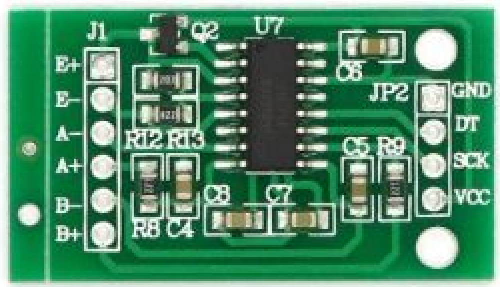

Figure 6.10 HX711 amplifier

Based on Avia Semiconductor's patented technology, HX711 is a precision 24-bit analog to-digital converter (ADC) designed for weigh scales and industrial control applications to interface directly with a bridge sensor. The input multiplexer selects either Channel A or B differential input to the low-noise programmable gain amplifier (PGA). Channel A can be programmed with a gain of 128 or 64, corresponding to a full-scale differential input voltage of ±20 mV or ±40 mV respectively, when a 5V supply is connected to AVDD analog power supply pin. Channel B has a fixed gain of 32. Onchip power supply regulator eliminates the need for an external supply regulator to provide analog power for the ADC and the sensor. Clock input is flexible. It can be from an external clock source, a crystal, or the on-chip oscillator that does not require any external component. On-chip poweron-reset circuitry simplifies digital interface initialization. There is no programming needed for the internal registers. All controls to the HX711 are through the pins.

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Chapter 7
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Annexure

Annexure

Manual for operating the robot:

1) Hardware connections:

The on-board Raspberry pi should be connected to the Arduino using USB 2.0 cable so that serial commands can be passed to arduino.

The connections from the arduino to the motor drivers are as follows:

A) Motor driver 1 (L298n used for propellor motors)

Arduino pin 10 to Enable A of L298n
Arduino pin 9 to pin 1 of L298n
Arduino pin 8 to pin 2 of L298n
Arduino pin 7 to pin 3 of L298n
Arduino pin 6 to pin 4 of L298n
Arduino pin 5 to pin Enable B of L298n
Arduino 5V pin to 5V of L298n
Arduino GND to GND pin of L298n

B) Motor driver 2 (L298n used for Conveyor Belt)

Arduino pin 2 to pin 1 of L298n
Arduino pin 13 to pin 2 of L298n
Arduino 5V pin to 5V of L298n
Arduino GND to GND pin of L298n

C) Motor driver 3 (TB6560 used for Unloading mechanism)

Arduino pin 11 to pin Clk+ of TB6560
Arduino pin 2 to pin CW+ of TB6560
CLK- and CW- of TB6560 to GND of arduino

D) Connection for motor driver 1 (L2998n) and propeller motors

Out 1 and Out 2 are used for the left propeller motor
Out 3 and Out 4 are used for the right propeller motor

E) Connection for motor driver 2 (L298n) and conveyor motors

Out 1 and Out 2 are used for both the conveyor motors (Both the motors are connected together)

F) Connection for motor driver 3 (TB6560) and Stepper Motor

A+ of TB6560 will be connected with the Red wire from the stepper motor
A- of TB6560 will be connected with the Blue wire from the stepper motor
B+ of TB6560 will be connected with the Green wire from the stepper motor
B- of TB6560 will be connected with the Black wire from the stepper motor

The excitation settings and current settings can be modified using the switches on the TB6560 driver. Using the information in its datasheet, toggle the switches to get the desired conditions.

Motor driver 1 and motor driver 2 will be connected to a 12V lithium polymer battery. A separate 12V lithium polymer battery should be used to power up the TB6560 motor driver. After all the connections are done and both the batteries are connected then the on-board raspberry pi should be powered up using the power bank. Another Raspberry-Pi which will be on the bank should also be powered up simultaneously. The software part is explained below.

2) Required list of softwares:

a) Python
b) Arduino IDE
c) PuTTY (Used to access terminal of the Pi on another computer)
d) VNC (Used for remote access of the Pi on another computer)

3) Software operation

The most important thing is that the Raspberry Pi and the laptop with which the Pi will be remotely accessed must be connected to the same network (same mobile hotspot). Start a mobile hotspot which will be most probably used to provide network connectivity to the Pi. Once the Pi is given an IP address by the mobile hotspot, it almost always gets the same IP address.

To use PuTTY and VNC, we first must enable SSH (Secure Shell) and (VNC) from the Raspberry Pi configuration window as shown below:

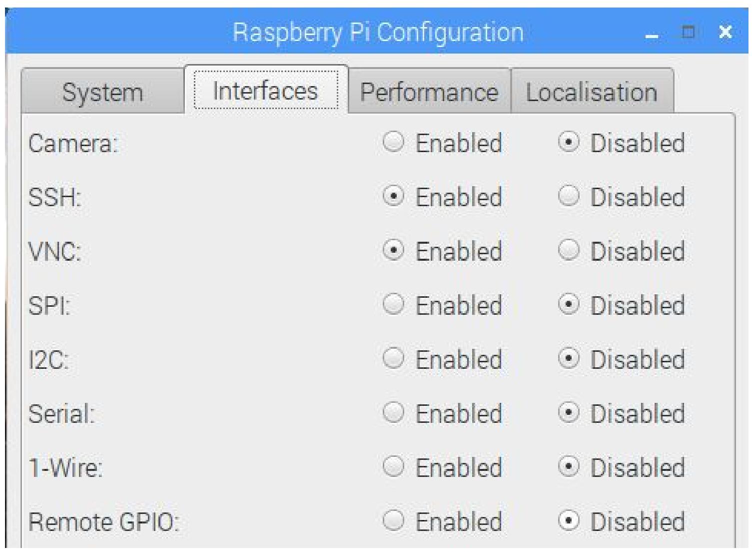

Figure A

This helps us in getting a constant IP address all the time which is useful in accessing the RPi conveniently, remotely since we have to enter the IP address of the Raspberry Pi while using PuTTY and VNC softwares. For the first time boot, we require monitor, keyboard and mouse to be connected to the Pi to know its IP address by hovering the mouse over the WiFi symbol on the upper right hand bar. Otherwise, you can also find out the IP address by writing the command 'sudo ifconfig' in the command window of the Pi. Note down the address.

After the first boot, we do not need any external peripherals to be connected to the Pi. We just need a power source like a power bank which is used to turn on the Pi. Along with it, we need the same mobile hotspot that was used to give connectivity to it. After it, the Pi will automatically get connected to the network created by the hotspot and be assigned the same network address. This was step 1. The next information that is needed is the Hostname and the password of the Pi which can be obtained from the RPi configuration window as shown further:

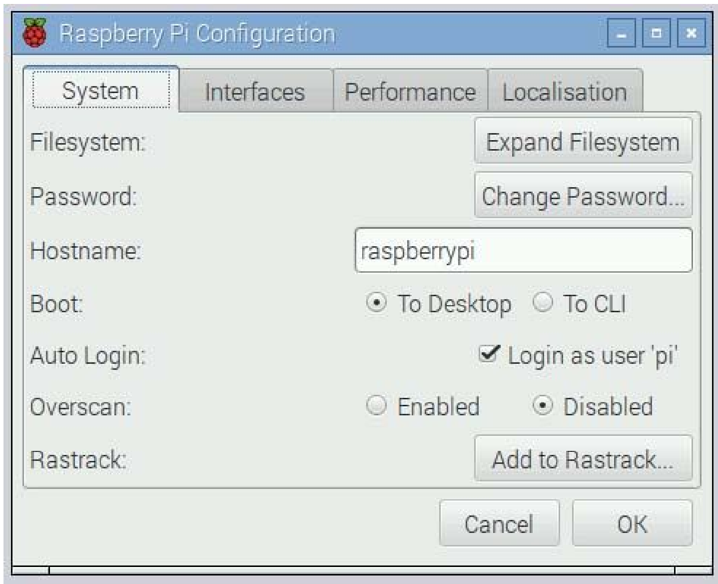

Figure B

The default hostname and password is ‘pi’ and ‘raspberry’ which can be changed as per wish. After noting down the hostname and the password, three things have been obtained: The IP address, hostname and password. These are the three things that are needed to access the Pi remotely using PuTTY.

After installing PuTTY on another laptop, open it and the following window will be seen:

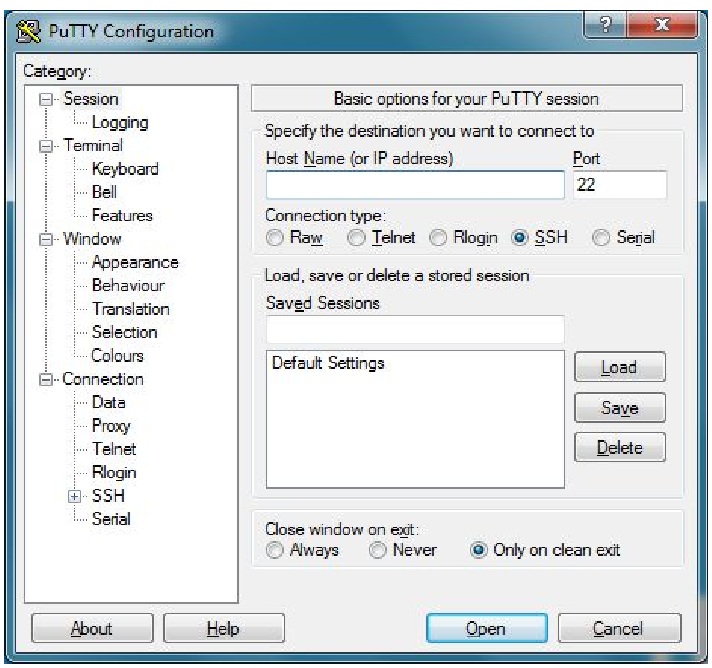

Figure C

Enter the IP address of the Pi in the space provided for it. After entering the correct IP address, a window will open which will ask for the Pi's hostname and the password. Entering the correct name and the password will get you access to the command terminal of the Pi which will allow you to execute and run any script in the Pi. Since the practicality and working of the project does not allow the use of external peripherals connected to the main processor (Raspberry Pi), remote control/access of the Pi via another laptop is more efficient and feasible. Thus, the use of PuTTY is justified.

There are three files in total to be needed for the execution of the project. One Python file, one html file and one Arduino file. The Arduino file containing the code is to be uploaded to the Arduino UNO board. In the Raspberry Pi, which is going to act as the central processing unit and a web server, create a folder named, for e.g. 'Project', on the desktop of the Pi. Inside the folder, there should be a python file named 'app.py' and another folder named 'templates' which contains 'main.html' file. The 'app.py' python file creates a web server when run and calls the main.html file as a html web page. This 'main.html' web page and the 'app.py' created web server act like an interface between the user commands and the robot movements. The Raspberry Pi must be connected to the Arduino UNO via the USB A to B cable. This interface acts as the serial communication channel between the Pi and the Uno board.

Using the steps for PuTTY as explained earlier, open the Raspberry Pi control terminal on the remote laptop (which is connected to the same network as the Pi).

Navigate to the folder named 'Project' and execute the python file 'app.py' using the commands as follows:

cd Desktop → cd Project → python app.py

If the above steps have been carried out properly, the python script should run and the terminal should look like this:

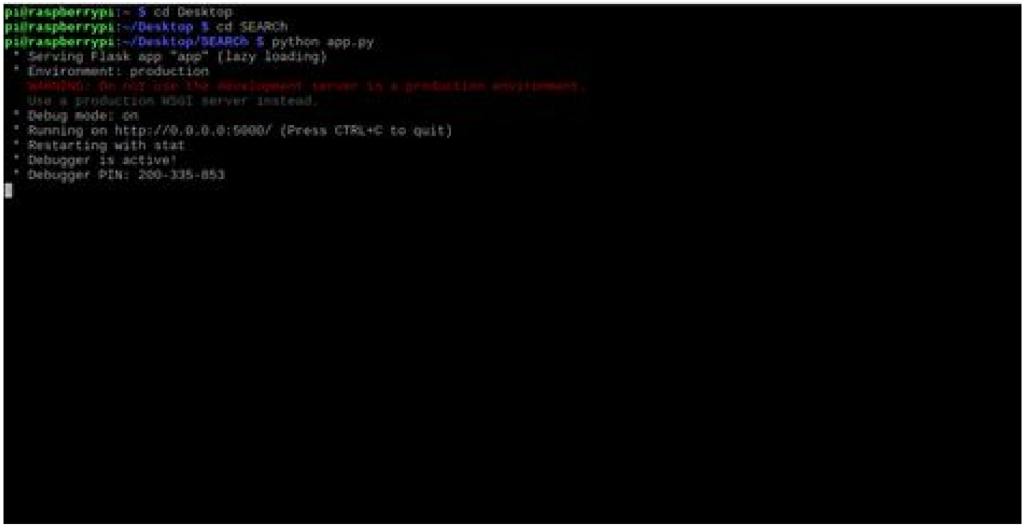

Figure D

If an error comes up which says "Error: serial device '/dev/ttyAMA0' does not exist" remove the USB cable connecting Arduino and Pi, reconnect it and rerun the script. If some or the other error in the execution of the script persists, check all the connections and the code as well for bugs. Debug the code and execute the script again. Still, if the script refuses to execute, then reboot the Pi and perform the process from the top. Once the script is successfully executed, open any browser (preferably Chrome) in your laptop and enter the IP address of the Pi in the URL bar followed by ':5000' which is a port number for web server. For example, if the IP address of the Pi is 192.168.12.2 then type in the URL box: 192.168.12.2:5000

The website should open. To test the working, click on the conveyor button. If all the hardware connections are proper, the conveyor motor should work and the conveyor belt should move. If it does not work, check the Pi terminal in the PuTTY application from where the script was executed. If 'conveyor on' is printed on the terminal, it means there is no issue with the Raspberry Pi or the serial communication between the Pi and Arduino. The problem is with the hardware connections and they should be checked before further testing. The possible parameters for checking include proper connections of the batteries and appropriate polarities, motor driver connections, the motor driver itself (many times the motor driver may receive too much load and might blow up in which case the motor drivers need to be changed).