DAYANANDA SAGAR COLLEGE OF ENGINEERING

(An Autonomous Institute affiliated to VTU, Belagavi – 590018, Approved by AICTE & ISO 9001) Accredited by National Assessment & Accreditation Council (NAAC) with 'A' grade

Project Report on

Data Visualizer Rover

Submitted in partial fulfillment for the award of degree of

Bachelor of Engineering

in

Electrical and Electronics Engineering

Submitted by

NAME OF THE CANDIDATES	USN
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Under the Guidance of
Satish B A
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VISVESVARAYA TECHNOLOGICAL UNIVERSITY
JNANASANGAMA, BELAGAVI-59001
2023-24

DAYANANDA SAGAR COLLEGE OF ENGINEERING

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Shavige Malleshwara Hills, Kumaraswamy Layout, Bengaluru-560078

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

DECLARATION

We, Sai Swaroop K Devarmane (1DS20EE060), Syed Rayyan (1DS20EE082), Utkarsh Vashishth (1DS20EE086), Vinit Hanabar (1DS20EE090), respectively, hereby declare that the project work entitled "Data Visualizer Rover" has been independently done by us under the guidance of 'Satish B A', Professor, EEE department and submitted in partial fulfillment of the requirement for the award of the degree of Bachelor of Engineering in Electrical & Electronics Engineering, at Dayananda Sagar College of Engineering, an autonomous institution affiliated to VTU, Belagavi during the academic year 2023-2024.
We further declare that we have not submitted this report either in part or in full to any other university for the award of any degree.

NAME OF THE CANDIDATES	USN
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DATE:

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CERTIFICATE

Certified that Project Work Phase-1 report entitled "**Data Visualizer Rover**" carried out by **Sai Swaroop K Devarmane, Syed Rayyan, Utkarsh Vashishth, Vinith Hanabar** bearing **USN: 1DS20EE060, 1DS20EE082, 1DS20EE086, 1DS20EE090** respectively are bonafide students of **DAYANANDA SAGAR COLLEGE OF ENGINEERING**, an autonomous institute affiliated to VTU, Belagavi in partial fulfillment for the award of **Bachelor of Engineering** in **Electrical and Electronics Engineering** during the year **2023-2024**. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report. The **Project Work Phase-1 (19EE7ICPR1)** report has been approved as it satisfies the academic requirements in respect of **Project work** prescribed for the above said Degree.

Signature of the Guide	Signature of the HOD	Signature of the Principal
Satish B A	Dr. Premkumar M	Dr. B G Prasad
Assistant Professor	Associate Professor & HOD	Principal
Dept. of E&E Engg.	Dept. of E&E Engg.	DSCE, Bengaluru
DSCE, Bengaluru - 78	DSCE, Bengaluru - 78	

Name of the Examiners **Signature with date**

1.. ....

2.. ....

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Bengaluru-560078

Project Course Outcomes and Mapping

Course Outcomes: The Students would be able to

CO1.	**Able to generate ,develop an idea and information to carry out project work**
CO2.	**Analyze and assemble the basic information to find a tangible solution of the complex engineering problem by using suitable method/procedure.**
CO3	**Use/ implement modern Engineering tools/ technologies to get optimized results**
CO4	**Adapt collaborative skills to work in a team.**
CO5.	**Develop presentation ,communication and report writing skills**
CO6	**Apply the knowledge and understanding of principles of management ,**

CO\PO\PSO	**CO-PO-PSO Mapping**														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											1			
CO2		**3**										1			
CO3												1			
CO4					**3**							1			
CO5							**3**					1			
CO6										**3**		1			

ABSTRACT

The Data Visualizer Rover represents a groundbreaking innovation in environmental data collection and analysis, integrating cutting-edge technologies to providecomprehensive insights into our surroundings. At its core, the rover is equipped with an arrayof advanced sensors capable of measuring various environmental parameters such as temperature, humidity, and gas composition. These sensors are complemented by high-resolution cameras that capture detailed images of the rover's surroundings, allowing for a holistic understanding of the environment.

What sets the Data Visualizer Rover apart is its ability to not only collect data but also analyze it onboard in real-time. This capability is facilitated by a powerful microcontroller that processes the data onboard, enabling immediate insights and seamless transmission of processed data to a central database via Wi-Fi connectivity. This feature allows for remote monitoring of environmental conditions and supports advanced data analysis from anywhere in the world.

In addition to its technical capabilities, the Data Visualizer Rover prioritizes user-friendliness in its design. A dedicated mobile application provides users with instant access to real-time data streams, empowering them tomake informed decisions and take timely action based on the information received. Furthermore, an upcoming website will feature interactive visualizations that make complex data sets easily understandable and actionable for a wider audience.

The potential impact of the Data Visualizer Rover spans across various sectors, including research, education, and professional industries. Researchers can leverage its capabilities to gain deeper insights into environmental phenomena, allowing for more accurate modeling andprediction of environmental changes. Educators can use the rover as a hands-on tool for teaching data analysis concepts, engaging students in real-world applications of STEM principles.This comprehensive integration of advanced sensors, real-time analysis, and user-friendly interface positions the Data Visualizer Rover as a transformative tool for environmental monitoring and data-driven decision-making.

CHAPTER 1:

INTRODUCTION

1.1 INTRODUCTION

Robotics occupies a special place in the arena of interactive technologies because it combines sophisticated computation with rich sensory input in a physical embodiment that can exhibit tangible and expressive behavior in the physical world.

Introducing the Data Visualizer Rover—a groundbreaking innovation designed to revolutionize environmental data collection and analysis. The choice of using a rover for environmental exploration is motivated by several key factors. Firstly, its terrain accessibility allows the rover to navigate diverse landscapes, providing insights into otherwise challenging environments. With extended exploration duration and durability, the rover can withstand prolonged missions, offering consistent data collection over time. Its payload capacity supports the integration of various sensors and equipment, enhancing its capabilities for comprehensive environmental analysis.

Moreover the rover's ability to operate in diverse environmental conditions, combined with physical interaction capabilities, enables it to gather data in real-world scenarios efficiently. Communication reliability is ensured through robust onboard systems, facilitating seamless data transmission and remote control. What sets our rover apart is the ingenious inclusion of a dedicated slot for a customizable Integrated Circuit (IC) and global accessibility. This distinctive feature empowers users to seamlessly incorporate specialized sensor modules, tailored to specific applications, thereby enhancing the rover's adaptability, controllability and functionality.

The potential impact of the Data Visualizer Rover spans various sectors, empowering researchers to gain deeper insights into environmental phenomena and educators to engage students in practical STEM applications. With its integration of advanced sensor technologies, real-time analysis capabilities, and user-friendly interfaces, the Data Visualizer Rover is poised to transform environmental monitoring, research, and decision-making across industries

1.2 LITERATURE SURVEY

1. A detailed examination of autonomous rover technology, emphasizing its significance in security, surveillance, and diverse applications. It discusses critical elements including locomotion mechanisms, navigation strategies, sensor arrays, obstacle avoidance techniques, communication protocols, and control mechanisms. The analysis underscores the importance of integrating multiple sensors for precise and dependable data acquisition in autonomous rover operations. By shedding light on both challenges and advancements in autonomous rover development, this study serves as a valuable resource for guiding future research and design endeavors in this domain.

2. This review offers an extensive overview of the rocker-bogie suspension system utilized in planetary rovers. It showcases various iterations and setups of this suspension system developed by different countries, such as the United States, Russia, Switzerland, and China. By comparing these suspension systems, it highlights their distinctive features, maneuverability, stability, and adaptability to rugged terrains. This comprehensive survey provides valuable insights into the evolution and innovations within planetary rover suspension technology, offering a significant reference point for prospective research and development initiatives in this area.

3. The paper "Robotic Rover Development with Controller & Vision System" outlines the creation and evolution of a robotic rover engineered with a primary focus on safety and surveillance applications. The rover integrates various mechanical elements, including a robotic arm, gripper, and continuous track, alongside electrical components such as servo motors and an advanced vision system. Notably, the vision system offers a real-time first-person view (FPV) for remote monitoring, rendering it particularly suitable for applications involving safety oversight and rescue missions. Rigorous testing of the rover's lifting capabilities and vision system performance yielded promising results. This research underscores the potential for a versatile and cost-efficient robotic rover adaptable to a spectrum of applications, thus offering pertinent insights for the ongoing development of your Data Visualizer Rover project.

4. The JPL Open Source Rover initiative, spearheaded by NASA's Jet Propulsion Laboratory (JPL), introduces an open-source, educational platform tailored for enthusiasts keen on delving into mechanical engineering, software development, electronics, and robotics. Drawing inspiration from the design principles of Mars rovers, this downscaled rover is constructed using readily available consumer-grade components, rendering it both accessible and economically viable for educational purposes. Noteworthy features include the incorporation of the Rocker-Bogie suspension system and control via Raspberry Pi, fostering hands-on exploration across various engineering disciplines. At its core, the project endeavors to ignite the curiosity and passion of budding scientists and engineers by providing a tangible educational robotics platform conducive to exploring and comprehending our solar system.

5. "IOT-Based Rover Design & Fabrication" chronicles the creation of a solar-powered multifunctional robot tailored for surveillance applications. Central to its design is the integration of an Arduino microcontroller and Wi-Fi module, facilitating Internet of Things (IoT) connectivity that enables remote control via laptops or mobile devices. The proposed rover serves as a viable solution to bolster surveillance capabilities, enabling remote exploration of otherwise inaccessible regions and efficient monitoring operations. This endeavor resonates with our Data Visualizer Rover project, as it underscores the utilization of IoT technology and sensor integration for streamlined data collection and remote operational control.

6. Evangeline Asha B.'s "Surveillance Rover for Scientific Applications" details the creation of a rover outfitted with an array of sensors and locomotion mechanisms tailored for scientific endeavors. This rover boasts the capability to detect parameters like smoke, temperature fluctuations, electric fields, and the presence of living organisms while simultaneously capturing audio and video data. Powered by a rechargeable battery, the rover maneuvers on wheels, with integrated sensors enhancing its functionality. The article elaborates on the sensor suite, encompassing smoke detectors, temperature sensors, electric field sensors, living organism detectors, and audio-video transmitters. With applications spanning surveillance, navigation, monitoring, and rescue operations in areas with restricted accessibility, the rover proves invaluable for security tasks and identifying extreme conditions across diverse environments. The project entails the creation of self-designed and fabricated printed circuit boards (PCBs), merging electronics and mechanics to birth a fully operational scientific rover for comprehensive data collection. This publication serves as a significant resource for guiding the development of your Data Visualizer Rover project.

7. Trinity University's Autonomous Planetary Rover project endeavors to imbue a rover platform with autonomous movement, sensing, and navigation capabilities. The project entailed mechanical modifications to enhance rover mobility, the development of subsystems for wheel assembly and odometry, the establishment of power delivery and control circuitry, and motor control utilizing an ESP32 MCU. Additionally, obstacle detection and navigation were achieved using a ZED2 stereo camera and the Robot Operating System (ROS). Despite encountering challenges and component failures, the project culminated in the creation of a functioning prototype that met several project requirements and design criteria.

8. This scholarly article delves into the development of an agricultural rover tailored for tasks like plowing, harvesting, and various agricultural functions. Specifically engineered to gather environmental data, the rover delivers real-time data insights to farmers through graphical, tabular, and other user-friendly formats. The centralized control system, accessible via a dedicated app, enables seamless rover management for farmers, ensuring efficient operation throughout agricultural operations.

9. This research study introduces advancements in rover control by transitioning from Bluetooth, which imposes range limitations, to direct internet connectivity. This upgrade eradicates the constraints associated with limited-range control, facilitating more extensive rover operations. Moreover, real-time data collection capabilities have been implemented, with the collected data presented in diverse formats to enhance accessibility and usability.

10. Drawing from insights gleaned from this research paper, the concept of modular rover design emerges, allowing users to customize their rovers to suit various needs, including agriculture, surveillance, and deployment in disaster-prone areas. By offering multiple modules, users can tailor their rovers to specific applications, enhancing versatility and adaptability across diverse scenarios

11.Mobile robots are increasingly vital in navigating challenging terrain like planetary surfaces and combat zones. However, existing control and localization algorithms often overlook crucial factors like the vehicle's physical characteristics and its surroundings. This paper addresses this gap by proposing methods to detect wheel slippage and sinkage, particularly on soft sandy terrain. By leveraging onboard sensors and innovative vision-based algorithms, these techniques enhance the robot's mobility and reduce risks of mission failure. Experimental validation with a Mars rover-type robot and a wheel sinkage testbed confirms their effectiveness in detecting wheel slip and sinkage.

12.Soldiers are crucial defenders of our nation, particularly in India where border protection is of utmost importance. To address the safety concerns of soldiers in hazardous areas, we propose deploying smart rovers equipped with Sniper Guns for defense purposes. These rovers, controlled by servo motors, offer flexibility in aiming and shooting in any direction. The project comprises Defense and Surveillance components. A wireless night vision camera is mounted for surveillance, while a Sniper Gun is utilized for defense. Powered by DC motors and Wi-Fi technology, the rover's movement and operations are controlled remotely. The project employs the Node MCU microcontroller and Tinker Cad simulation software. Managed through the Remote XY mobile app, this rover serves in defense and surveillance roles under specific circumstances.

13.The Revamped Surveillance Rover is tailored to excel in Industrial and Defense Surveillance, representing a modernized approach to rover technology. With real-time data analysis capabilities, it swiftly identifies potential threats and issues timely alerts, enhancing situational awareness. Its communication system enables remote operation and live data transmission, reducing human exposure to risks. In industrial settings. the rover monitors critical infrastructure and manufacturing facilities, detecting anomalies and ensuring safety compliance. In military applications. it bolsters security, border surveillance, and reconnaissance efforts. Key enhancements include improved mileage and battery life, autonomous and controlled operations, onboard sample testing capabilities, and utilization of Jetson Nano for processing and mapping. Designed for rover competitions, this project is adaptable for Industrial and Defense Surveillance applications.

14.Landmine detection is critical in warfare to ensure the safe passage of armed vehicles into enemy territory. Main battle tanks follow the path of pilot tanks manually operated to minimize damage and protect defense crews. Post-warfare, detecting and diffusing mines is essential to prevent civilian casualties. This research proposes a prototype land-mine detection robot (LDR) operable via Wi-Fi technology. Equipped with range sensors for obstacle avoidance, the robot is made of lightweight, temperature-resistant metal. It incorporates a GPS sensor for location tracking and employs path planning and obstacle avoidance algorithms for precise navigation. An Arduino microcontroller manages operations, including landmine detection using a metal detector and issuing warning alarms. Locomotion is facilitated by DC motors, with communication to a PC via ZigBee.

15.In this study, we establish serial communication between a quadcopter drone and a six-wheeled land rover bot. A Raspberry Pi is installed on the drone, while an Arduino is employed on the bot, facilitating serial communication via a Bluetooth module. This setup enables obstacle avoidance, with the drone capable of transmitting images to a PC, effectively serving as a surveillance system. The implications of this technology are significant in defense, mining, and rescue operations. Key terms include Drone, Rocker-bogie bot, Serial Communication, Arduino, Raspberry Pi, Ardupilot Pixhawk.

16.The Ingenuity Helicopter, slated for deployment from the Perseverance Rover shortly after landing, represents a groundbreaking advancement in Mars exploration. This $1.8 kg, 1.2 m diameter helicopter, equipped with twin rotors, will conduct a Technology Demonstration experiment, showcasing autonomous controlled flight in the Martian atmosphere. The rover facilitates communication between the helicopter and Earth-based mission operators, enabling the collection of valuable data from a series of planned flights lasting up to 90 seconds each. Insights gained from these flights will inform the development of future Mars helicopter designs, ranging from 4 kg to 30 kg, capable of covering significant distances daily and carrying science payloads of 1 kg to 5kg

These helicopters can serve as scouts for future rovers, aiding in target selection and route planning, while larger craft can operate independently with a suite of science instruments. Additionally, helicopters can collaborate with central landers for wide-area sampling and scientific investigations, and in the future, they may play a role in human exploration by providing reconnaissance.

17.The Japanese MMX mission to Phobos by JAXA will feature a rover developed by CNES and DLR for in situ analysis of the Martian moon's surface. While past images reveal a regolith-covered surface, little is known about its mechanical and compositional properties. Understanding these properties is crucial for tracing Phobos' history and supporting data interpretation from MMX spacecraft instruments. The rover will carry instruments including a Raman spectrometer (RAX), an infrared radiometer (miniRad), navigation and science cameras (NavCams), and wheel interaction cameras (WheelCams). Deployed before MMX samples Phobos, this rover will be the first to traverse a Martian moon's surface in low gravity.

18.Mission-critical exploration demands robust methods for acquiring information in uncertain environments. Traditional metrics like Shannon entropy and KL divergence may introduce bias in bimodal probability distributions. Utilizing standard deviation SD mitigates bias while distinguishing between high and low-risk distributions. High SD areas can be explored safely and swiftly using an autonomous Mars Helicopter, aiding in efficient path planning for ground-based rovers. This study introduces a single-agent information-theoretic utility-based path planning method and a two-stage multiagent framework for rapidly exploring random trees. The framework guides the Mars helicopter through high SD regions to reduce uncertainty for the rover. Monte Carlo simulations compare the information-theoretic approach with rover-only and naive helicopter scouting methods. Results demonstrated in a Mars case study, reveal improved travel times for the rover when employing the information-theoretic helicopter compared to rover-only or helicopter scouting approaches.

19.Surveillance is crucial for border security, but assigning this task to soldiers can endanger their lives. Instead, employing surveillance rovers proves effective in monitoring border areas. These compact rovers possess advanced capabilities for surveillance and reconnaissance without revealing their ownership. They provide real-time video streaming and image capture, enabling operators to swiftly assess and respond to threats. With their agile design and functionality, surveillance rovers offer a versatile and economical solution for various surveillance tasks, enhancing safety and minimizing risks associated with manual monitoring. Key features include real-time image processing, monitoring capabilities, and integration with GSM modules.

20.The surge in mobile device usage has led to a significant increase in data generation and consumption, overwhelming current mobile networks in terms of cost and bandwidth. Concurrently, advancements in vehicle technology enable us to leverage their computing, caching, and communication capabilities for various smart city applications. This includes utilizing connected vehicles to gather, store, and distribute diverse urban street data, facilitating location-aware services for citizens. However, due to the high mobility and intermittent connectivity of vehicles on urban roads, retrieving relevant content presents a challenge for users. To tackle this issue, we propose ROVERS, a system allowing service providers to select the most suitable vehicles for offering location-based applications in urban environments. Utilizing a distributed ranking scheme called CarRank, vehicles autonomously assess their importance to urban users' interests. Additionally, we introduce a centralized recruitment scheme employing game theory, enabling service providers to fairly and optimally select vehicles based on desired coverage, redundancy, and quality criteria. Through comprehensive simulations using realistic mobility data from 2986 vehicles, comparative analysis demonstrates that ROVERS outperforms other selection methods, yielding superior results in vehicle selection for urban services.

1.3 GAP ANALYSIS

Challenges in Sensor-Equipped Rover Operations

Efficient operation of sensor-equipped rovers relies on several key factors, including real-time data processing, storage capabilities, and user accessibility. Let's explore these challenges in greater detail:

1. Real-Time Data Analysis:

While contemporary sensor-equipped rovers excel at collecting vast amounts of data, the ability to derive immediate insights from this data remains limited. Ideally, rovers should possess the capability to analyze and process data as it's generated, enabling real-time decision-making in critical situations. For example, in scenarios such as environmental monitoring or disaster response, timely insights are crucial for taking appropriate actions and mitigating risks effectively.

2. Storage Capacity for Continuous Data Streams:

Sensor-equipped rovers often generate voluminous and continuous streams of data, especially during extended missions or continuous monitoring tasks. Existing storage solutions may struggle to cope with the sheer volume of data, leading to potential data loss and missed opportunities for analysis. Addressing this challenge requires robust storage solutions capable of handling large datasets efficiently, ensuring that valuable information is retained for subsequent analysis and decision-making processes.

3. Broadening User Accessibility:

The data collected by sensor-equipped rovers holds immense value not only for scientists and researchers but also for mission controllers, educators, and the general public. However, current systems may lack user-friendly interfaces and tools for easy data exploration, visualization, and analysis. Enhancing user accessibility involves developing intuitive interfaces that enable diverse stakeholders to access and interpret rover data effectively. This may involve the development of mobile applications, web-based platforms, or other user-friendly interfaces tailored to different user groups and their specific needs.

4. Transitioning from Manual Data Retrieval:

Many existing rover systems rely on manual data retrieval processes, where data is physically retrieved from the rover's storage devices or transmitted manually to a central repository. However, manual retrieval processes are inherently time-consuming, error-prone, and may not be feasible in situations where immediate access to data is critical. Automating data transmission processes can significantly improve efficiency by eliminating manual intervention, enabling seamless and timely access to rover data for analysis and decision-making purposes.

5. Global Control Beyond Local Internet:

While current rover control systems may offer reliable control through internet-based platforms such as Firebase, there are limitations in terms of global accessibility and user experience. For instance, users operating rovers from remote or international locations may encounter connectivity issues or latency issues due to geographical distance. Improving global control beyond local internet access requires a deeper analysis and optimization of existing control systems, ensuring seamless operation and responsiveness from any internet-connected location worldwide.

Addressing these challenges is essential for maximizing the effectiveness and utility of sensor-equipped rovers across a wide range of applications, from scientific research to environmental monitoring and beyond. By enhancing real-time data analysis capabilities, expanding storage capacities, improving user accessibility, automating data retrieval processes, and optimizing global control systems, sensor-equipped rovers can become indispensable tools for gathering, analyzing, and interpreting valuable data in various contexts.

1.4 PROBLEM STATEMENT

This project aims to address the absence of a versatile rover capable of efficiently collecting and processing real-time data from multiple sensors, offering integrated solutions for user-friendly data access through mobile app. The goal is to develop a comprehensive rover platform that supports various sensor modules and incorporates advanced data processing capabilities to cater to diverse user needs. By adopting a modular approach, users can customize the rover with different sensor modules tailored to specific applications. Additionally, the project emphasizes global accessibility and controllability, enabling remote access and management of the rover's operations from anywhere in the world.

1.5 OBJECTIVES

1. Open Source Rover System:
Develop a rover system based on open-source principles, allowing for transparency, collaboration, and community-driven development of the hardware and software components.

2. Long Range Controllability (Global Access):
Implement technologies that enable long-range communication and control of the rover, ensuring operators can access and manage the rover's functions from anywhere in the world.

3. Mobile App for Controlling, Video Surfing, and Data Visualization:
Create a dedicated mobile application that provides intuitive control interfaces, live video streaming capabilities for real-time surveillance, and interactive data visualization tools to present collected data in accessible formats.

4. **Real-Time Data Processing:**
Incorporate onboard data processing capabilities using advanced algorithms and microcontrollers, enabling the rover to analyze and derive insights from sensor data in real-time.

5. Customizable Functionality:
Design the rover with modular components and interfaces to support customizable functionality, allowing users to easily integrate and swap sensor modules, actuators, and other peripherals according to specific application requirements.

CHAPTER 2:

METHODOLOGY

2.1 DESIGN & METHODOLOGY

A. Navigation & Controlling (Mobility):

- **Hardware Setup:**

  The project utilizes an ESP32 microcontroller interfaced with a motor driver kit, specifically the L298N, for controlling the rover's mobility. The ESP32 serves as the central processing unit for coordinating the movement of the rover based on received commands.

- **Real-time Database Integration:**

  To enable global accessibility and remote control, the rover's movement is managed through a real- time database system, such as Firebase. Firebase provides a platform for storing and synchronizing data in real-time, allowing users to control the rover from anywhere with an internet connection.

- **Interfacing with GPS:**

  The ESP32 also interfaces with a GPS module to collect longitude and latitude data. The GPS module continuously updates the rover's current location, which is then transmitted to the Firebase database in real-time. This ensures that users can access the rover's precise location from anywhere, enabling effective monitoring and control.

- **Control Flow:**

  The control flow of the rover involves receiving commands from the Firebase database through the ESP32. These commands dictate the direction and speed of the rover's movement. The ESP32 processes these commands and sends corresponding signals to the motor driver kit, which in turn controls the motors of the rover to achieve the desired movement. When the Boolean value is TRUE the rover mover forward, but when the Boolean value is FALSE the rover stops after 3s lag. Same functions are for reverse movement, left movement, right movement.

- **Data Transmission:**

  Alongside controlling the rover's movement, the ESP32 continuously transmits data, including sensor readings and location information, to the Firebase database. This data transmission occurs in real-time, providing users with up-to-date insights into the rover's surroundings and status.

- **User Interface:**

  The Firebase database is accessed through a user-friendly mobile application or web interface, allowing users to send commands to the rover and receive real-time updates on its location and sensor readings. The interface provides intuitive controls for directing the rover's movement and visualizing collected data, enhancing the overall user experience.

B. Camera Accessibility & Live Streaming:

- **ESP32 CAM Interfacing with FTDI:**

  The ESP32 CAM module is a compact camera module integrated with the ESP32 microcontroller. To program and control the ESP32 CAM module, it needs to be interfaced with an FTDI (USB-to-serial) module. This module acts as a bridge between the ESP32 CAM module and the development environment, facilitating communication for uploading code and controlling the camera.

- **Code Uploading and Live Streaming:**

  Once the ESP32 CAM module is connected to the FTDI module, the required firmware or code is uploaded to the ESP32 microcontroller. This code includes instructions for initializing the camera, capturing video footage, and establishing a live streaming connection. The ESP32 microcontroller handles the camera operation and streaming process based on the uploaded code.

- **Long-Range Capability:**

  The ESP32 microcontroller, which is the heart of the rover's control system, is known for its robust Wi-Fi capabilities. By leveraging Wi-Fi connectivity, the rover can establish a long-range connection to transmit the live video stream. This allows users to remotely access the rover's camera feed from anywhere with internet access, enabling real-time monitoring of the rover's surroundings.

C. Sensors & Instrumentation:

Imaging Sensors:

- **ESP32 CAM Module:**

  The ESP32 CAM module integrates a camera sensor with the ESP32 microcontroller. It captures live video footage of the rover's surroundings, providing visual data for navigation and environmental monitoring

- **LIDAR Sensor/Ultrasonic Sensor:**

  In addition to the camera, the rover is equipped with either a LIDAR sensor or an ultrasonic sensor for 3D mapping and obstacle detection. These sensors enhance the rover's perception capabilities, enabling it to navigate complex environments and avoid collisions.

- **Environmental Sensor:**

  Temperature & Humidity Sensor (DHT11): The DHT11 sensor measures temperature and humidity levels in the surrounding environment. It provides valuable data for assessing environmental conditions and ensuring the rover's operation within safe parameters.

- **Gas Sensor:**

The gas sensor detects hazardous gases in the surrounding area, such as carbon monoxide or methane. It helps to ensure the safety of the environment and personnel by alerting users to potentially harmful gas levels. When the value is retrieved by the gas sensor it goes to the firebase Then that value is shown in the application

Radiation Sensor:

- **PIR (Passive Infrared) Sensor:**

The PIR sensor detects motion and proximity using infrared radiation. It enhances the rover's ability to detect nearby objects and obstacles, improving its navigation and obstacle avoidance capabilities

Geological Sensor:

- **Soil Moisture Sensor:**

The soil moisture sensor measures the moisture content of the soil, providing insights into soil health and environmental conditions. It can be used for applications such as agriculture, environmental monitoring, and soil science research.

- **Interfacing and Data Transmission:**

Each sensor is interfaced with the ESP32 microcontroller, which collects data from all sensors. The collected sensor data is then transmitted to the Firebase real-time database for storage and remote access. This integration allows users to monitor environmental conditions in real-time and make informed decisions based on the data collected by the rover.

D. Software:

- **Mobile Application Development:**

A dedicated mobile application is developed to provide users with remote control and access to the rover's live video stream. The application features an intuitive user interface that allows users to send commands to the rover for navigation and view the live video feed from the ESP32 CAM module in real-time.

- **Global Accessibility:**

The mobile application is designed to provide global accessibility, allowing users to control the rover and view the live video stream from anywhere with an internet connection. This is achieved by integrating Wi-Fi connectivity and leveraging Firebase for real-time data transmission. Users can access the rover's data and video feed from any location, enabling remote monitoring and control capabilities.

Real-Time Analysis:

The rover's onboard processing capabilities enable real-time data analysis, delivering immediate insights into environmental conditions. This facilitates prompt decision-making and response to emerging situations, enhancing the rover's effectiveness in environmental monitoring tasks.

User-Friendly Data Accessibility:

Integration of a mobile application and web platform enables convenient remote control and real-time data visualization. Users can easily access data insights and visualizations, enabling informed decision-making and broader engagement with environmental concerns.

By combining mobility, sensor flexibility, real-time analysis, and user-friendly design, the Data Visualizer Rover represents a significant leap forward in environmental data collection and analysis. It promises to equip researchers, educators, and professionals with the necessary tools to better comprehend and manage our environment in an increasingly data-centric world.

2.2 CONVENTIONAL METHOD DESCRIPTION.

Conventional Environmental Data Collection: Limitations and Challenges

Traditional methods of gathering environmental data have historically faced limitations, impeding their ability to offer timely and comprehensive insights into our surroundings. Below are descriptions of common approaches and their drawbacks:

Manual Sampling:

This technique entails physically gathering environmental samples like soil or water, which are later analyzed in laboratories. Although manual sampling yields detailed and accurate data, it is often laborious, time-consuming, and poses safety risks in hazardous environments.

Static Monitoring Stations:

Fixed monitoring stations are strategically positioned to continuously collect data. However, their immobility restricts their ability to capture data variations across wider areas, limiting their utility in monitoring dynamic environmental changes.

Mobility:

Designed to traverse diverse terrains, the rover effortlessly collects data from various locations, including remote or inaccessible areas, thus providing valuable insights into environmental conditions across different landscapes

Sensor Flexibility:

With its modular design, the rover accommodates a wide array of sensors, catering to diverse data collection needs. Users can equip the rover with sensors tailored to specific environmental parameters, expanding the range of collectible and analyzable data.

2.3 COMPONENTS DESCRIPTION

ESP32: Microcontroller

The ESP32 is a versatile microcontroller and Wi-Fi module widely used in IoT applications. It features dual-core processing, Bluetooth connectivity, and a rich set of peripherals. The ESP32 supports Wi-Fi and Bluetooth protocols, making it ideal for wireless communication and IoT projects requiring connectivity and processing capabilities in a compact package.

Fig-2.3.1. ESP32: Microcontroller

GPS : NEO-6M GPS MODULE

A GPS (Global Positioning System) module is a device that receives signals from GPS satellites to determine its precise location on Earth. It typically includes a GPS receiver, antenna, and processing unit. The module communicates with a microcontroller or other devices to provide accurate latitude, longitude, altitude, and time information, enabling location-based applications like navigation, tracking, and mapping.

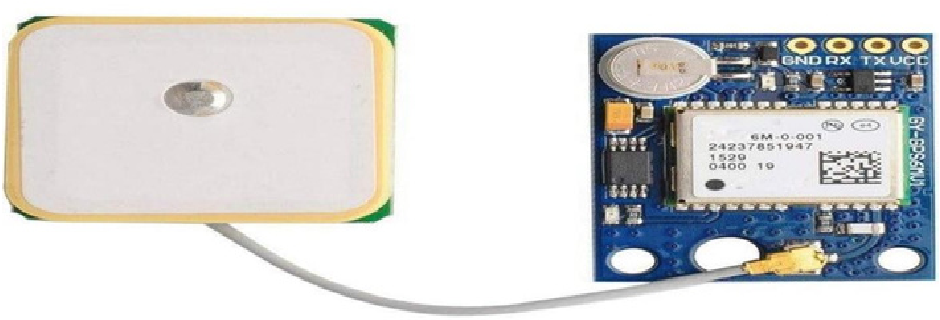


Fig-2.3.2 GPS : NEO-6M GPS MODULE

- **L298N MOTOR DRIVE SHIELD**

The L298N motor driver module is a popular choice for controlling DC motors and stepper motors in various electronic projects. This versatile module provides dual H-bridge circuits, allowing bidirectional control of two motors simultaneously. It can handle motor voltages up to 35 volts and currents up to 2 amps per channel, making it suitable for a wide range of motor types and sizes. With its built-in protection diodes and thermal shutdown mechanism, the L298N ensures reliable operation and safeguards against damage due to overcurrent or overheating. Its simple interface and compatibility with microcontrollers like Arduino make it an ideal choice for hobbyists, educators, and professionals alike, seeking efficient motor control solutions for their projects.

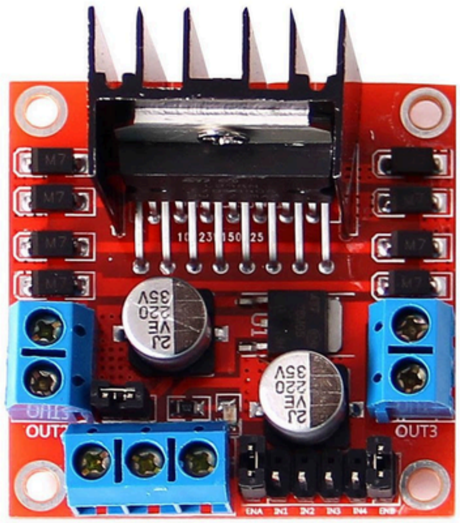


Fig-2.3.3 L298N MOTOR DRIVE SHIELD

- **ULTRASONIC SENSOR : HC-SR04**

An ultrasonic sensor is a device that uses sound waves at frequencies higher than the human audible range to measure distances and detect objects. It typically consists of a transmitter that emits ultrasonic waves and a receiver that listens for the waves to bounce back after hitting an object. By calculating the time taken for the waves to return, the sensor can determine the distance to the object.

Fig-2.3.4 ULTRASONIC SENSOR : HC-SR04

ESP32-CAM

The ESP32-CAM module is a compact development board based on the ESP32 chip, featuring a camera module for image and video processing applications. It integrates a camera sensor (OV2640 or OV7670) and supports Wi-Fi connectivity, making it suitable for IoT projects requiring real-time image capture and transmission.

Fig-2.3.5 ESP32-CAM

PIR SENSOR A PIR (Passive Infrared)

sensor detects motion by sensing changes in infrared radiation emitted by nearby objects. It consists of a pyroelectric sensor that generates a voltage when exposed to infrared radiation, triggering the sensor's output. PIR sensors are used in security systems, automatic lighting, and occupancy detection applications for energy efficiency.

2.3.6. PIR sensor

- **DHT 11 SENSOR**

The DHT11 sensor is a low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure air temperature and relative humidity. The sensor outputs temperature and humidity data digitally, making it easy to interface with microcontrollers like Arduino. The DHT11 is commonly used in weather stations, environmental monitoring systems, and indoor climate control applications.

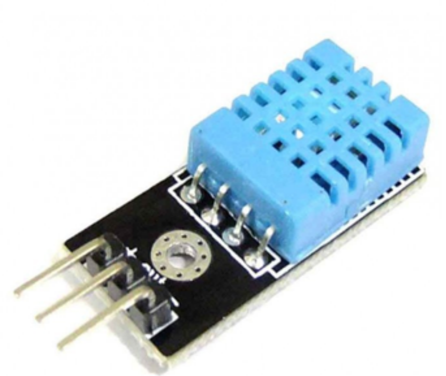


Fig-2.3.7 DHT 11 SENSOR

DC MOTOR: 60RPM-12V Centre Shaft DC Geared Motor

A 60RPM-12V center shaft DC geared motor is a small, slow speed, high torque electric motor. It runs at 60 rotations per minute at 12V and is commonly used in robotics and DIY projects.which means that under normal operating conditions the motor's output shaft rotates at a speed of 60 revolutions per minute

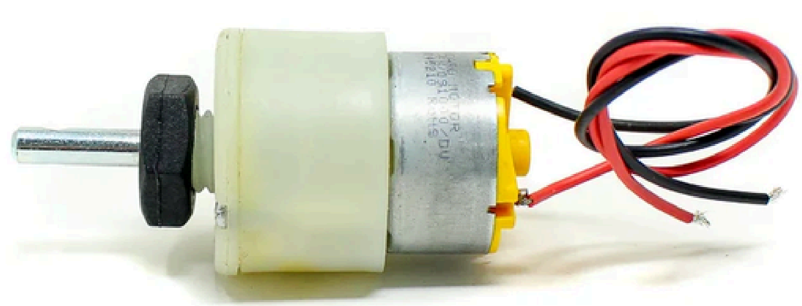


Fig-2.3.8 DC MOTOR: 60RPM-12V Centre Shaft DC Geared Motor

GAS SENSOR: MQ135

The MQ-135 is an air quality sensor that detects various gases like smoke and ammonia. It uses conductivity to measure gas levels and is cheap and easy to use. However, it can't pinpoint specific gases and needs warmup for reliable readings.

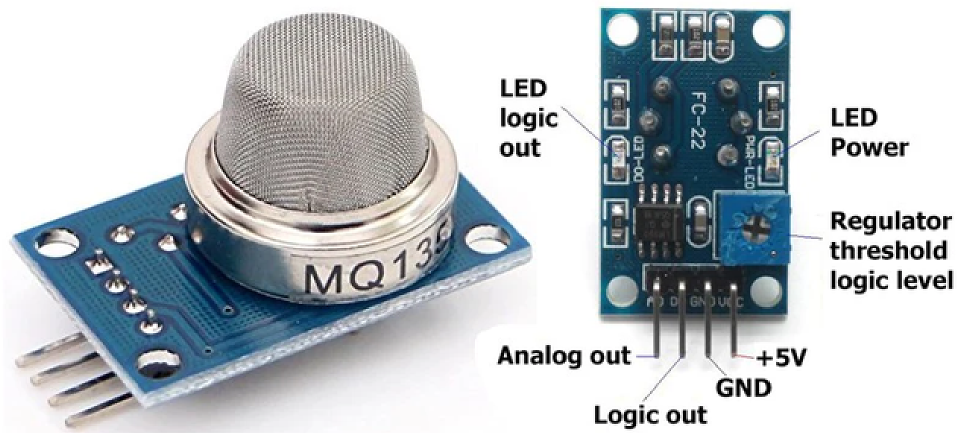


Fig-2.3.9 GAS Sensor: MQ135

SOIL Moisture Sensor

A soil moisture sensor is a device used to measure the moisture content in soil. It's commonly employed in agriculture, gardening, and environmental monitoring to ensure optimal conditions for plant growth or to prevent overwatering.

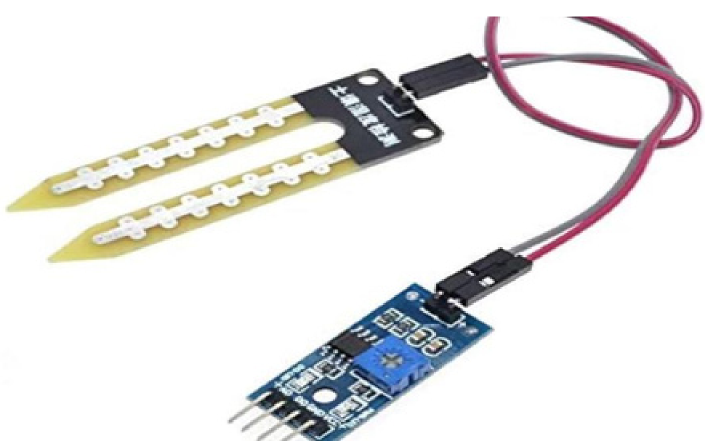


Fig-2.3.10 SOIL Moisture Sensor

OLED DISPLAY

OLED (Organic Light Emitting Diode) displays are a type of flat panel display technology that is becoming very popular in various electronic devices such as like the smartphones, televisions, and wearable devices.

Fig-2.3.11. OLED DISPLAY

SERVO MOTOR

The servo motor, an integral component of modern automation, breaks rotational movement into discrete steps. Its ubiquitous presence spans industries such as robotics, 3D printing, and CNC machining. Renowned for their precision, the stepper motors enable meticulous handling of position and velocity. By translating electrical impulses into mechanical motion, they excel in scenarios demanding exactitude and reliability.

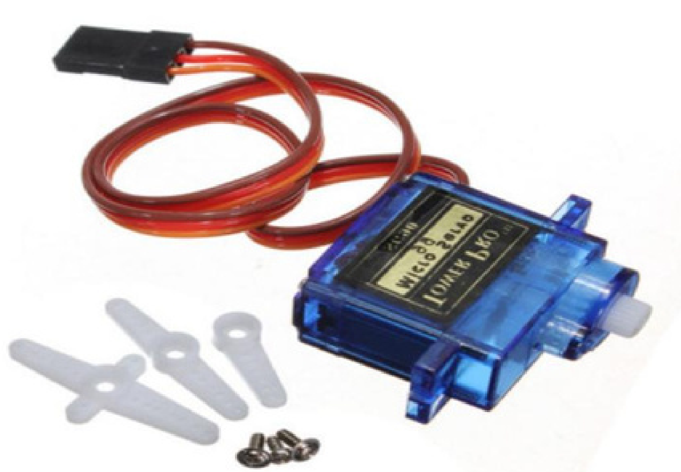


Fig-2.3.12. SERVOMOTOR

Multi Output Voltage Conversion Module

The Multi Output Voltage Conversion Module is a versatile electronic component designed to provide multiple voltage outputs from a single input source. This module serves as an essential tool in various electronic systems where different components require distinct voltage levels for optimal operation. With its compact design and efficient conversion capabilities, the Multi Output Voltage Conversion Module offers convenience and flexibility in power management, enabling engineers and hobbyists to streamline their projects and enhance overall system performance.

Fig-2.3.13 Multi Output Voltage Conversion Module

- **3.7V,1200mAh, Li-ion rechargeable battery**

The rechargeable lithium-ion battery, rated at 3.7 volts and 1200mAh, epitomizes portable power efficiency. Ubiquitous in smartphones, tablets, and cameras, it ensures stable voltage output for diverse electronic needs. Its 1200mAh capacity guarantees prolonged usage between charges. Renowned for lightweight design and enduring performance, lithium-ion batteries are the cornerstone of modern electronic ecosystems.

Fig-2.3.14 Li-ion rechargeable battery

2.4 WORKING

The Data Visualizer Rover isn't just another data-collecting machine; it's a user-centric platform designed to empower exploration and informed decision-making. Here's a deeper dive into its core functionalities:

1. Sensor Activation and Real-Time Data Acquisition:

The rover's mission begins with the activation of its versatile sensor suite. This includes environmental sensors like temperature and humidity gauges, alongside a GPS module for precise location tracking. Gas sensors provide insights into air quality, while PIR sensors (for passive infrared detection) can detect motion or heat signatures in the surrounding environment. Additionally, a high-resolution camera captures valuable visual data, offering a comprehensive picture of the rover's surroundings.

A key innovation lies in the custom-built mobile application. This app acts as the mission control center, allowing users to activate and control these sensors in real-time. Firebase, a mobile backend platform, facilitates seamless communication between the app and the rover. This ensures data collection happens precisely when users trigger commands through the app, eliminating unnecessary data capture and optimizing battery life.

2. Secure and Efficient Data Transmission and Storage:

The collected sensor data doesn't wait – it's instantly transmitted over Wi-Fi to a secure cloud storage solution powered by Firebase. Here, the data isn't just stored, but also continuously updated, creating a comprehensive and readily accessible repository of environmental and situational information. This real-time data transmission ensures minimal data loss while enabling immediate analysis and response capabilities.

3. Global Rover Control from the Palm of Your Hand:

The user-friendly mobile application empowers users to not only control sensor activation but also the rover's movements and functionalities. Firebase integration plays a crucial role once again, enabling real-time control from any location with an internet connection. This global reach empowers users to operate the rover remotely, maximizing its operational potential. Imagine researchers stationed across the globe collaborating on environmental monitoring projects, or disaster response teams deploying the rover from afar to assess hazardous situations.

4. Adaptable Sensor Suite for Diverse Applications:

The Data Visualizer Rover takes adaptability to a whole new level with its unique customizable IC slot. This dedicated slot allows users to tailor the rover's sensor suite based on specific needs. Imagine incorporating specialized soil moisture sensors for agricultural applications, methane detectors for environmental monitoring, or thermal cameras for search and rescue operations! This feature significantly enhances the rover's versatility, making it a valuable tool across a wide range of scenarios.

5. Intuitive Data Visualization for Informed Decision-Making:

The power of the Data Visualizer Rover lies not just in data collection but also in its ability to transform raw data into actionable insights. The data collected by the rover is retrieved in real-time and presented on our custom-built website in a user-friendly, structured graphical format. This intuitive data visualization empowers users to gain valuable insights from the collected information, facilitating informed decision-making. Researchers can analyze environmental trends, farmers can optimize irrigation practices based on real-time soil moisture data, and disaster response teams can leverage the data to strategize rescue efforts.

By combining real-time control, efficient data acquisition and transmission, user-driven customization, and insightful data visualization, the Data Visualizer Rover establishes itself as a powerful and adaptable platform for environmental exploration, data gathering, and ultimately, driving positive change in various fields.

CIRCUIT DIAGRAM :

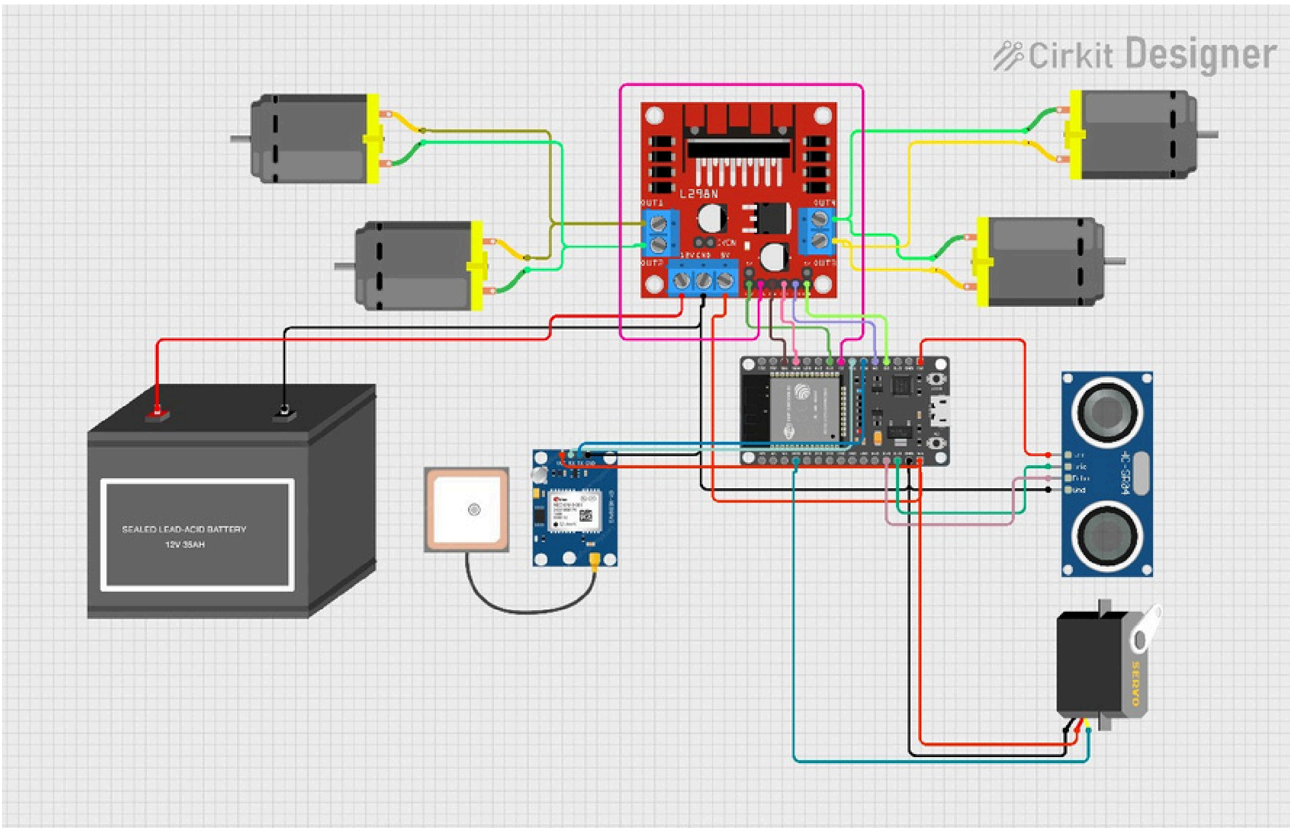


Fig-2.4.1 Navigation and Mobility Circuit diagram

CIRCUIT DIAGRAM :

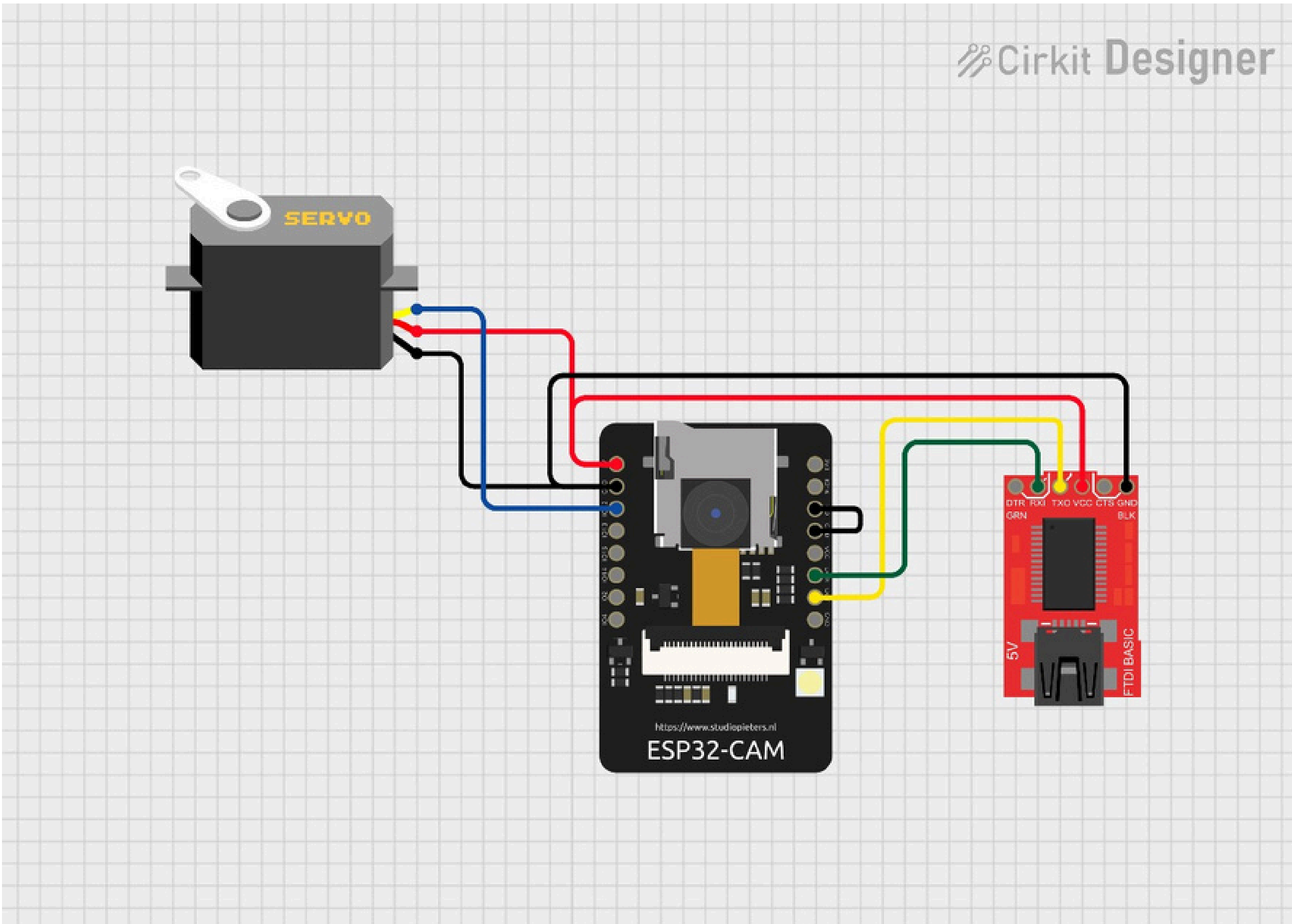


Fig-2.4.2 ESP32 CAM module integration with servomotor

CIRCUIT DIAGRAM :

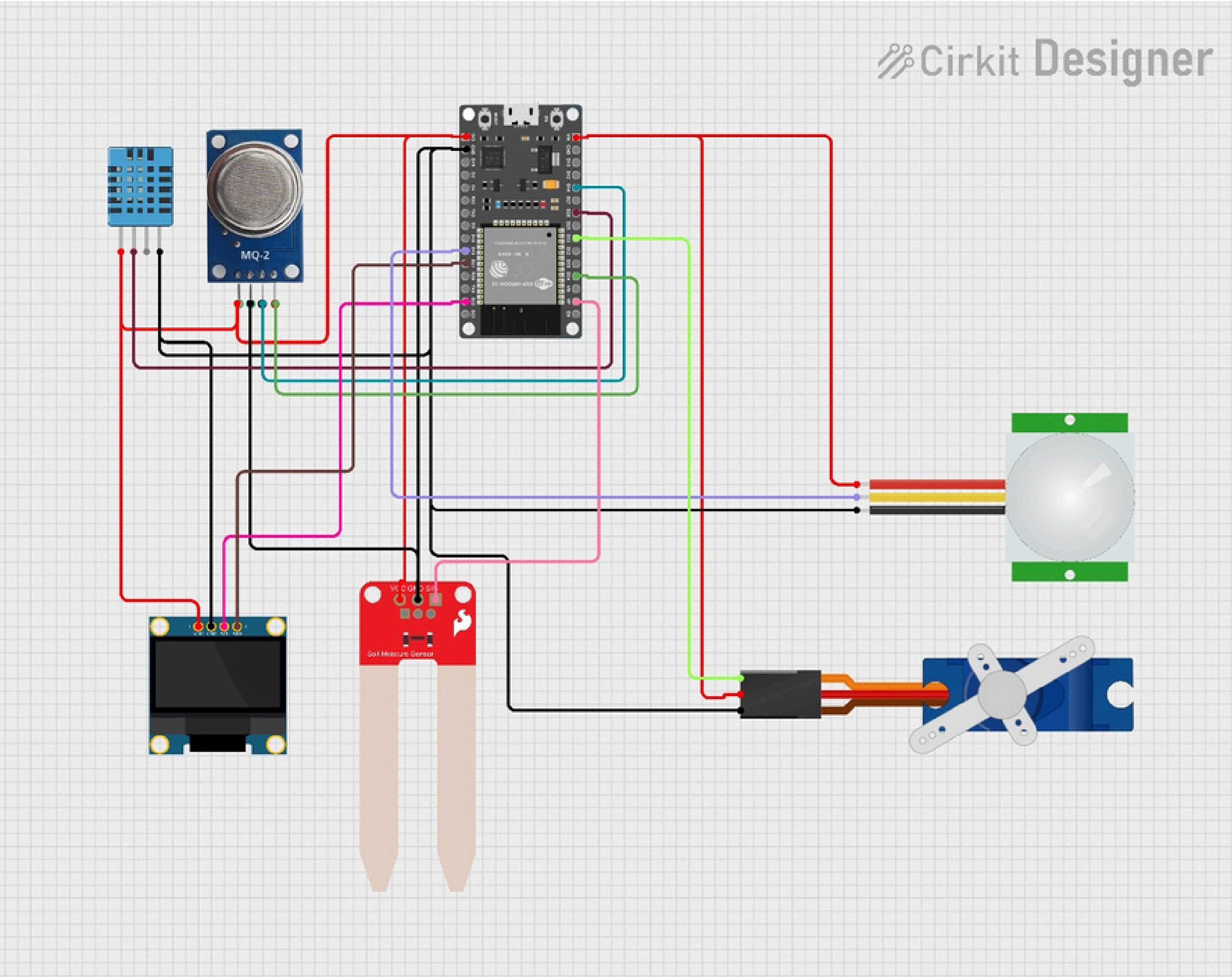


Fig-2.4.3 Circuit Diagram of Sensors Integration with ESP32

BLOCK DIAGRAM

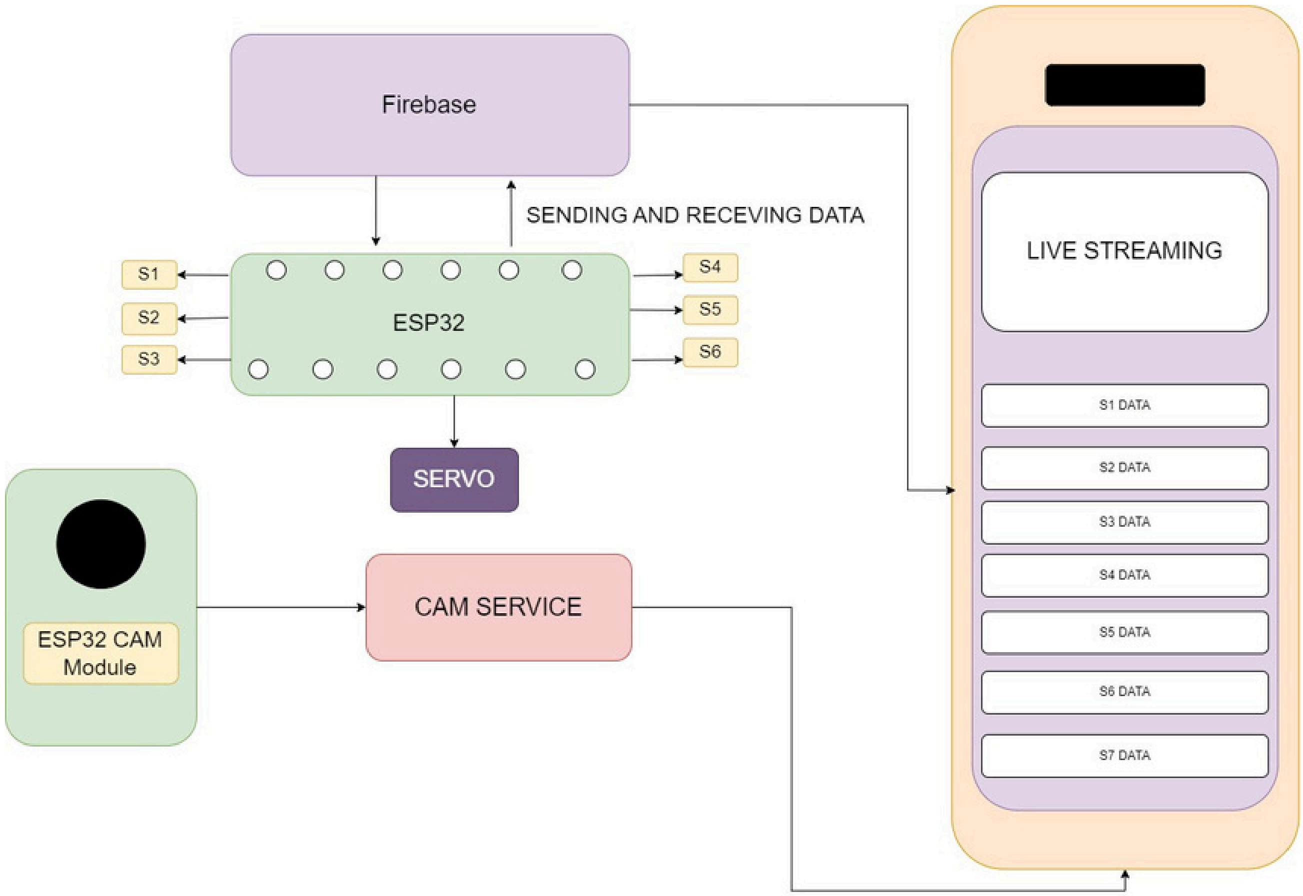


Fig-2.4.4 Block Diagram which depicts the for sensor and cam module

BLOCK DIAGRAM

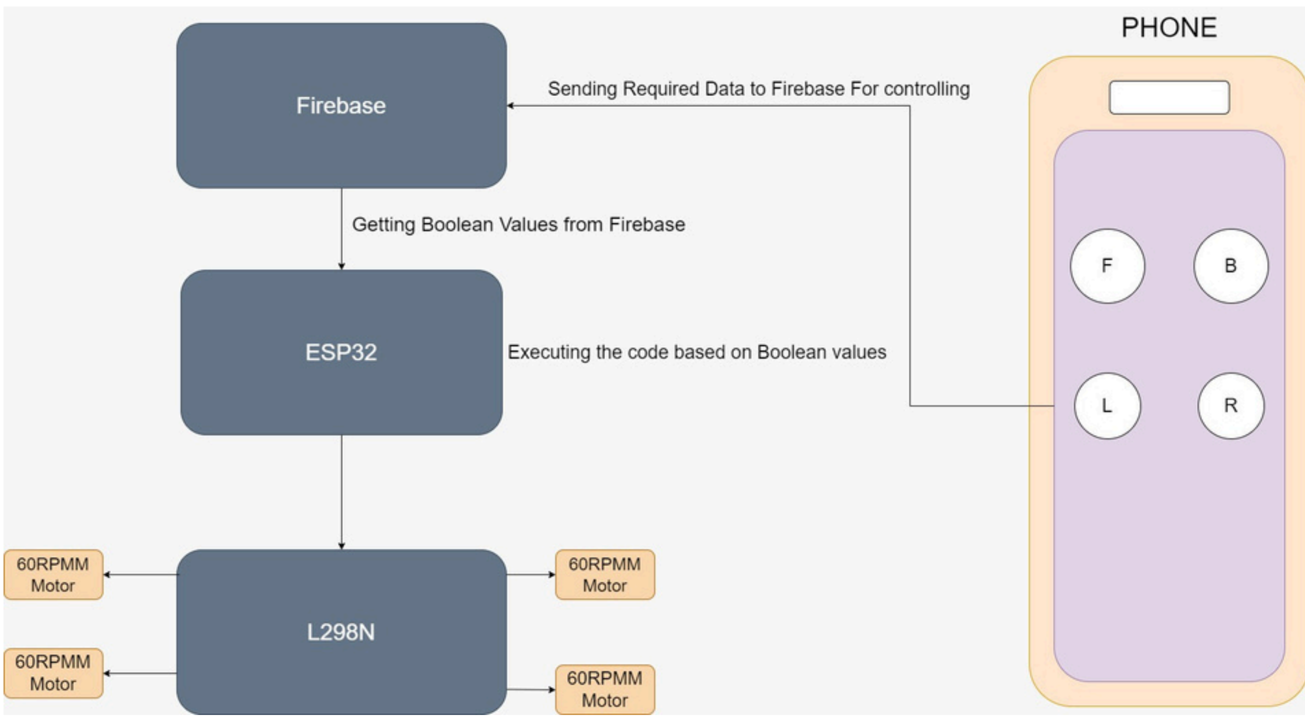


Fig-2.4.5 Block Diagram which depicts the overview of our Rover

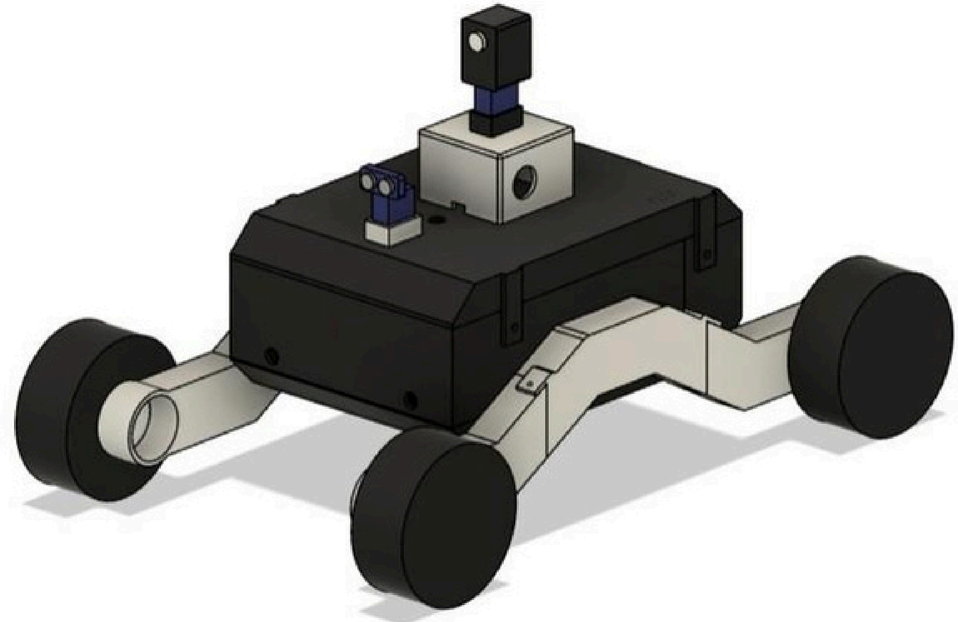
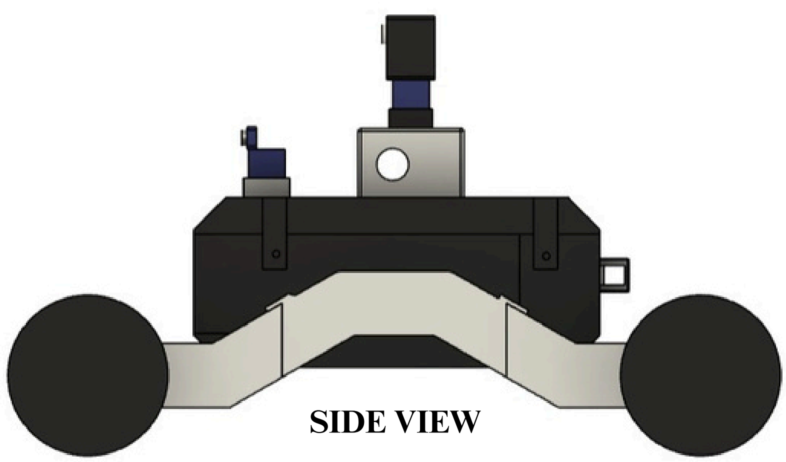
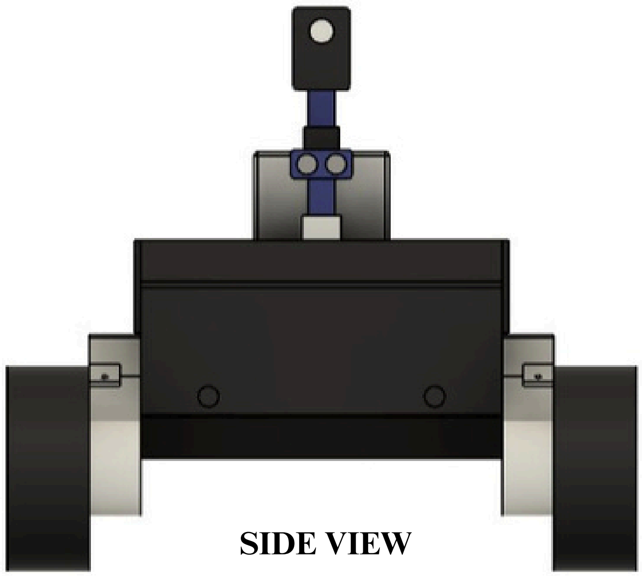


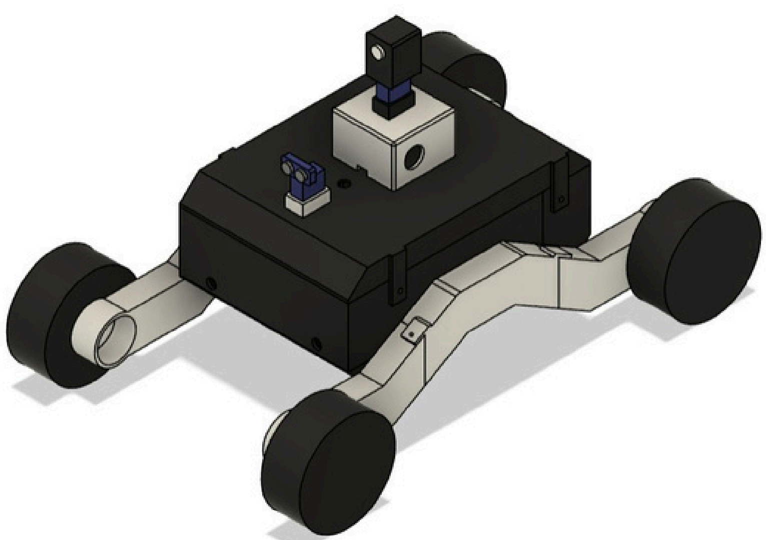
Fig-2.4.6 3D of ROVER MODEL(Hardware)



SIDE VIEW



SIDE VIEW



TOP VIEW

CHAPTER 3.

OUTCOME OF THE PROJECT

3.1 Result with Images

Output on firebase of various sensor:

The image depicts a Firebase project overview page titled "Output on firebase of various sensor". This title suggests the page is designed to monitor real-time sensor readings. Specific sensor data is displayed belowa with labels like "gsensor," "humidity," "LED," "PIR," "temperature," and "USensor" identifying the sensor types. Values are presented alongside each sensor label, providing a snapshot of the current environment. For instance, the gsensor value is 1, humidity is at 64%, and the temperature reads 28.5 degrees Celsius. This visualization allows for quick monitoring and analysis of various environmental conditions

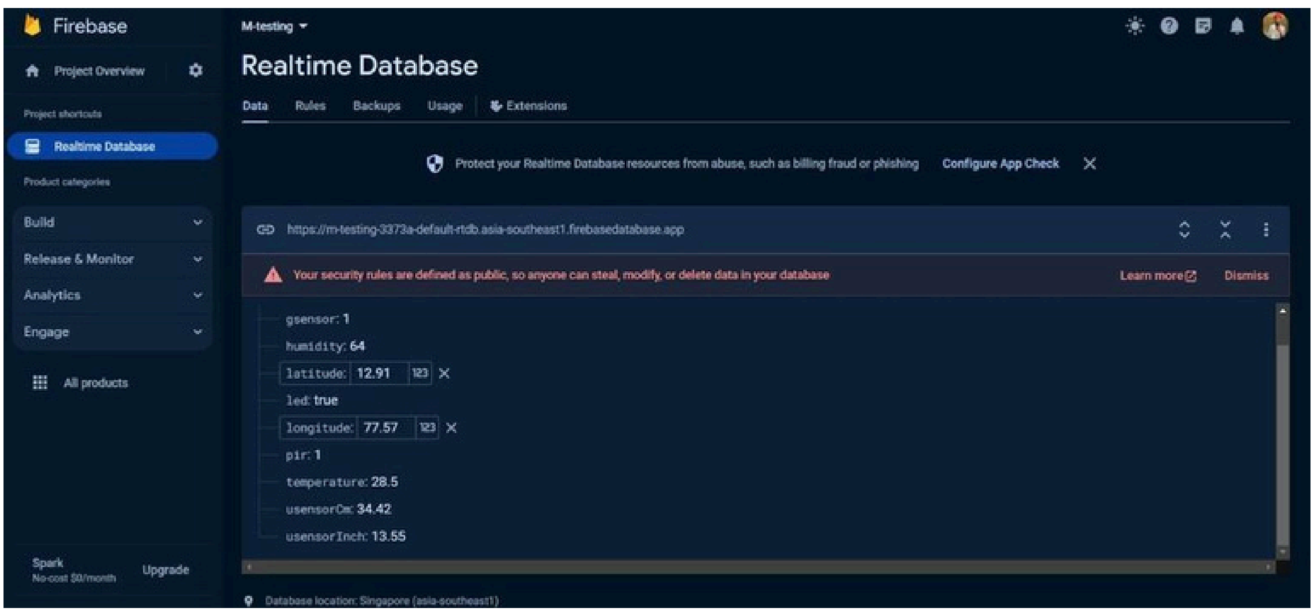


Table- 3.1.1 : The figure shows the real- time values sensed by the different sensors.

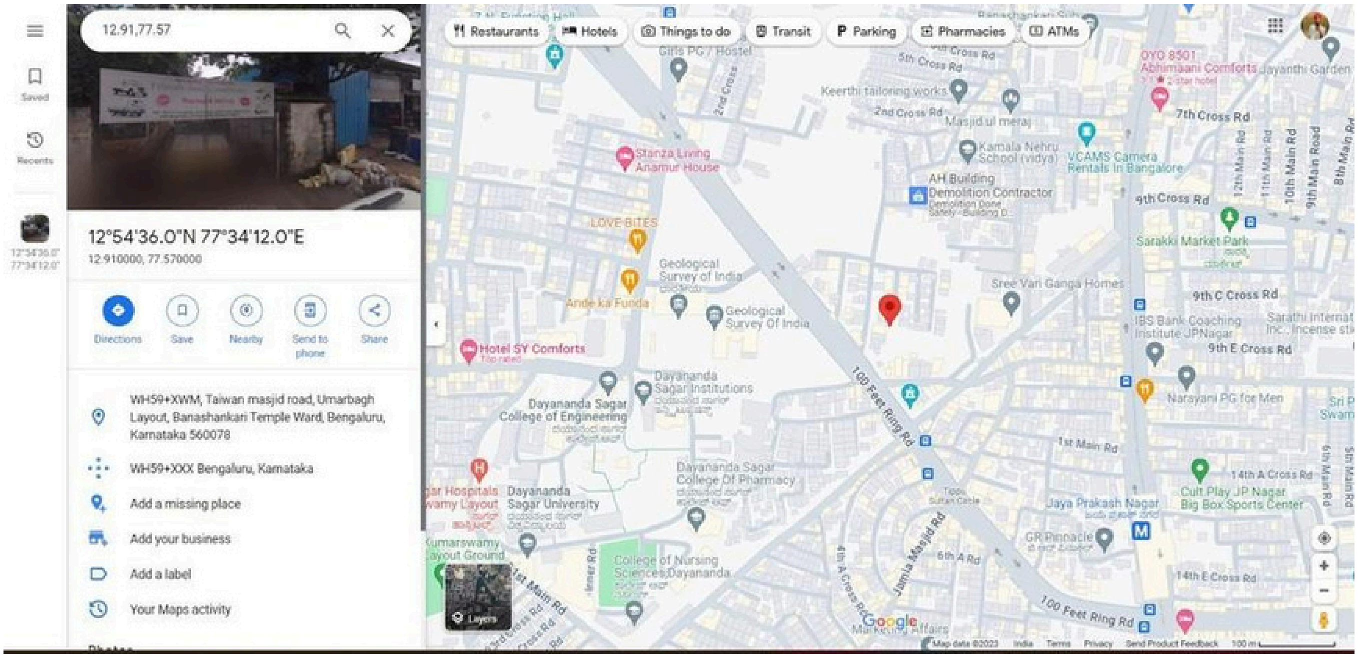


Table-3.1.2 Google Maps location retrieved from longitude and latitude collected by our GPS.

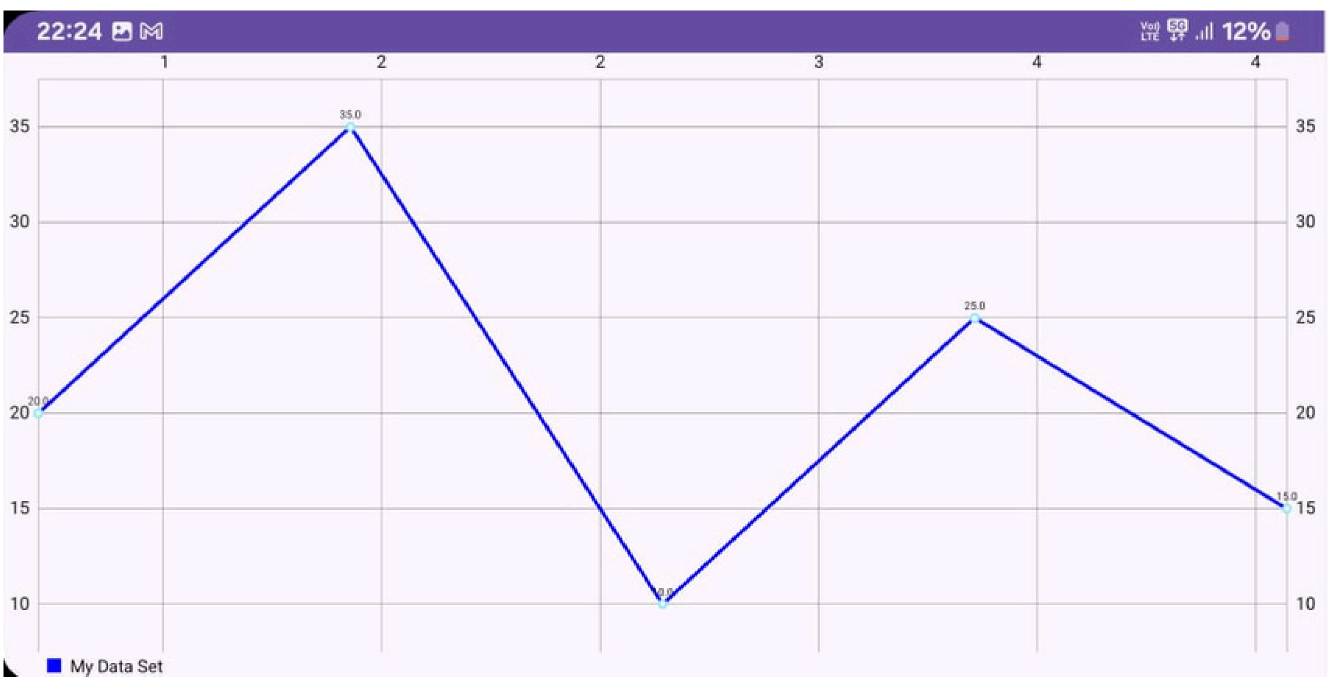


Table-3.1.3: Graphical representation of sensor data.

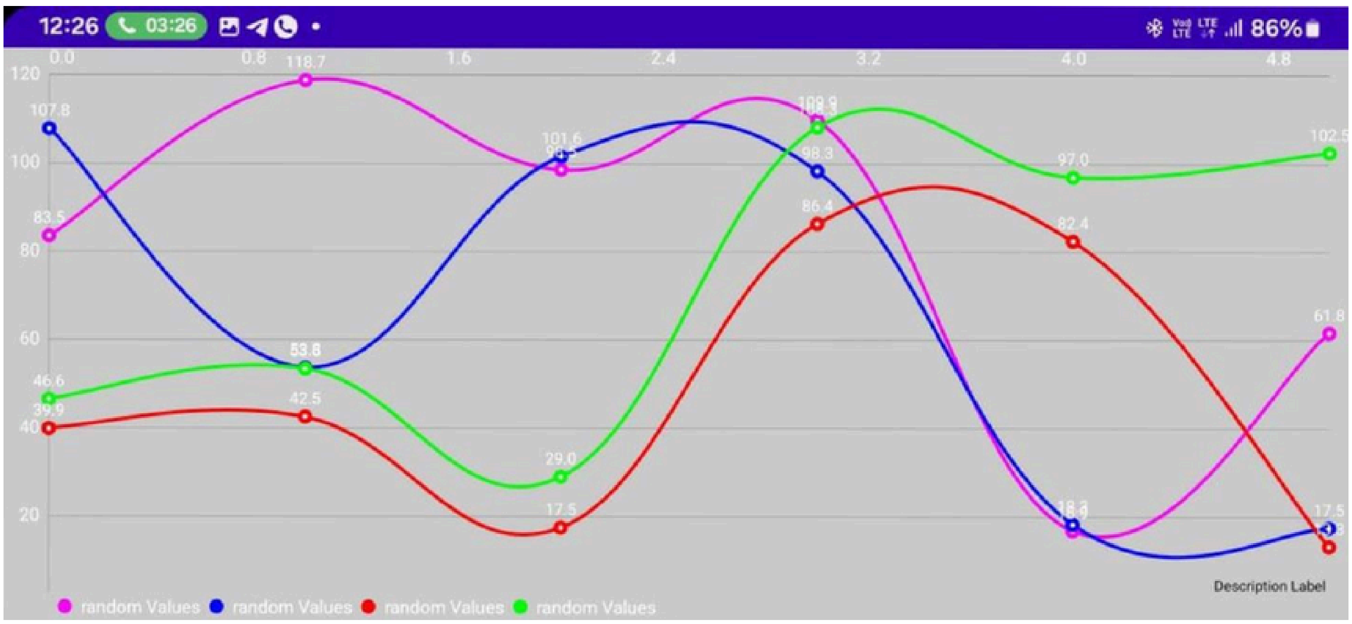


Table-3.1.4 Testing of output with firebase

3.2 APPLICATIONS

1. Environmental Monitoring:

Climate and Weather Analysis: The rover's ability to collect temperature and humidity data makes it invaluable for climate studies, weather forecasting, and environmental research. By gathering real-time data from different locations, researchers can analyze trends, monitor climate patterns, and predict weather phenomena more accurately, aiding in disaster preparedness and resource management efforts.

2. Agriculture:

Soil Condition Assessment: Deploying the rover to assess soil conditions enables farmers and agronomists to make informed decisions about crop selection, irrigation scheduling, and soil management practices. By analyzing soil moisture levels, pH levels, and nutrient content, the rover can recommend customized agricultural interventions, optimizing crop yields and promoting sustainable farming practices.

3. Security and Surveillance:

Remote Surveillance: The rover's capability for remote surveillance offers enhanced security measures in various settings. Whether used for security patrols in urban environments or monitoring remote areas with limited accessibility, the rover provides real-time monitoring and video surveillance, aiding in crime prevention, perimeter monitoring, and emergency response activities.

4. Research:

Scientific Research: The data collected by the rover supports a wide range of scientific studies across disciplines such as geology, biology, and environmental science. Researchers can leverage the rover's mobility and sensor capabilities to gather field data in remote or inaccessible locations, contributing to the advancement of scientific knowledge in areas such as ecosystem dynamics, habitat monitoring, and geological exploration.

5. Educational Applications:

The rover serves as an engaging educational tool for teaching robotics, sensors, and data collection concepts to students and enthusiasts. Through hands-on exploration and experimentation with the rover, learners can develop practical skills in programming, electronics, and data analysis, fostering interest and proficiency in STEM (Science, Technology, Engineering, and Mathematics) fields. Additionally, the rover's open-source nature encourages collaboration and innovation within educational communities, empowering learners to contribute to ongoing research and development efforts in robotics and environmental science.

6. Disaster Response and Management:

In disaster-stricken areas, such as areas affected by earthquakes, floods, or wildfires, the rover can be deployed for rapid assessment and response. It can collect data on environmental conditions, structural integrity, and hazards, helping emergency responders prioritize resources and coordinate rescue efforts effectively.

7. Infrastructure Inspection:

The rover's mobility and sensor capabilities make it ideal for inspecting infrastructure such as bridges, dams, and pipelines. By conducting routine inspections and monitoring structural health parameters, the rover can identify potential issues early, preventing costly failures and ensuring the safety and reliability of critical infrastructure assets.

8. Wildlife Conservation and Monitoring:

In conservation efforts, the rover can gather data on wildlife populations, habitat conditions, and biodiversity. By conducting surveys in remote or sensitive ecosystems, it provides valuable insights for conservation planning, species management, and ecosystem restoration initiatives.

9. Urban Planning and Development:

In urban environments, the rover can collect data on air quality, noise pollution, and traffic patterns. This information aids urban planners and policymakers in making informed decisions about infrastructure development, transportation planning, and environmental regulations, ultimately creating more sustainable and livable cities.

10. Exploration and Mapping:

The rover's mobility enables exploration and mappingof uncharted or inaccessible terrain, such as caves, mountains, or polar regions. It can create high-resolution maps, document geological features, and identify potential resources, supporting scientific exploration and resource discovery efforts.

11. Search and Rescue Operations:

During search and rescue missions in wilderness areas or disaster zones, the rover can assist in locating missing persons or survivors. Equipped with cameras and sensors, it can cover large areas quickly, providing real-time data to aid in search coordination and decision-making.

12. Environmental Impact Assessment:

In industrial or construction projects, the rover can conduct environmental impact assessments by monitoring changes in land use, vegetation cover, and ecosystem health. This data informs decision-makers about potential environmental risks and helps develop mitigation strategies to minimize adverse impacts on the environment.

CHAPTER 4

CONCLUSION AND FUTURE SCOPE

4.1 CONCLUSION

In conclusion, the envisioned rover project represents a pioneering endeavor in the field of robotics and environmental monitoring. By embracing open-source principles and modular design, the project aims to foster collaboration and innovation within the community. The integration of long-range controllability, a dedicated mobile app for intuitive control and data visualization, and real-time data processing capabilities will empower users to explore and analyze environments remotely and efficiently. Future enhancements, such as LIDAR integration for 3D mapping and advanced machine learning for environmental analysis, promise to elevate the rover's capabilities and broaden its applications. With a commitment to continuous improvement and adaptability, this project not only addresses current challenges but also sets a solid foundation for future developments in autonomous robotics and environmental exploration.

4.2 FUTURE SCOPE

The future scope of the project extends beyond its initial objectives and can include several advanced features and capabilities:

1. Integration of LIDAR Sensor for 3D Mapping:

As mentioned, integrating a LIDAR sensor will enable the rover to perform 3D mapping and visualization of the environment. This can involve using GSL (Geographical Survey Language) software or other mapping tools to create detailed and accurate representations of terrain and surroundings.

2.Autonomous Navigation and Path Planning:

Implementing algorithms for autonomous navigation and path planning will enhance the rover's capabilities to navigate complex environmentswithout constant human intervention. This can involve integrating technologies like SLAM (Simultaneous Localization and Mapping) to create maps and localize the rover in real-time.

3. Machine Learning for Environmental Analysis:

Leveraging machine learning techniques, such as pattern recognition and anomaly detection, to analyze environmental data collected by the rover. This can enable the rover to identify and respond to specific environmental conditions or changes autonomously.

4. Enhanced Communication and Connectivity:

Improving communication protocols and integrating technologies like satellite communication or mesh networks toensure the robust and reliable connectivity, especially in remote or challenging environments.

5. Multi-Rover Collaboration:

Exploring the capability of coordinating multiple rovers for collaborative data collection and exploration missions. This can involve developing communication protocols and coordination algorithms for efficient task allocation and information sharing among multiple rovers.

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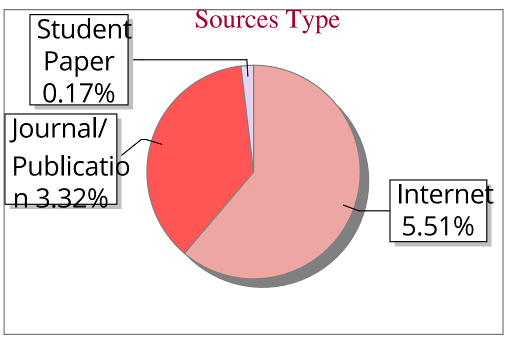

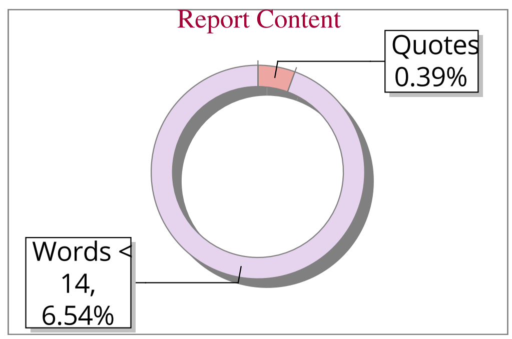

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