ISSN 1533-9211

DOI: 10.5281/zenodo.10224371

ROBOTIC INNOVATION IN E-DELIVERY SYSTEMS: A DESIGN AND MODELING APPROACH

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Abstract

Cutting-edge Autonomous Robots represent a technological leap forward, poised to ease the burden on last-mile deliveries. This research seeks to enhance the efficiency and safety of delivery services by exploring the capabilities of autonomous robots. Recognized for its heightened effectiveness, autonomous robot technology becomes increasingly crucial in the face of climate change. This study demonstrates the self-navigating and obstacle-avoidance capabilities of an autonomous robot, employing ultrasonic and lidar image processing while seamlessly integrating with the Pixhawk system to fulfill user-specified delivery locations.

Keywords: Autonomous, Delivery, Robotics, Self-Navigating, Obstacle Avoidance, Ultrasonic, Lidar,Pixhawk.

I. INTRODUCTION

In the realm of electronics, an autonomous robot, referred to as an autorobot or autobot, exhibits a high degree of autonomy in performing tasks and behaviors. The landscape of Autonomous Delivery Robots (ADRs) is experiencing rapid evolution, potentially transforming how commercial and residential clients receive groceries and packages.

On-Road Autonomous Delivery Robots (RADRs) might address the escalating demands of E-Commerce, growing at a double-digit yearly rate, with sensor-equipped and navigation-enabled robots capable of navigating roads, highways, and sidewalks without on-site delivery personnel.

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ISSN 1533-9211

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While smaller ADRs may efficiently maneuver through narrow urban centers, it's acknowledged that human involvement may still be necessary for parcel delivery, even with automated vehicles.

The advantages of Autonomous Delivery Robots encompass reduced delivery costs, accelerated customer service, energy conservation, enhanced sustainability, improved safety for delivery personnel, and precise delivery of packages to the correct recipients.

The foundational elements of an Autonomous Delivery Robot involve a Raspberry Pi 3B+, Arduino UNO, and Pixhawk, with inputs from 6 Ultrasonic sensors, 4 Lidars, and a Pi NoIR Camera V2. The 6 Ultrasonic sensors play a pivotal role in detecting obstacles, relaying captured input to the Arduino UNO for further processing.

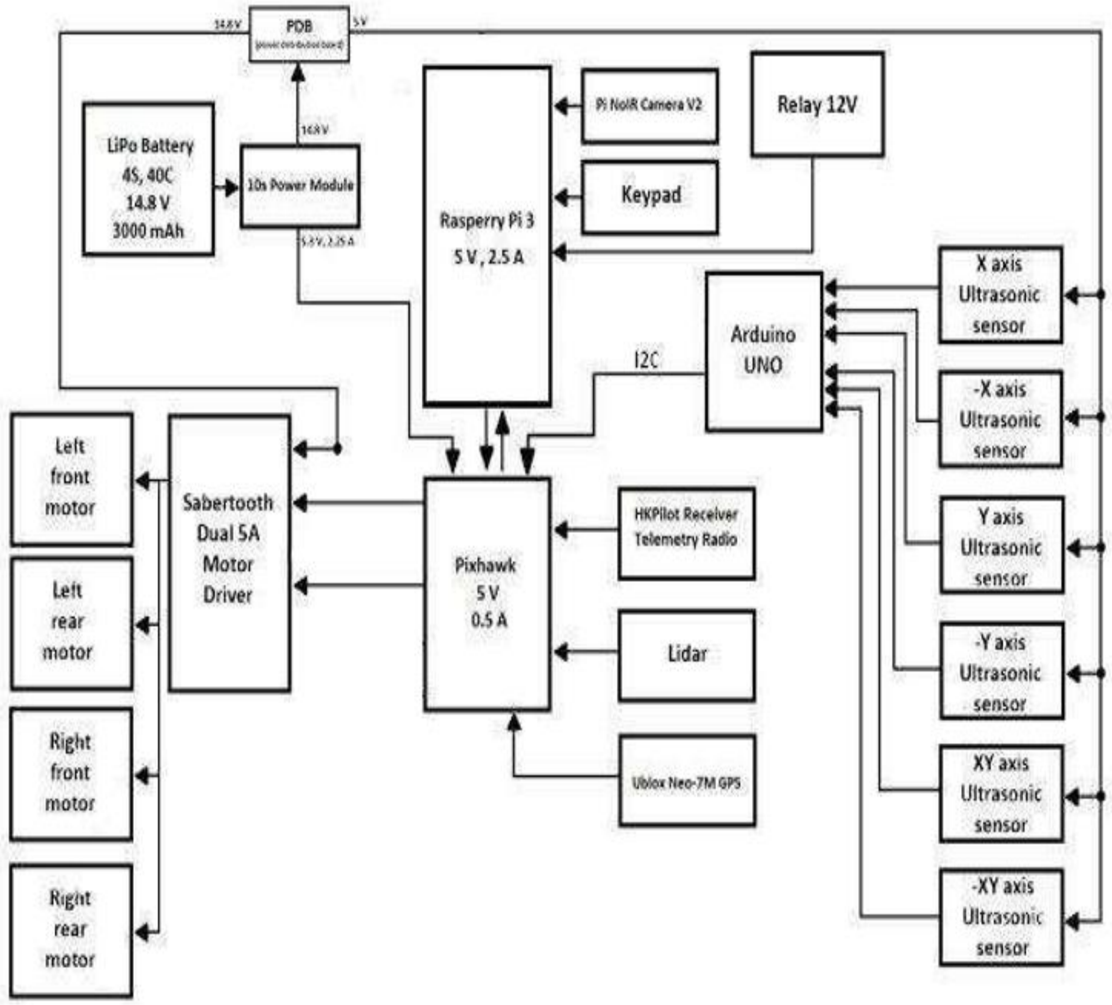

Figure 1: Block diagram

ISSN 1533-9211
DOI: 10.5281/zenodo.10224371

A) Hardware Connections:

The robot will be controlled autonomously for navigation using a Raspberry Pi and an Arduino UNO. The single-line diagram comprising all hardware components is in Figure 2.

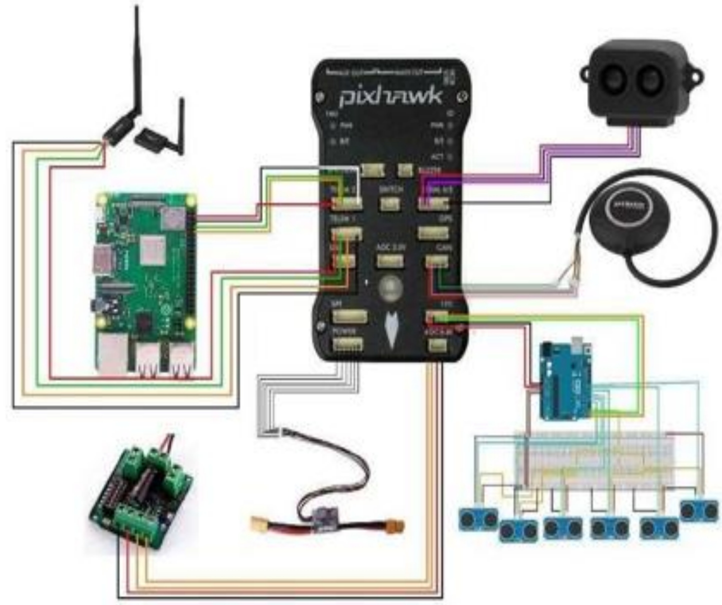

Figure 2: circuit connection

At the heart of the design, three processors are used: Raspberry Pi 3B+, Arduino UNO, Pixhawk. The Pixhawkcomes, with an inertial measurement unit (IMU) that consistsof 3-axis gyroscope, 3-axis accelerometers, 3-axis magnetometer, and a barometer to continuously measure theorientation and acting forces on the robot, which is thencompared to the desired orientation indicated by the inputs.

The PixHawk takes navigation commands as input from twosources: The Raspberry Pi, which uses a camera to generatesteering commands for autonomous navigation with the helpof image processing and the Arduino UNO, which uses Ultrasonic sensors to generate steering commands for autonomous navigation with the help of object detection.

Moreover, a GPS module is used to capture the initial position of the robot before going to the destination, so thatapproximated distance travelled from the source to the destination can be referred to a GPS coordinate point.

Also, a set of radio telemetry transceivers is used to link the robot to a ground station in order to monitor the robot while in operation by recording, viewing, and analyzing telemetry logs shown in Figure 3.

ISSN 1533-9211

DOI: 10.5281/zenodo.10224371

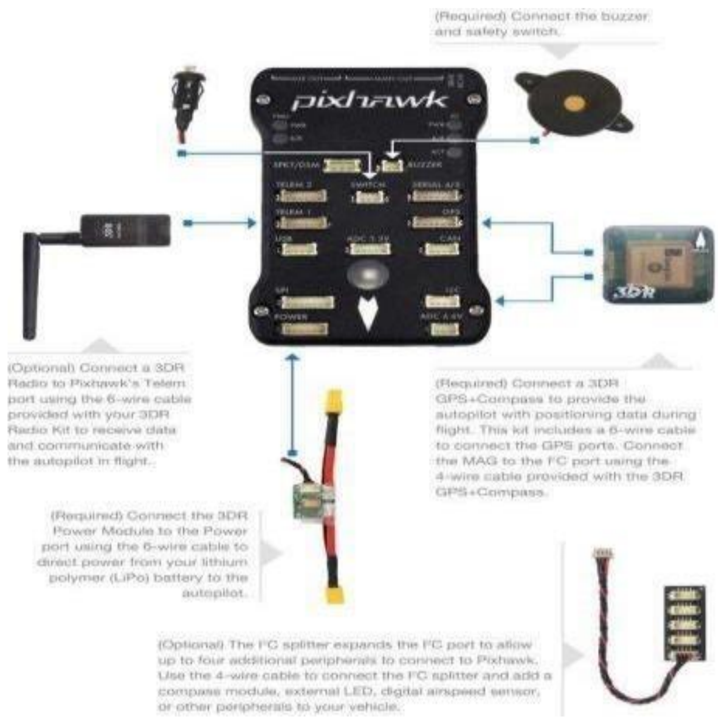

Figure 3: Pixhawk Connections

The PixHawk adjusts each motor speed, by generating PWM signals to motor controller. The motor controller are used to generate a limited voltage from a LiPo battery, which is required to run the motors by sending a sequence of signals generated from the motor driver circuitry that corresponds to the PWM signal generated by the PixHawk. The rpm is varied bychanging the pulse width of the signal to each phase at a constant switching frequency as shown in the Figure 4

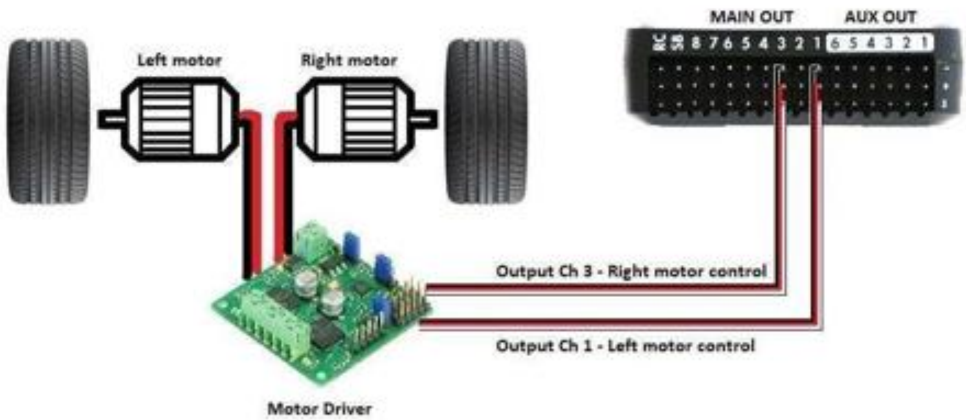

Figure 4: Pixhawk to Motor driver interface

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DOI: 10.5281/zenodo.10224371

The Raspberry Pi interfaces with the Pi Camera V2, which does not have an Infrared filter on the lens, making it suitablefor capturing video recording in low light environments, as shown in Figure 5 is the Raspberry Pi interfaced with camera.

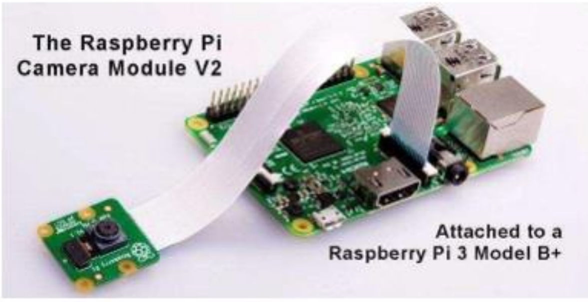

Figure 5: Raspberry pi Interfaced with camera

The Raspberry Pi and Pixhawk interact via the MAVLINK protocol, which is designed for two-way communication withsmall unmanned vehicles. Figure 6 shows the interface between the raspberry Pi and Pixhawk

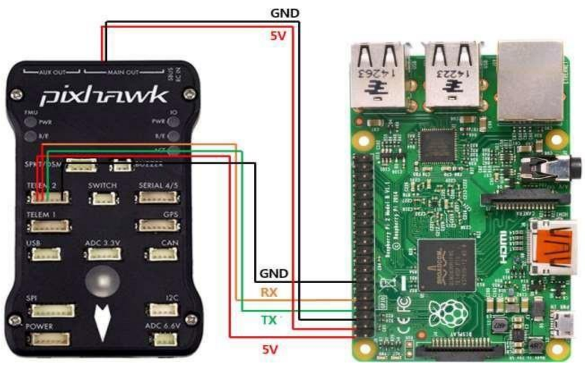

Figure 6: Pixhawk to Raspberry Pi interface

The Arduino Mega interfaces with the Lidars, which helps inobject detection, making it suitable for object avoidanceshown in Figure 7

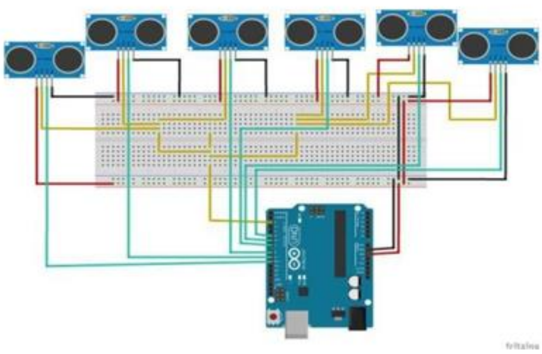

Figure 7: Arduino Mega interfaced with lidars

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The Arduino UNO and Pixhawk communicate over a serial link, using auxiliary pins. The Pixhawk has 6 'auxiliary' outputs that can be configured as either general purpose input/output or PWM output. The auxiliary pins are configured at Arduino according to the BRD_PWM_COUNTparameter.

Figure 8: Pixhawk to Arduino interface

Additionally, a keypad and a lock are used to secure the food.For security we use OTP (One-time Password). An alphanumeric membrane keypad for typing in the codes; a serial displays so to display the state of the lock and of the codes that have been typed shown in Figure 9a and 9b.

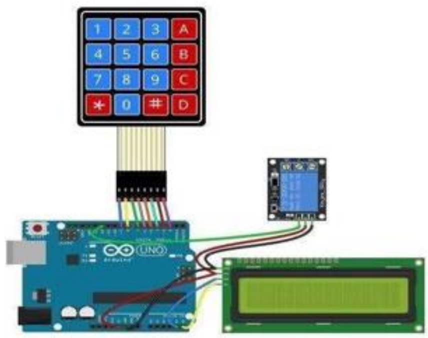

Figure 9a: Keypad, display, relay interface with Arduino

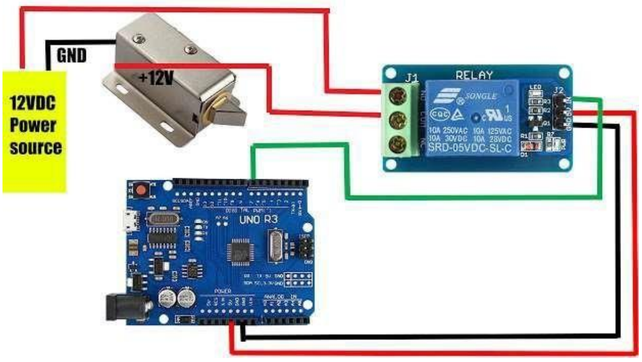

Figure 9b: Lock and relay interfacing

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DOI: 10.5281/zenodo.10224371

The Framework of the body is 3D printed using PLA filament. Dimensions of the 3D printed box are: Length=260mm, Width =180mm, Height = 200mm. The boxcomes with an opening and closing lid on top for easy accessof the food and security shown in Figure 10

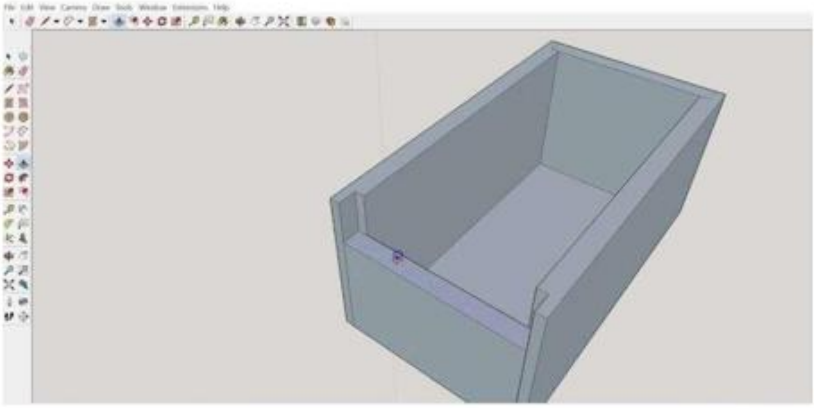

Figure 10: Design of 3D printed box

The framework of the robot is built using acrylic sheets. Thechassis used is a 6 wheeled robotic rover. The motors used are150 RPM high quality BO motors and wider Wheels withrocker-bogie suspension wheel mechanism shown in Figure 11.

Figure 11: Chassis and Motor

Which will be monitored by a human. This is to monitor the movement of the robot and to check if all deliveries are donesafely and smoothly shown in Figure 12

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DOI: 10.5281/zenodo.10224371

Figure 12: Camera

This camera shown in figure 12 is just a surveillance camera and is not used for the digital image processing.

The Lidar is directly connected to the serial pin of the Pixhawk, which helps in object detection, making it suitable for object avoidance as shown in Figure 13.

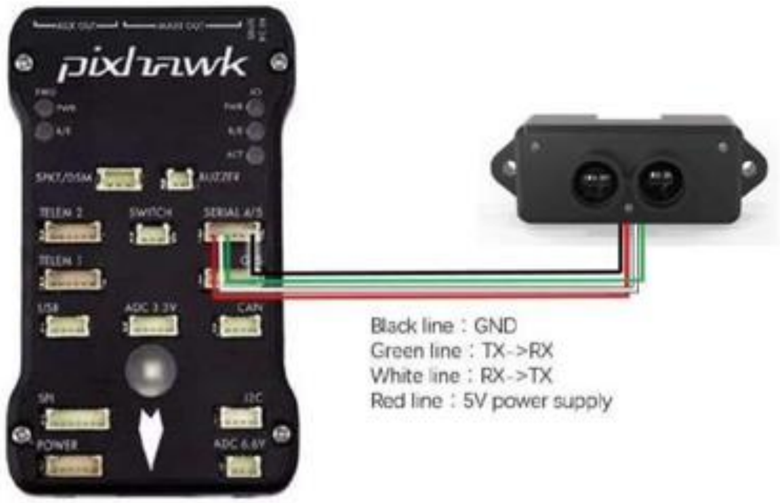

Figure 13: Pixhawk and Lidar interfacing

B) Software Implementation

The ArduPilot open-source autopilot project's MissionPlanner is a full-featured ground station programme. This page offers information on the history of Mission Planner as well as the structure of this website.

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Figure 15: Home Page of Mission Planner

Mission Planner is the ground control station for Plane, Copter, and Rover. It's only compatible with Windows. Mission Planner can function as a configuration tool or a dynamic control system, complement for your self-driving car here are a few examples of what Mission Planner can achieve for you. Load the firmware (software) into the autopilot board that controls your vehicle (i.e., Pixhawk series). Set up, adjust, and optimize your car to its maximum potential. With simple point-and-click way-point entry on Google or other maps, you can plan, save, and load autonomous trips into your autopilot.

Your autopilot's mission logs can be downloaded and analysed. To develop a full hardware-in-the-loop UAV simulator, connect it to a PC flight simulator. With the right telemetry hardware, you can:

- Keep track of your vehicle's state while it's on theroad.
- Keep telemetry logs, which contain a lot moreinformation than the autopilot logs on board.
- Examine and interpret the telemetry logs.
- Fly your car in first-person view (FPV) (first personview)

In the image below, a robot mission begins with an auto startat 20 meters, then moves to WP 2 at 100 meters, waits a few seconds, then moves to WP 3 at 50 meters, and finally returnsto the start location. After you've arrived at the starting spot. The mission assumes that the start position is set at the homeposition.

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DOI: 10.5281/zenodo.10224371

Figure 16: Screenshot of the waypoint plan

Waypoints and other commands can be entered using the keyboard (see the Mission commands section below for moreinformation). Select the desired command from the dropdownchoices on each row. The column heading will change to reflect the information required by that command. By clicking on the map, you can enter the latitude and longitude. Verify the position means that the Mission Planner will change your position based on Google Earth topology data. At each waypoint, the desired position should reflect the ground position.

Select Write when you're finished with your assignment, and it'll be delivered to APM and saved in EEPROM. By selecting Read, you may double-check that everything is as you can save multiple mission files to your local hard driveby selecting Save WP File from the right-click menu, or reading files by selecting Load WP File:

Figure 17: Save the WP File

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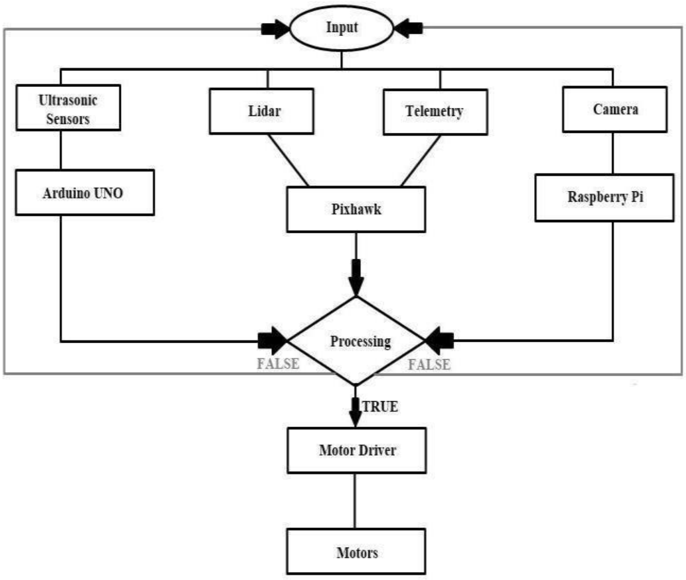
C) Flowchart of Software Implementation

The flowchart of the navigation process is shown in figure 18. Where the inputs are taken from the ultrasonic sensors, lidar, telemetry and camera and are processed, if any image or obstruction is found then the processor sees possible ways ofchanging the path by changing the speed of motor.



II. VERIFICATION

This robot is a versatile vehicle therefore to ensure it is safe, reliable and trustworthy to use it a thoroughly confirmed verification process is necessary for it 100% efficiency.

Verify if the system we use are using to develop the robot id dependable and fault-tolerant.

This system employs agent simulation approach. Which is a class of computational models for simulating the activities and interactions of autonomous agents in order to analyze their overall influence on the system?

All devices used such as camera, Raspberry PI, Arduino UNO, motor driver, GPS model are checked if they are working correctly.

After all components and connections are setup the system runs with real time data of readings given as input by the camera and sensors.

The software used to set the way points for accurate operation of the robot is Mission Planner. Where the number of Points of Origin (POO or pickup points) and Points of Delivery (POD) are set manually.

The point-to-point way points are also verified manually so that the robot does not face any hindrance while executing the task.

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III. APPLICATIONS

1) Food Delivery Robots
2) E-commerce Delivery Robots
3) Cargo Delivery Robots
4) National Health Service (NHS) Delivery Robot.

IV. OUTCOMES

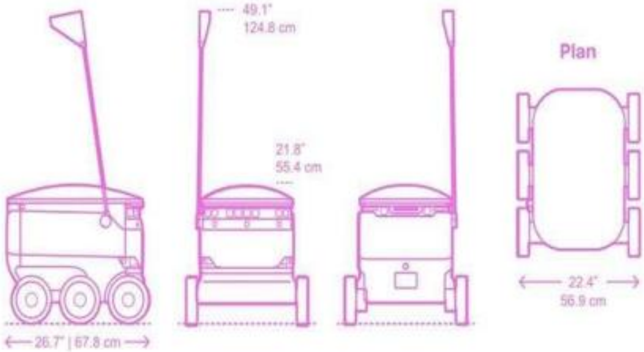

Figure 18: Expected Outcome

A fully working delivery robot equipped with the fore mentioned features to provide efficient and safe delivery services.

Estimated weight – 1.5 Kgs, Distance travel – 1.2 km, Max Speed – 2.5 km/hour

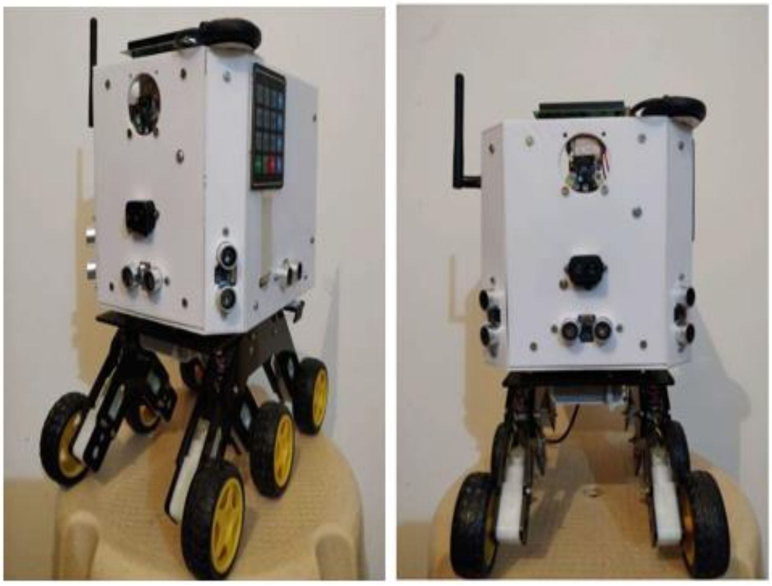

Figure 19: Final Outcome

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DOI: 10.5281/zenodo.10224371

V. CONCLUSION

In conclusion, the advent of cutting-edge Autonomous Robots marks a significant technological advancement, offering promising solutions to alleviate the challenges associated with last-mile deliveries. This research has been dedicated to the pursuit of improving the efficiency and safety of delivery services through a comprehensive exploration of the capabilities inherent in autonomous robots. The heightened effectiveness of autonomous robot technology is particularly noteworthy, gaining importance in the context of the ongoing challenges posed by climate change.

This study serves as a testament to the potential of autonomous robots, showcasing their remarkable self-navigating and obstacle-avoidance capabilities. The incorporation of ultrasonic and lidar image processing technologies enhances their adaptability and responsiveness, ensuring a seamless integration with the Pixhawk system. The result is a sophisticated and efficient delivery system that can fulfill user-specified locations with precision and reliability.

As we move forward, the findings of this research contribute not only to the field of robotics but also to the broader landscape of logistics and transportation. Autonomous robots, with their advanced features and intelligent navigation, hold promise in revolutionizing the way we approach last-mile deliveries, offering a glimpse into a future where efficiency, safety, and environmental considerations converge in a harmonious solution to meet the evolving demands of the delivery ecosystem.

References

1) Starship (2018).Starship Technologies Launches Commercial Rollout of Autonomous Delivery. https://www.starship.xyz/press_releases/2708/. Accessed July 1, 2018

2) Starship (2017). Starship Technologies launches pilot program with Domino's Pizza Enterprises, https://www.starship.xyz/press_releases/starshiptechnologies-launches-pilot-program-with-dominos- pizza-enterprises/, Accessed July 25, 2018.

3) H. Girish, T. G. Manjunat and A. C. Vikramathithan, "Detection and Alerting Animals in Forest using Artificial Intelligence and IoT," 2022 IEEE Fourth International Conference on Advances in Electronics, Computers and Communications (ICAECC), 2022, pp. 1-5, doi: 10.1109/ICAECC54045.2022.9716679.

4) A. Devipriya, H. Girish, V. Srinivas, N. Adi Reddy and D. Rajkiran, "RTL Design and Logic Synthesis of Traffic Light Controller for 45nm Technology," 2022 3rd International Conference for Emerging Technology (INCET), 2022, pp. 1-5, doi: 10.1109/INCET54531.2022.9824833.

5) S. Vaddadi, V. Srinivas, N. A. Reddy, G. H, R. D and A. Devipriya, "Factory Inventory Automation using Industry 4.0 Technologies," 2022 IEEE IAS Global Conference on Emerging Technologies (GlobConET), 2022, pp. 734-738, doi: 10.1109/GlobConET53749.2022.9872416.

6) T G Manjunath , A C Vikramathithan , H Girish, "Analysis of Total Harmonic Distortion and implementation of Inverter Fault Diagnosis using Artificial Neural Network", Journal of Physics: Conference Series, Volume 2161, 1st International Conference on Artificial Intelligence, Computational Electronics and Communication System (AICECS 2021) 28-30 October 2021, Manipal, India. https://iopscience.iop.org/issue/1742-6596/2161/1

The Seybold Report

ISSN 1533-9211

DOI: 10.5281/zenodo.10224371

7) GIRISH H , “Internet of Things Based Heart Beat Rate Monitoring System”, © September 2022 | IJIRT | Volume 6 Issue 4 | ISSN: 2349-6002 IJIRT 156592 International Journal Of Innovative Research In Technology 227

8) Dr Girish H, Dr. Mangala Gowri , Dr. Keshava Murthy , Chetan Naik J, Autonomous Car Using Deep Learning and Open CV, Page No: 107-115, Volume 8 Issue 10 2022, Gradiva review journal, ISSN NO : 0363-8057, DOI:10.37897.GRJ.2022.V8I8.22.50332

9) Girish H. "Intelligent Traffic Tracking System Using Wi-Fi ." International Journal for Scientific Research and Development 8.12 (2021): 86-90.

10) Girish H, Shashikumar D R, “Emission monitoring system using IOT”, Dogo Rangsang Research Journal, UGC Care Group I Journal, ISSN: 347-7180, Vol – 8 Issue-14, No.6, 2020.

11) Girish H, Shashikumar D R, “Display and misson computer software loading”, International journal of engineering research & Technology (IJERT), ISSN: 2278-0181, Vol – 10 Issue-08, No.13, August 2020.

12) Girish H, Shashikumar D R, “A Novel Optimization Framework for Controlling Stabilization Issue in Design Principle of FinFET based SRAM”, International Journal of Electrical and Computer Engineering (IJECE) Vol. 9, No. 5 October 2019, pp. 4027~4034. ISSN: 2088-8708, DOI: 10.11591/ijece.v9i5.pp.4027-4034

13) Girish H, Shashikumar D R, “PAOD: a predictive approach for optimization of design in FinFET/SRAM”, International Journal of Electrical and Computer Engineering (IJECE) Vol. 9, No. 2, April 2019, pp. 960~966. ISSN: 2088-8708, DOI: 10.11591/ijece.v9i2.pp.960-966

14) Girish H, Shashikumar D R, “SOPA: Search Optimization Based Predictive Approach for Design Optimization in FinFET/SRAM”, © Springer International Publishing AG, part of Springer Nature 2019 Silhavy (Ed.): CSOC 2018, AISC 764, pp. 21–29, 2019. https://doi.org/10.1007/978-3-319-91189-2_3.

15) Girish H, Shashikumar D R, “Cost-Effective Computational Modelling of Fault Tolerant Optimization of FinFET-based SRAM Cells”, © Springer International Publishing AG 2017 R. Silhavy et al. (eds.), Cybernetics and Mathematics Applications in Intelligent Systems, Advances in Intelligent Systems and Computing 574, DOI 10.1007/978-3-319-57264-2_1.

16) Girish H, Shashikumar D R, “A Survey on the Performance Analysis of FinFET SRAM Cells for Different Technologies”, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-4 Issue-6, 2016.

17) Girish H, Shashikumar D R, “Insights of Performance Enhancement Techniques on FinFET-based SRAM Cells”, Communications on Applied Electronics (CAE) – ISSN: 2394-4714, Foundation of Computer Science FCS, New York, USA .Volume 5 – No.6, July 2016 – www.caeaccess.org

18) Girish H, Shashikumar Dr, “Design Of Finfet”, International Journal of Engineering Research ISSN: 2319-6890) (online), 2347-5013(print) Volume No.5 Issue: Special 5, pp: 992-1128, doi: 10.17950/ijer/v5i5/013 2016.

19) Analysis of Smart helmets and Designing an IoT based smart helmet: A cost effective solution for Riders by Divyasudha N, Arulmozhivarman P School of Electrical Engineering VIT University, Vellore Tamil Nadu, India- 632014 Rajkumar E.R Senior Architect at Robert Bosch engineering and solutions Bengaluru, Karnataka, India- 560103.

20) World Health Organisation, “Global status report on road safety 2018,” 2018

21) Nitin Agarwal, Anshul Kumar Singh, Pushpender Pratap Singh Rajesh Sahan. "Smart Helmet, International Research Journal of Engineering and Technology. Volume 2, issue 2, May 2015.

The Seybold REPORT
ISSN 1533-9211
DOI: 10.5281/zenodo.10224371

22) Professor Chitte P.P, Salunke Akshay S. Tharat Aniruddha, N Bhosale, "Smart Helmet & Intelligent Bike System". International Research Journal of Engineering and Technology (IRJET) Volume 03 issue: 05, May-2016.

23) Shoeb Ahmed Shabbeer. Merin Meleet Smart helmet for accident detection and notification 2nd IEEE International conference on computational systems and information technology 201.

24) Dr. Mangala Gowri S G, Dr. Shashidhar T M, Dr. Sunitha R, Shylaja V, Dr. Girish H, "Design Of 3-Bit Cmos Wallace Multiplier" , Seybold report, ISSN 1533-9211, Volume 18, Page No: 1260-1271 DOI: 10.5281/zenodo.8300481

25) Dr. Mangala Gowri S G, Dr. Girish H, Ramesh N, Dr. Nataraj Vijaypur, "IOT based plant monitoring system and smart irrigation using new features" ResMilitaris, vol.13, n°2, January Issue 2023 https://resmilitaris.net/menu-script/index.php/resmilitaris/article/view/3312/2608

26) Girish H.2023, Smart Theft Security vehicular System Using Iot. Int J Recent Sci Res. 14(02), pp. 2881-2884. DOI: http://dx.doi.org/10.24327/ijrsr.2023.1402.0591
https://www.recentscientific.com/smart-theft-securityvehicular-system-using-iot

27) Dr. Mangala Gowri S G, Dr. Girish H, Dr. Santosh Dattatray Bhopale, Weed Detection based on Neural Networks, International Journal of All Research Education and Scientific Methods (IJARESM), ISSN: 2455-6211 Volume 11, Issue 3, March-2023, Impact Factor: 7.429, Available online at: www.ijaresm.com DOI: https://doi.org/11.56025/IJARESM.2023.11323351

28) Shashidhara, K.S., Girish, H., Parameshwara, M.C., Rai, B.K., Dakulagi, V. (2023). A Novel Approach for Identification of Healthy and Unhealthy Leaves Using Scale Invariant Feature Transform and Shading Histogram-PCA Techniques. In: Shetty, N.R., Patnaik, L.M., Prasad, N.H. (eds) Emerging Research in Computing, Information, Communication and Applications. Lecture Notes in Electrical Engineering, vol 928. Springer, Singapore. https://doi.org/10.1007/978-981-19-5482-5_47

29) Nanalize (2016).Starship Technologies and Ground Delivery Drones, https://www.nanalyze.com/2016/06/starship- ground-delivery-drones/, Accessed July 1, 2018. NURO (2018). https://nuro.ai/, Accessed June 1,2018.