AUTONOMOUS GEO-EXPLORATION ROVER

A PROJECT REPORT

ABSTRACT

The Autonomous Geo-Exploration Rover (AGER) project represents a significant advancement in geo-exploration and agricultural technology. Designed to address the limitations of existing methodologies, AGER offers a versatile and efficient platform for optimizing agricultural practices and environmental monitoring in sandy environments.

AGER's key features include autonomous navigation, real-time data collection, and analysis capabilities. Equipped with sensors for soil moisture, nutrient levels, and pest infestations, AGER provides farmers with valuable insights to optimize irrigation, fertilizer application, and pest management practices. By leveraging advanced technologies such as GPS navigation and LoRa communication, AGER can operate autonomously while transmitting data to remote operators for real-time monitoring and decision-making.

The development of AGER involved thorough testing and validation processes to ensure functionality and performance. Unit and integration testing confirmed the seamless integration of individual components, while navigation testing showcased AGER's ability to navigate diverse terrains accurately. Data collection and analysis testing validated the accuracy of collected data, providing meaningful insights for agricultural optimization. Field testing further demonstrated AGER's reliability and effectiveness in real agricultural environments, while endurance testing highlighted its long-term operational capability.

AGER's successful validation underscores its potential impact on improving crop yield, resource management, and scientific research in sandy environments. It holds promise for revolutionizing agricultural practices by providing farmers with precise and timely information to optimize resource use and enhance productivity. Moreover, AGER's capabilities extend to environmental monitoring and conservation efforts, contributing to sustainable agriculture and land management practices.

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CHAPTER 1

INTRODUCTION

The Autonomous Geo-Exploration Rover (AGER) project arises from the pressing need for efficient exploration and data collection in sandy environments, particularly in agriculture. Sandy soils present unique challenges for agriculture, characterized by poor water retention, low nutrient availability, and susceptibility to erosion. Traditional methods of exploration and monitoring in these environments are often labour-intensive, time-consuming, and limited in scope, leading to suboptimal agricultural practices and potential yield losses.

AGER aims to address these challenges by offering a versatile and efficient platform for geo-exploration and agricultural optimization. By integrating advanced sensor technologies, GPS navigation, and autonomous operation capabilities, AGER seeks to revolutionize how data is collected, analyzed, and utilized in sandy environments. The project's scope encompasses precision farming, environmental monitoring, geological exploration, scientific research, educational outreach, and disaster management.

In precision farming, AGER's ability to autonomously navigate fields and collect real-time data on soil moisture, nutrient levels, and pest infestations promises to optimize irrigation, fertilizer application, and pest management practices. This not only enhances crop yield and quality but also promotes resource efficiency and environmental sustainability in agriculture.

Environmental monitoring is another critical aspect of AGER's capabilities. By surveying sandy environments prone to erosion and desertification, AGER provides valuable insights for land conservation and restoration efforts. By monitoring soil health, vegetation cover, and other environmental parameters, AGER contributes to the assessment and mitigation of land degradation, fostering environmental resilience and sustainability.

In geological exploration, AGER's capacity to conduct surveys in sand-rich regions opens up new possibilities for identifying potential mineral deposits and supporting mineral resource exploration and mining operations. This has implications for economic development and resource management, offering opportunities for sustainable exploitation of mineral resources while minimizing environmental impact.

Scientific research is also a key focus area for AGER. By serving as a versatile platform for data collection and experimentation, AGER supports research initiatives in fields such as agronomy, environmental science, geology, and robotics. Its capabilities enable researchers to study various phenomena, develop innovative solutions, and advance scientific knowledge in sandy environments.

AGER's potential as an educational tool is another noteworthy aspect. In universities and research institutions, AGER can be used to teach students about robotics, sensor technology, and their applications in agriculture and environmental science. Hands-on experience with AGER enhances learning and fosters innovation among future generations of scientists and engineers.

Figure 1.1 Autonomous Geo-Exploration Rover

CHAPTER 2

LITERATURE SURVEY

Autonomous Exploration Rovers in Remote Environments

Abstract

This study examines the role of autonomous exploration rovers in remote environments like deserts. Challenges in designing autonomous rovers for navigation through harsh terrains are discussed, drawing insights from existing missions.

Conclusion

Autonomous rovers are vital for scientific research and environmental monitoring in remote areas. Design considerations such as mobility and sensor integration are crucial for their success.

Sensor Integration for Environmental Monitoring

Abstract

This research explores techniques for integrating sensors into autonomous systems for environmental monitoring. Methods for sensor selection, calibration, and data fusion are discussed, focusing on applications in agriculture and environmental science.

Conclusion

Sensor integration enhances the utility of autonomous systems for environmental monitoring, providing accurate and reliable data for decision-making.

Terrain Traversal Techniques for Rovers

Abstract

This study investigates strategies for navigating sandy terrains using autonomous rovers. Different locomotion methods, including caterpillar tracks, are evaluated for their effectiveness.

Conclusion

Caterpillar tracks offer stability and traction, making them promising for navigating sandy environments with autonomous rovers.

Geological Analysis and Mapping Using Autonomous Systems

Abstract

This research explores methodologies for geological analysis and mapping using autonomous systems. Strategies for data collection and integration into digital mapping platforms are discussed.

Conclusion

Autonomous systems facilitate high-resolution geological analysis and mapping, enhancing our understanding of geological processes.

CHAPTER 3

PROBLEM DEFINITION

The Autonomous Geo-Exploration Rover (AGER) project emerges from a critical analysis of the challenges pervading agricultural, environmental monitoring, and geological exploration, with a specific focus on sandy environments. Conventional methods of data collection in these areas, typically involving labour-intensive manual sampling, are marred by inefficiencies, hindering timely and comprehensive insights. This inadequacy severely impedes decision-making processes crucial for optimizing agricultural practices, exacerbating challenges in resource management and environmental conservation.

Sandy soils, characterized by poor water retention and nutrient availability, pose a significant obstacle to achieving optimal crop yields, necessitating precision farming techniques tailored to these unique conditions. Moreover, the prevalence of environmental degradation in sandy environments, manifesting in erosion and desertification, underscores the urgent need for robust monitoring and assessment to guide effective conservation and restoration efforts.

The identification of potential mineral deposits in sand-rich regions further compounds these challenges, as existing exploration methodologies struggle to penetrate these terrains effectively. Additionally, limited access to educational and research resources stifles innovation and scientific progress in related fields, hampering efforts to develop sustainable solutions to complex environmental problems. Furthermore, natural disasters, such as floods and wildfires, present acute challenges in sandy environments, necessitating agile and effective disaster management strategies to mitigate their impact on agricultural productivity and ecosystem health.

In response to these multifaceted challenges, the AGER project is conceived as a groundbreaking initiative to provide a versatile and efficient platform for data collection, analysis, and exploration in sandy environments. Leveraging state-of-the-art technologies such as autonomous navigation, real-time data collection, and analysis capabilities, AGER aims to redefine the boundaries of exploration and monitoring in these challenging terrains. By integrating advanced sensors for soil moisture, nutrient levels, and pest infestations, AGER empowers farmers with precise and timely information to optimize irrigation, fertilizer application, and pest management practices, thereby enhancing crop yields and promoting resource efficiency.

Furthermore, AGER's capacity to conduct surveys in sandy environments offers unparalleled insights into land degradation and mineral exploration, supporting efforts to conserve natural resources and promote sustainable development. Additionally, AGER serves as an invaluable educational tool, providing students and researchers with hands-on experience in robotics, sensor technology, and their applications in agriculture and environmental science. Through its innovative design and demonstrated capabilities, AGER holds immense potential for revolutionizing agricultural practices, advancing scientific research, and contributing to environmental conservation efforts in sandy environments and beyond.

CHAPTER 4

OBJECTIVES

The objectives of the Autonomous Geo-Exploration Rover (AGER) project are ambitious and far-reaching, encompassing a comprehensive approach to addressing the challenges and opportunities presented by sandy environments. AGER aims to revolutionize agricultural practices, environmental monitoring, and geological exploration through the development of a versatile and efficient platform for data collection, analysis, and exploration. One of the primary objectives is to enhance data collection and analysis capabilities by equipping AGER with advanced sensors and autonomous navigation systems.

By autonomously navigating sandy terrains and collecting real-time data on soil moisture, nutrient levels, and pest infestations, AGER will provide farmers with precise and timely information to optimize agricultural practices. Additionally, AGER aims to support precision farming techniques by empowering farmers with actionable insights for irrigation, fertilizer application, and pest management, thereby increasing crop yields and promoting resource efficiency. Moreover, AGER seeks to contribute to environmental monitoring and conservation efforts by monitoring and assessing land degradation, erosion, and desertification in sandy environments.

Furthermore, AGER will conduct geological surveys to identify potential mineral deposits in sand-rich regions, supporting economic development while minimizing environmental impact. Additionally, AGER will serve as an educational tool for universities and research institutions, engaging students and researchers in robotics, sensor technology, and their applications in agriculture and environmental science.

CHAPTER 5

EXISTING METHODOLOGY

The existing methodologies for geo-exploration and agricultural monitoring in sandy environments encompass a range of approaches, each with its own strengths and limitations.

Manual Sampling and Testing

Historically, manual sampling and testing have been the primary methods for gathering data in sandy environments. This approach involves physically collecting soil samples from various locations and conducting laboratory analyses to assess soil properties such as moisture content, nutrient levels, and pH. While manual sampling provides accurate data, it is labour-intensive, time-consuming, and limited in spatial coverage, making it impractical for comprehensive exploration and monitoring efforts.

Figure 5.1 Manual Soil Sampling and Testing

Satellite Imaging

Satellite imaging offers a remote sensing approach to monitoring sandy environments over large spatial scales. While satellite imaging provides valuable insights into broad-scale environmental trends, its spatial resolution

may be insufficient for detailed analysis at the field level, and data may not be available in real-time, limiting its utility for time-sensitive applications.

Figure 5.2 Satellite Imaging of Soil Testing

Unmanned Aerial Vehicles (UAVs)

UAVs, or drones, offer a more agile and flexible alternative to satellite imaging for data collection in sandy environments. UAVs can capture high-resolution imagery and collect data on soil properties, vegetation health, and terrain morphology with greater spatial and temporal resolution. However, flight time and weather conditions can limit data collection, and operational costs may be prohibitive for some users.

Figure 5.3 Drones in Soil Testing

Ground-based Sensor Networks

Ground-based sensor networks consist of a network of sensors deployed across a study area to collect data on various environmental parameters. These sensors can measure soil moisture, temperature, and other soil properties in real-time, providing continuous monitoring capabilities. However, deploying and maintaining sensor networks requires significant initial investment and ongoing maintenance, and data interpretation may be complex due to spatial variability and sensor calibration issues.

Handheld Sensor Devices

Handheld sensor devices offer a portable and cost-effective solution for on-the-go data collection in sandy environments. These devices typically measure soil moisture, nutrient levels, and other soil properties using integrated sensors. While handheld devices are easy to use and provide rapid results, their scalability and coverage may be limited for large-scale agricultural operations, and data interpretation may require expertise.

CHAPTER 6

PROPOSED METHODOLOGY

The proposed methodology for the Autonomous Geo-Exploration Rover (AGER) project involves a comprehensive approach to data collection, analysis, and exploration in sandy environments. The key components of the proposed methodology are as follows,

Real-time Data Collection

- AGER will be outfitted with a suite of sensors to collect real-time data on soil moisture, nutrient levels, temperature, and other environmental parameters.
- These sensors will provide continuous monitoring capabilities, allowing AGER to gather comprehensive data sets for analysis and decision-making.

Advanced Sensor Technologies

- AGER will integrate advanced sensor technologies, including NPK sensors for soil nutrient analysis, thermal imaging cameras for pest detection, and LiDAR sensors for terrain mapping.
- These sensors will enable AGER to capture detailed and accurate data on soil conditions, crop health, and environmental characteristics.

Remote Operation and Control

- AGER will feature remote operation and control capabilities, allowing users to monitor and control the rover from a distance using wireless communication technologies such as LoRa.
- This remote operation capability will enhance AGER's versatility and accessibility, enabling users to deploy the rover in remote or hazardous environments with ease.

Localization and Navigation

- Integrating GPS modules with a 5Hz update rate provides accurate localization for the rover.
- Navigation algorithms utilizing GPS data enable efficient path planning and obstacle avoidance, ensuring optimal exploration routes and minimizing the risk of collisions.

Communication System

- Implementing LoRa modules facilitates long-range bidirectional communication between the rover and the base station.
- Reliable data transmission protocols over LoRa ensure seamless exchange of information, enabling real-time monitoring and control of the rover's operations.

Camera System

- Choosing a drone FPV camera with wireless transmission capabilities allows for real-time viewing of the rover's surroundings.
- Setting up a receiver system connected to an Android device enhances situational awareness for operators, enabling remote monitoring and decision-making.

Field Testing and Validation

- The proposed methodology will be validated through extensive field testing in real-world agricultural and environmental settings.
- Field tests will evaluate AGER's performance in navigating diverse terrains, collecting accurate data, and operating autonomously under various conditions.

CHAPTER 7

HARDWARE REQUIREMENTS

7.1 ARDUINO MEGA

The Arduino Mega is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, 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 an AC-to-DC adapter or battery to get started.

Figure 7.1 Arduino Mega

Feature	Specification
Microcontroller	ATmega2560
Operating Voltage	5V
Digital I/O Pins	54 (15 PWM)
Analog Input Pins	16

Flash Memory	256 KB
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
USB Interface	ATmega16U2
Communication	UART, SPI, I2C/TWI
Programming	ICSP, Preloaded with bootloader
Dimensions	101.52 mm x 53.3 mm
Weight	37 g
Operating Temperature	-40°C to +85°C

Table 7.1 Specifications of Arduino Mega

7.2 ARDUINO NANO

The Arduino Nano is a small, breadboard-friendly board that provides all the functionalities of the Arduino Uno in a smaller form factor. It's popular for projects where space is limited and is commonly used in prototyping and embedded systems.

Figure 7.2 Arduino Nano

Feature	Specification
Microcontroller	ATmega328
Architecture	8-bit AVR
Clock Speed	16 MHz
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA (recommended)
Flash Memory	32 KB
SRAM	2 KB
EEPROM	1 KB
Input Voltage (Vin)	7-12V
USB Interface	CH340G
Communication	UART (via USB connection), SPI, I2C/TWI

Table 7.2 Specifications of Arduino Nano

7.3 NPK SENSOR

A Soil NPK (Nitrogen, Phosphorus, and Potassium) sensor is a device used to measure the nutrient levels in soil, particularly the concentrations of these three essential nutrients. NPK stands for the three primary nutrients essential for the growth and flourishing of plants: nitrogen, phosphorus, and potassium.

- Nitrogen is responsible for the growth and greenness of plant leaves.
- Phosphorus helps the plant grow strong roots, fruit, and flowers.
- Potassium improves the overall health and hardiness of a plant.

Figure 7.3 NPK Sensor

Feature	Specification
Communication Interface	RS485
Operating Voltage	5V
Maximum Power Consumption	≤0.15W
Operating Temperature Range	-40°C to 80°C
NPK Parameters	Range: 0-1999 mg/kg (mg/L)
Resolution	1 mg/kg (mg/L)
Precision	±2%FS
Response Time	≤1 second
Protection Grade	IP68
Probe Material	316 Stainless Steel
Sealing Material	Black Flame-Retardant Epoxy Resin
Default Cable Length	2 meters (customizable)
Dimensions	45 mm x 15 mm x 123 mm
Compatibility	Compatible with RS485 devices and systems

Table 7.3 Specifications of NPK Sensor

7.4 MAX845

The MAX485 TTL to RS485 Module facilitates communication between devices using the RS485 standard, which is particularly suitable for long-range, high-speed communication in noisy environments. It enables data transfer between microcontrollers and devices over long distances, making it ideal for industrial applications and similar environments.

Figure 7.4 MAX485

Feature	Specification
Signal Conversion	TTL to RS485
Operating Voltage	5V
Communication Standard	RS485
Maximum Devices	Up to 32 devices
Maximum Cable Length	Up to 1.2 km (4000 ft)
Maximum Data Rate	10 Mbit/s
Application	Office and industrial applications
Isolation	Non-isolated

Table 7.4 Specifications of MAX845

7.5 GPS NEO-6M

The U-blox NEO-6M GPS Module is a standalone GPS receiver designed to provide accurate positioning and timing information. It features advanced anti-jamming technology and offers multiple interfaces for communication with external devices. With its compact size and low power consumption, it is suitable for various applications such as navigation, tracking, and timing synchronization.

Figure 7.5 GPS NEO-6M

Feature	Specification
Receiver Type	Standalone GPS Receiver
Communication Interface	UART
Channels	50 channels (GPS L1 frequency - SBAS: WAAS, EGNOS, MSAS, GAGAN)
Time-To-First-fix (TTFF)	Cold Start: 32 seconds
	Warm Start: 23 seconds
	Hot Start: <1 second
Maximum Navigation Update Rate	5Hz (5 updates per second)
Default Baud Rate	9600 bps
Memory	EEPROM with battery backup

Sensitivity	-160 dBm
Supply Voltage	3.6V
Maximum DC Current at Any Output	10mA
Operation Limits	Gravity: -4g
	Altitude: 50000m
	Velocity: 500m/s
Operating Temperature Range	-40°C to 85°C

Table 7.5 Specifications of GPS NEO-6M

7.6 LoRa 433MHz

The E32-433T30D1B LoRa Wireless Transmitter and Receiver RF Module is a high-performance wireless communication module designed for long-range transmission in various applications. It utilizes LoRa modulation technology to achieve long-distance communication with low power consumption. With its flexible interface and robust RF performance, it offers reliable data transmission over extended distances.

Figure 7.6 LoRa 433MHz

Feature	Specification
Model	E32-433T30D1B

Type	CDMA (Code Division Multiple Access)
Working Frequency	433 MHz
RF Connector	SMA-K
Input Supply Voltage (VDC)	2.3 - 5.5V
Transmitting Power	10 - 20 dBm
Interface	UART
Receiving Sensitivity	-146 dBm
Air Data Rate	0.3 kbps - 19.2 kbps
Buffer	512 bytes
Maximum Communication Distance	8000 meters
RF IC	SX1278, SX1276

Table 7.6 Specifications of LoRa 433MHz

7.7 SMA ANTENNA

The 433MHz LoRa antenna is designed to enhance the wireless communication performance of devices operating within the 433MHz frequency band, particularly those utilizing LoRa modulation technology. With its optimized design and characteristics, it helps to improve the signal transmission and reception capabilities of LoRa-enabled devices, enabling reliable long-range communication in various applications.

Figure 7.7 SMA Antenna

Feature	Specification
Center Frequency	433 MHz
Wavelength	¼-wave
VSWR (Voltage Standing Wave Ratio)	< 2.0 typical at center
Peak Gain	3.6 dBi
Impedance (Ω)	50
Operating Temperature	-20°C to +85°C
Connector	RP-SMA (SubMiniature version A)

Table 7.7 Specifications of SMA Antenna

7.8 DC MOTOR

The 33GB-520 DC Motor is a high-speed metal gear motor suitable for various applications requiring precise control over speed and torque. With its robust construction and efficient design, it provides reliable performance in demanding environments. This motor is designed for use with a rated voltage of 12V and features a brush commutation system for smooth operation.

Figure 7.8 DC Motor

Specification	Value
Model	33GB-520
Rated Voltage	12V DC

No-load Current	100mA
Operating Voltage Range	6-12V
Commutation	Brush
Efficiency	IE 4
Weight	100g
Maximum Current	1.2A
Maximum Torque	0.2 Nm
Speed	350 rpm
Gear Type	Metal gears

Table 7.8 Specifications of DC Motor

7.9 L298N MOTOR DRIVER

The L298N Motor Driver is a popular dual H-bridge motor driver module widely used in robotics, automation, and other projects requiring precise control over DC motors. It provides bidirectional control of two motors or one stepper motor, allowing for forward and reverse motion as well as speed control. The module incorporates the L298N IC, which consists of two H-bridge circuits capable of handling currents up to 2A per channel. With its wide operating voltage range of 5V to 35V, it is suitable for various applications.

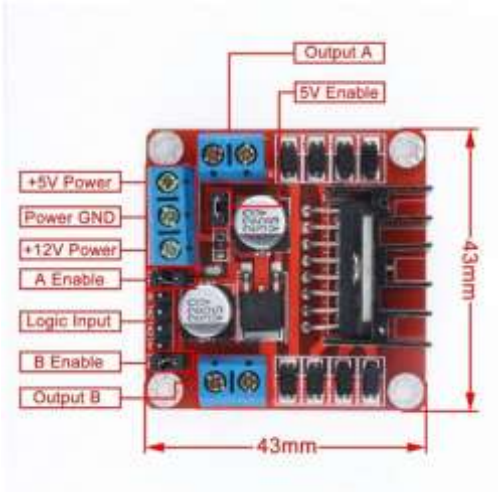

Figure 7.9 L298N Motor Driver

Specification	Value
Item Type	L298N Motor Driver
Current Rating (A)	2
Voltage Rating (V)	5 to 35
Driver IC	Double H Bridge L298N
Max. Supply Voltage (V)	46
Operating Voltage (VDC)	5 ~ 35
Max. Operating Current (A)	2
Logical Voltage (V)	5V
Driver Current (A)	2A
Logical Current (mA)	0-36mA
Max. Continuous Power (W)	25W

Table 7.9 Specifications of L298N Motor Driver

7.10 LINEAR SCREW DRIVE STEPPER MOTOR

The SM15-80L 2 Phase 4 Wire Drive Stepper Motor Linear Screw is a precision sliding table designed for use as the XY axis in DIY laser engraving machines. It features a high-quality stainless steel construction, offering durability, corrosion resistance, and a long service life. This sliding table provides smooth and accurate linear motion, making it suitable for precise positioning and movement in laser engraving applications.

Figure 7.10 Linear Screw Drive Stepper Motor

Specification	Value
Screw Diameter	3 mm
Screw Length	90 mm
Slider Width	15 mm
Step Angle	18 degrees
Voltage	DC 4-9V
Current	500mA
Dimensions (LxWxH)	105 x 15 x 14 mm
Motor Type	2 phase 4 wire

Table 7.10 Specifications of Linear Screw Drive Stepper Motor

7.11 A4988 DRIVER

The A4988 is a popular stepper motor driver module widely used in 3D printers, CNC machines, and other applications requiring precise control over stepper motors. It is designed to provide efficient and reliable motor control, enabling smooth and accurate movement of stepper motors. With its compact size and versatile features, the A4988 is favoured by hobbyists and professionals alike for its ease of use and performance.

Figure 7.11 A4988 Driver

Specification	Value
Model Series	A4988 Series
Voltage Rating (V)	8 to 35VDC
Current Rating (A)	1 to 2
Input Voltage (VDC)	8 ~ 35
Logic Voltage (V)	3 ~ 5.5
Current (A) w/o Heatsink	1A
Current (A) with Heatsink	2A

Table 7.11 Specifications of A4988 Driver

7.12 BUCK CONVERTOR

The LM2596S DC-DC Buck Converter Power Supply is a versatile module capable of converting DC voltage levels efficiently. It supports an output current rating of 2A, with a maximum of 3A when equipped with an additional heatsink. Operating at a switching frequency of 150 kHz, it ensures stable performance while maintaining a high conversion efficiency of up to 92%. With precise load and voltage regulation of ±0.5%, it delivers reliable power output. Its industrial-grade temperature range of -40°C to +85°C makes it suitable for a wide range of applications.

Figure 7.12 Buck Convertor

Specification	Value
Output Current	Rated: 2A, Maximum: 3A (Additional heatsink required)
Switching Frequency	150 kHz
Operating Temperature	Industrial grade (-40°C to +85°C)
Conversion Efficiency	92% (highest)
Load Regulation	± 0.5%
Voltage Regulation	± 0.5%
Dynamic Response Speed	5% in 200 μs

Table 7.12 Specifications of Buck Convertor

7.13 Li-ION BATTERY

The Li-ion battery is a rechargeable energy storage solution, featuring a capacity of 2600mAh and an output voltage of 3.7V. Constructed with Lithium-Ion material, it offers reliability and durability for various applications. With a diameter of 18.2mm and a length of 65mm, it provides a compact form factor suitable for portable devices. This battery operates within a wide temperature range, making it versatile for use in different environments.

Figure 7.13 Li-Ion Battery

Parameter	Value
Current Capacity (mAh)	2600
Output Voltage (V)	3.7
Charge Rate	3C
Max Current Capacity (A)	7.8
Material	Lithium-Ion
Dimensions	Length: 65mm, Diameter: 18.2mm
Operating Temperature	Charge: 0 to 45°C, Discharge: -20 to 60°C
Storage Temperature	7 days: -20 to 60°C, 3 months: -20 to 40°C, 1 year: -20 to 25°C

Table 7.13 Specifications of Li-ion Battery

7.14 CAMERA WITH TRANSMITTER

The IDC-681H FPV Camera is a compact and lightweight camera designed for First Person View (FPV) applications. Featuring high picture quality at 600TVL resolution, it delivers clear and detailed video output. With its low power consumption and plug-and-play design, it is ideal for DIY projects and FPV racing. Equipped with a 25mW 40-channel video transmitter (VTX), it offers versatile frequency options and is powered by a 1S LiPo battery for convenient operation.

Figure 7.14 Camera with Transmitter

Specification	Value
Camera Type	FPV Camera
Resolution	600TVL
Power Output	25mW
Channels	40 channels with Race Band
Frequency	5.8GHz
Bands	6
Total Channels	48
Raceband Frequency	5658-5917MHz
Power Source	1S LiPo battery

Table 7.14 Specifications of Camera with Transmitter

7.15 CAMERA RECEIVER

The ROTG01 (UVC OTG FPV Receiver) is a compact and versatile receiver designed for use with Android smartphones or tablets. It enables users to transform their mobile devices into FPV monitors, allowing for real-time video transmission from FPV drones or other compatible sources. With its UVC (USB Video Class) OTG (On-The-Go) compatibility, it offers plug-and-play functionality with Android devices, making it convenient for FPV enthusiasts on the go.

Figure 7.15 Camera Receiver

Specification	Value
Model	ROTG01 (UVC OTG FPV Receiver)
Number of Channels	150
RF Range	5645~5945 GHz
Receiver Sensitivity (dBm)	-90
Operating Voltage (VDC)	5
Current Consumption (mA)	200
Operating Temperature (°C)	-10 to 60
Connector to Connect Antenna	SMA Female
Antenna Length (mm)	110
Video Format Supported	NTSC/PAL

Table 7.15 Specifications of Camera Receiver

CHAPTER 8

SOFTWARE REQUIREMENTS

8.1 ARDUINO IDE

The Arduino Integrated Development Environment (IDE) stands as a cornerstone in the world of microcontroller programming, offering a rich ecosystem of tools and features to support users at every level of expertise. At its core, the IDE provides a robust code editor equipped with essential functionalities such as syntax highlighting, auto-completion, and error detection, ensuring a smooth coding experience for beginners diving into the world of embedded systems.

Figure 8.1 Arduino IDE

Beyond the editor lies the heart of the IDE's functionality: the compilation and upload process. Seamlessly integrated into the workflow, the IDE's compilation engine translates human-readable code into machine-executable instructions, leveraging the power of the Arduino board's microcontroller to bring projects to life. Once compiled, the IDE orchestrates the transfer of these instructions onto the Arduino board, fostering a seamless connection between the user's code and the physical hardware.

8.2 PYTHON

Python's appeal lies in its simplicity, readability, and versatility. Its clean syntax, dynamic typing, and extensive standard library streamline development, while support for multiple programming paradigms accommodates diverse coding styles. Python's cross-platform compatibility ensures seamless deployment, and its integration capabilities facilitate interoperability with other languages and technologies. The language's active community and comprehensive documentation provide invaluable resources for learning and troubleshooting. With a vast ecosystem of libraries and frameworks spanning various domains, Python empowers developers to tackle complex projects efficiently. Whether building web applications, analyzing data, or delving into machine learning, Python remains a top choice for its accessibility and power.

8.2.1 Pyserial

PySerial is a Python library used for serial communication, enabling interaction between Python applications and devices connected via serial ports. It provides a simple interface for reading from and writing to serial ports, allowing Python programs to communicate with microcontrollers, sensors, and other hardware devices. PySerial supports various platforms, including Windows, macOS, and Linux, making it versatile for a wide range of applications. With PySerial, developers can easily establish serial connections, conFigureure communication parameters such as baud rate and parity, and exchange data with serial devices, facilitating tasks like data logging, device control, and sensor monitoring in Python applications.

Run the below command in the command prompt to install pyserial,

```
pip install pyserial
```

8.2.2 Tkinter

Tkinter is a Python library for building graphical user interfaces (GUIs), providing developers with tools to create interactive applications. With its simplicity and seamless integration with Python, Tkinter facilitates the rapid development of GUIs for various purposes. Developers can design interfaces by arranging widgets and defining event-driven behavior, making it accessible for both beginners and experienced programmers. While Tkinter may lack some advanced features found in other GUI frameworks, its cross-platform compatibility and ease of use make it a popular choice for desktop application development. Overall, Tkinter remains a versatile solution for building intuitive and interactive user interfaces in Python.

Run the below command in the command prompt to install pyserial,

```
pip install tkinter
```

8.2.3 Folium

Folium is a Python library used for creating interactive maps and visualizations. Leveraging the power of Leaflet.js, Folium allows developers to generate dynamic maps directly within Python code, eliminating the need for external tools or services. With Folium, users can customize maps with various features such as markers, popups, and tooltips, enhancing the presentation of geographical data. Its integration with data manipulation libraries like Pandas enables seamless visualization of spatial data, making it a valuable tool for geospatial analysis and visualization tasks. Folium's simplicity, flexibility, and rich feature set make it a popular choice among Python developers for creating compelling and informative maps effortlessly.

Run the below command in the command prompt to install pyserial,

```
pip install folium
```

8.2.4 Openpyxl

Openpyxl is a Python library for reading and writing Excel spreadsheet files (.xlsx). It provides an intuitive and powerful interface for manipulating Excel data, enabling developers to automate tasks such as creating, modifying, and analyzing spreadsheets programmatically. With Openpyxl, users can read and write data to individual cells, format cells and ranges, create charts, and perform various data manipulation operations. This library supports a wide range of Excel features, including formulas, hyperlinks, images, and styles. Openpyxl's simplicity and flexibility make it a valuable tool for automating Excel-related tasks in a wide range of applications, from data analysis to reporting and automation.

Run the below command in the command prompt to install pyserial,

```
pip install openpyxl
```

CHAPTER 9

MODELING

9.1 CHASSIS DESIGN

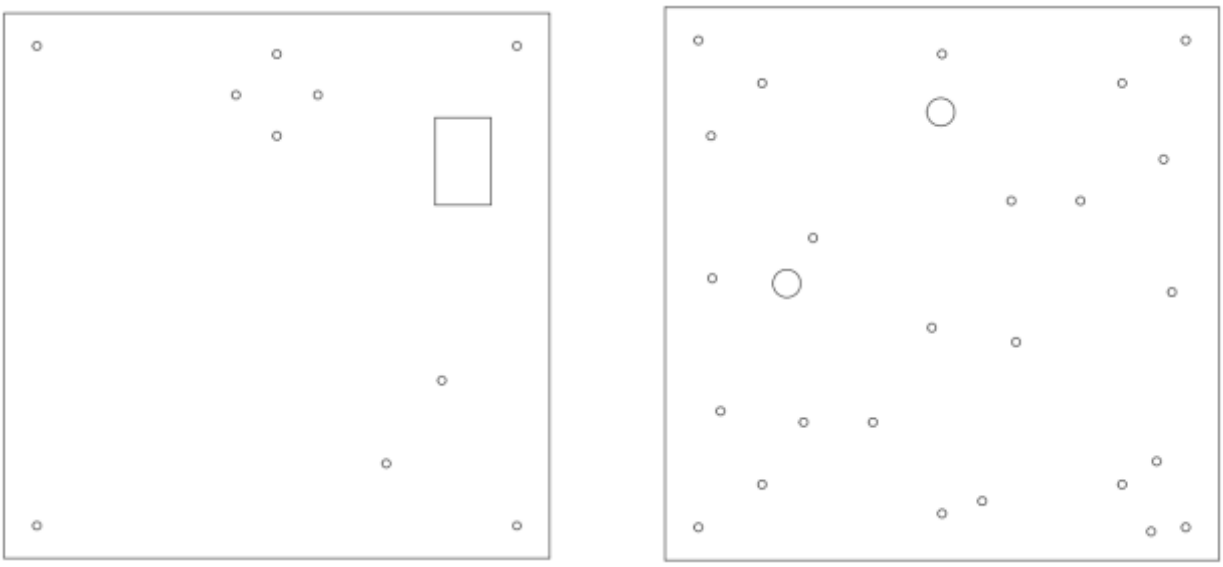

Figure 9.1.1 Top and Bottom Side of the Chassis

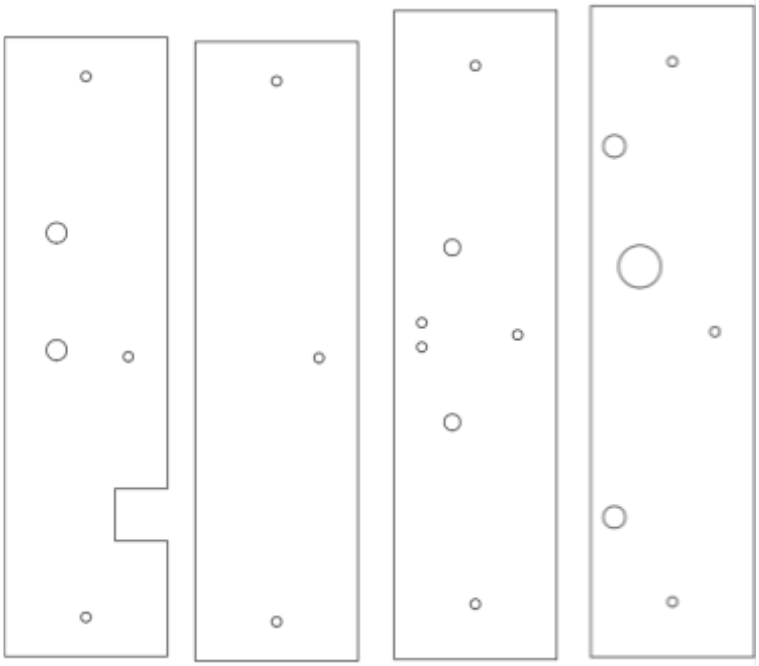

Figure 9.1.2 Lateral Sides of the Chassis

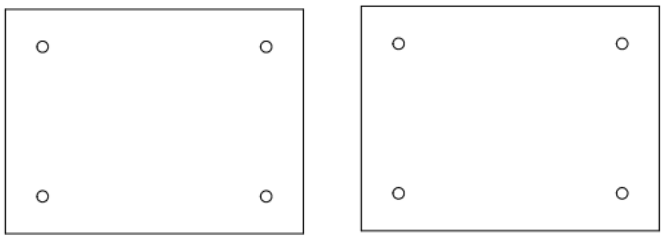

Figure 9.1.3 Receiver side Chassis Design

9.2 CIRCUIT DIAGRAM

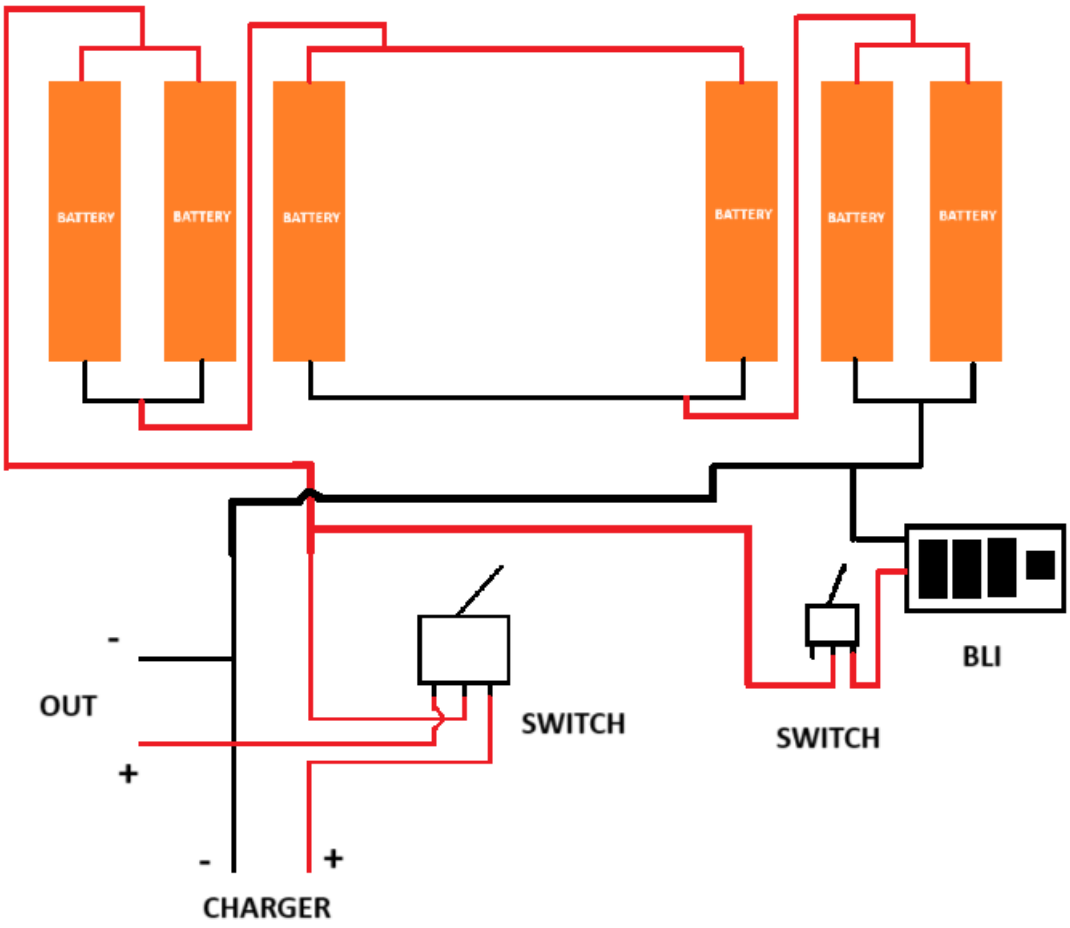

Figure 9.2 Circuit Diagram

9.3 BLOCK DIAGRAM

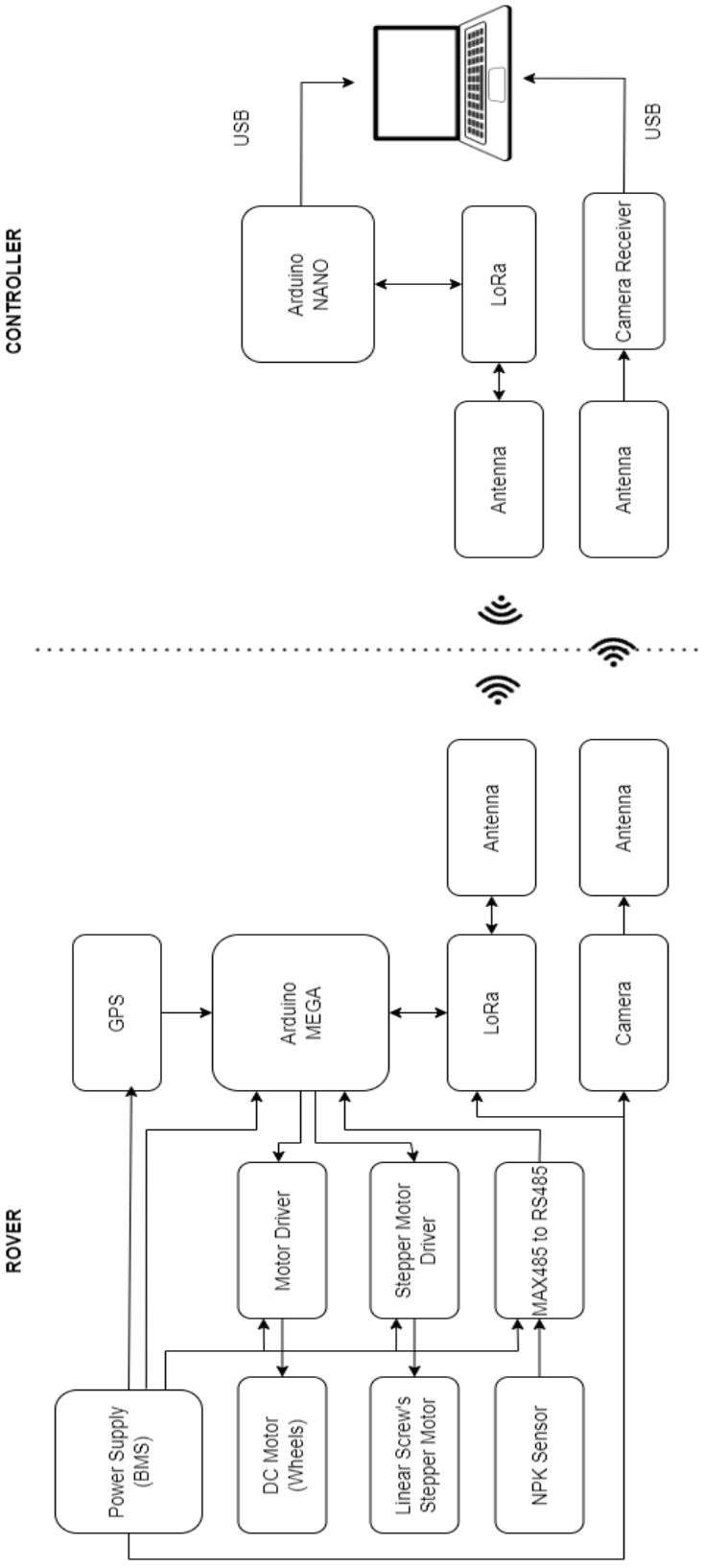

Figure 9.3 Block Diagram

9.4 WORKFLOW

The AGER (Autonomous Geo-Exploration Rover) project is controlled through remote control instead of autonomous navigation,

Initialization

- The AGER robot initializes its components, including the GPS module, NPK sensor, and camera, upon remote control activation.
- All hardware is powered on and ready for operation.

Remote Control Operation

- The AGER robot is operated remotely by a user through a control interface.
- The user can control the movement and direction of the robot using remote control inputs.

Figure 9.4.1 Remote Control

Location Monitoring

- The AGER robot continuously updates its live location by receiving GPS data.

- The GPS module provides real-time latitude and longitude coordinates, allowing the user to monitor the robot's position on a map interface.

Map Visualization

- Using the folium library in Python, the AGER robot visualizes its live location on a map.
- This map interface displays the robot's current position in real-time, providing the user with a visual representation of its movements.

Figure 9.4.2 NPK Sensor Data on a chosen location

Data Collection

- When directed by the user, the AGER robot collects NPK sensor data.
- The user can initiate data collection at specific locations or intervals as needed.

Data Storage

- The collected data, including the live location (latitude and longitude) and NPK sensor readings, are stored in an Excel workbook.

Figure 9.4.3 Excel Workbook

Map Update

- After collecting data, the map interface is updated to display the live location of the AGER robot along with the sensor data.
- This updated visualization allows the user to correlate the robot's position with environmental conditions.

Repeat Process

- The entire process can be repeated as directed by the user.
- The user can control the AGER robot's movement, collect data at different locations, and visualize the findings on the map interface iteratively.

By incorporating remote control operation, the AGER project provides users with direct control over the robot's movements and data collection activities, enabling efficient geo-exploration and monitoring under user supervision.

9.5 APPLICATIONS

The AGER (Autonomous Geo-Exploration Rover) project holds significant promise across various applications in agriculture, environmental monitoring, and scientific research. Here's a detailed overview of its applications:

Precision Agriculture

AGER can revolutionize precision agriculture by providing real-time data on soil health, moisture levels, and crop conditions.

Soil Exploration and Mapping

By gathering soil samples, measuring soil properties, and generating high-resolution maps, the rover enables detailed assessments of soil composition, texture, and fertility.

Environmental Monitoring

The rover's sensor suite and GPS navigation allow for comprehensive environmental monitoring in diverse ecosystems. AGER can monitor changes in vegetation cover, biodiversity, and land use patterns over time, providing valuable insights into ecosystem health and resilience.

Resource Assessment

In addition to agricultural and environmental applications, AGER can be deployed for resource assessment in sand-rich regions. The rover's ability to navigate sandy terrain and collect diverse data types makes it suitable for geological surveys, mineral exploration, and resource mapping.

Education and Outreach

AGER can also be used for educational purposes, providing hands-on learning experiences for students and outreach activities for communities.

CHAPTER 10

FABRICATION

10.1 3D PRINTED PARTS

Figure 10.1.1 Camera Mount

Figure 10.1.2 Camera Stand

Figure 10.1.3 NPK Sensor Mount

10.2 ASSEMBLY

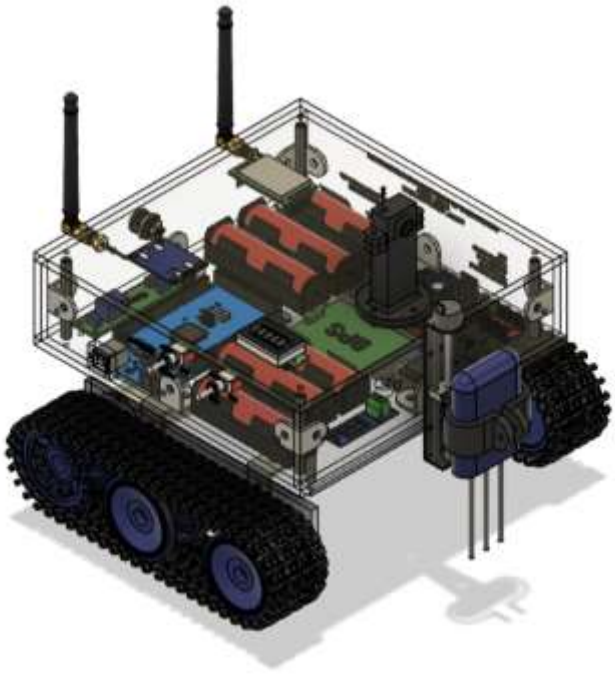

Figure 10.2.1 Assembly – Isometric View

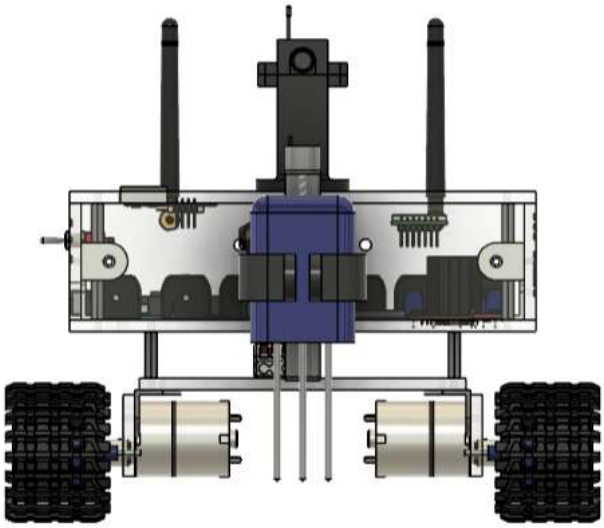

Figure 10.2.2 Assembly – Front View

10.3 COMPONENTS AND THEIR SPECIFICATIONS

S. No.	Component Name	Specifications	Quantity
1	DC Motor	Model: 33GB520 Voltage: 6-12V Current: 0.1 to 1.3 A Speed: 300RPM	2
2	Motor Driver	Voltage: 48V (Max) Continuous current: 2A	1
3	NPK Sensor	Voltage: 5V – 30V Current: 0.3A(Max) Output signal: RS485	1
4	MAX485 to RS485	-	1
5	GPS Module with Antenna	Voltage: 3.6V Current: 0.01A	1
6	LoRa Transmitter and Receiver	Range: Upto 8Km Max Voltage: 2.3 to 5.5 V Freq: 433MHz	2
7	LoRa Antenna	-	2
8	Controller for Transmitter	Arduino NANO	1
9	Controller for Receiver	Arduino MEGA Voltage: 7 to 12V Four Tx Rx Pins	1

10	FPV Camera	Freq: 5.8GHz Voltage: 3.7V, 5MP	1
11	Camera Receiver	Freq: 5.8GHz	1
12	Linear Screw Drive Stepper Motor	Stroke Length: 9 cm Voltage: 4 to 9V (500mA), Motor Model: 15BY 18 Degree	1
13	Stepper Motor Driver	Voltage: 8 to 35V Current: Max 2A	1
14	Battery	Current: 2600mAh Voltage: 3.7V (3C)	6
15	Battery Holder	-	6
16	Buck Convertor	12V to 5V	2
17	Switch	5A SPDT	2
19	Battery Level Indicator	3S 11.1 to 12.6V	1
22	Charger	12V 3A with 5.5/2.1 mm Jack	1
23	Power Jack Socket	5.5/2.1 Female	1

Table 10.3 Components and their Specifications

Figure 10.3.1 Arduino Mega

Figure 10.3.2 Arduino Nano

Figure 10.3.3 NPK Sensor

Figure 10.3.4 MAX485

Figure 10.3.5 GPS NEO-6M

Figure 10.3.6 LoRa 433MHz

Figure 10.3.7 SMA Antenna

Figure 10.3.8 DC Motor

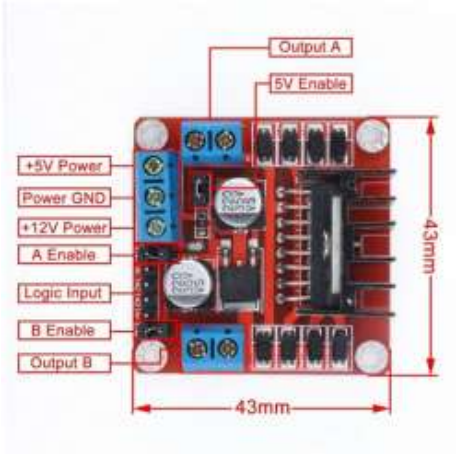

Figure 10.3.9 L298N Motor Driver

Figure 10.3.10 Linear Screw Drive Stepper Motor

Figure 10.3.11 A4988 Driver

Figure 10.3.12 Buck Convertor

Figure 10.3.13 Li-Ion Battery

Figure 10.3.14 Camera with Transmitter

Figure 10.3.15 Camera Receiver

CHAPTER 11

HARDWARE IMPLEMENTATION

DC Motor Driver	Arduino Mega
Ena	4
In1	5
In2	6
In3	7
In4	8
Enb	9

Table 11.1 DC Motor Driver to Arduino Mega

Stepper Motor	Stepper Motor Driver
Blue	1B
Black	1A
Yellow	2A
Red	2B

Table 11.2 Stepper Motor to Stepper Motor Driver

Stepper Motor Driver	Arduino Mega
Direction	30
Step	28
Enable	48

Table 11.3 Stepper Motor Driver to Arduino Mega

GPS	Arduino Mega
RX	14 (TX3)
TX	15 (RX3)

Table 11.4 GPS to Arduino Mega

LoRa	Arduino Mega
M0	GND
M1	GND
RX	16 (TX2)
TX	17 (RX2)

Table 11.5 LoRa to Arduino Mega

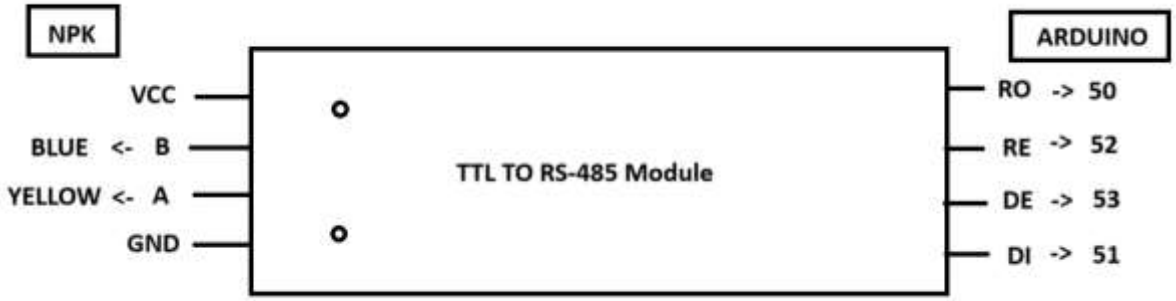

Figure 11.1 NPK - MAX485 – Arduino Mega

LoRa	Arduino Nano
M0	5
M1	4
RX	3 (Software Serial TX)
TX	2 (Software Serial RX)

Table 11.6 LoRa to Arduino Nano

CHAPTER 12

SOFTWARE IMPLEMENTATION

12.1 ARDUINO PROGRAM

12.1.1 Arduino Mega

```
#include <AccelStepper.h>

#include <SoftwareSerial.h>

#include <TinyGPS++.h>

TinyGPSPlus gps;

#define RE 52

#define DE 53

const byte nitro[] = {0x01,0x03, 0x00, 0x1e, 0x00, 0x01, 0xe4,
0x0c};

const byte phos[] = {0x01,0x03, 0x00, 0x1f, 0x00, 0x01, 0xb5,
0xcc};

const byte pota[] = {0x01,0x03, 0x00, 0x20, 0x00, 0x01, 0x85,
0xc0};

//Motor

int ena = 4;

int in1 = 5;

int in2 = 6;

int in3 = 7;

int in4 = 8;

int enb = 9;

byte values[11];

SoftwareSerial mod(50,51);

unsigned long previousMillis = 0;

const long interval = 2000;
```

```
int dirPin = 2;
int stepPin = 3;
#define motorInterfaceType 1
AccelStepper myStepper(motorInterfaceType, stepPin, dirPin);
void setup()
{
  Serial.begin(9600);
  //Lora
  Serial2.begin(9600);
  Serial3.begin(9600);
  //Motor
  pinMode(ena,OUTPUT);
  pinMode(in1,OUTPUT);
  pinMode(in2,OUTPUT);
  pinMode(in3,OUTPUT);
  pinMode(in4,OUTPUT);
  pinMode(enb,OUTPUT);
  analogWrite(ena,240);
  analogWrite(enb,240);
  myStepper.setMaxSpeed(200);
     myStepper.setAcceleration(50);
     myStepper.setSpeed(200);
  pinMode(10,OUTPUT);
  digitalWrite(48,HIGH);
  mod.begin(9600);
  pinMode(RE, OUTPUT);
  pinMode(DE, OUTPUT);
```

```
}
void loop()
{
  while(Serial2.available()>0)
  {
    char a = (char) Serial2.read();
    Serial.print(a);
    control(a);
  }
  unsigned long currentMillis = millis();
  if (currentMillis - previousMillis >= interval) {
      previousMillis = currentMillis;
      while (Serial3.available() > 0) {
        if (gps.encode(Serial3.read())) {
          if (gps.location.isValid()) {

Serial2.println("g,"+String(gps.location.lat(),6)+","+String(g
ps.location.lng(),6));
          }
          else {
          Serial2.println("g,"+String(0)+","+String(0));
          }
        }
      }
  }
}
void control(char input)
```

```
{
  switch(input)
  {
    case 'w':
      digitalWrite(in1,LOW);
      digitalWrite(in2,HIGH);
      digitalWrite(in3,HIGH);
      digitalWrite(in4,LOW);
      break;
    case 's':
      digitalWrite(in1,HIGH);
      digitalWrite(in2,LOW);
      digitalWrite(in3,LOW);
      digitalWrite(in4,HIGH);
      break;
    case 'd':
      digitalWrite(in1,LOW);
      digitalWrite(in2,HIGH);
      digitalWrite(in3,LOW);
      digitalWrite(in4,HIGH);
      break;
    case 'a':
      digitalWrite(in1,HIGH);
      digitalWrite(in2,LOW);
      digitalWrite(in3,HIGH);
      digitalWrite(in4,LOW);
      break;
```

```
    case 'm':
      digitalWrite(in1,LOW);
      digitalWrite(in2,LOW);
      digitalWrite(in3,LOW);
      digitalWrite(in4,LOW);
      break;
    case 'l':
      myStepper.move(-2100);
      digitalWrite(48,LOW);
      while(myStepper.isRunning()){
        myStepper.run();
      }
      digitalWrite(48,HIGH);
      byte val1,val2,val3;
      int c=5;
      while(c){
        val1 = nitrogen();
        delay(250);
        val2 = phosphorous();
        delay(250);
        val3 = potassium();
        delay(250);
        c-=1;
      }

Serial2.println("n,"+String(val1)+","+String(val2)+","+String(
val3));
```

```
      myStepper.move(2200);
      digitalWrite(48,LOW);
      while(myStepper.isRunning()){
        myStepper.run();
      }
      digitalWrite(48,HIGH);
      Serial2.println("k");
  }
}
byte nitrogen(){
  digitalWrite(DE,HIGH);
  digitalWrite(RE,HIGH);
  delay(10);
  if(mod.write(nitro,sizeof(nitro))==8){
    digitalWrite(DE,LOW);
    digitalWrite(RE,LOW);
    for(byte i=0;i<7;i++){
    //Serial.print(mod.read(),HEX);
    values[i] = mod.read();
    Serial.print(values[i],HEX);
    }
    Serial.println();
  }
  return values[4];
}
byte phosphorous(){
  digitalWrite(DE,HIGH);
```

```
  digitalWrite(RE,HIGH);
  delay(10);
  if(mod.write(phos,sizeof(phos))==8){
    digitalWrite(DE,LOW);
    digitalWrite(RE,LOW);
    for(byte i=0;i<7;i++){
    //Serial.print(mod.read(),HEX);
    values[i] = mod.read();
    Serial.print(values[i],HEX);
    }
    Serial.println();
  }
  return values[4];
}
byte potassium(){
  digitalWrite(DE,HIGH);
  digitalWrite(RE,HIGH);
  delay(10);
  if(mod.write(pota,sizeof(pota))==8){
    digitalWrite(DE,LOW);
    digitalWrite(RE,LOW);
    for(byte i=0;i<7;i++){
    //Serial.print(mod.read(),HEX);
    values[i] = mod.read();
    Serial.print(values[i],HEX);
    }
    Serial.println();
```

```
  }
  return values[4];
}
```

12.1.2 Arduino Nano

```
#include <SoftwareSerial.h>
SoftwareSerial lora(2,3);
void setup(){
  Serial.begin(9600);
  lora.begin(9600);
  pinMode(4,OUTPUT);
  pinMode(5,OUTPUT);
  digitalWrite(4,LOW);
  digitalWrite(5,LOW);
}
void loop()
{
  while(lora.available()>0)
  {
    char a = (char) lora.read();
    Serial.write(a);
  }
  while(Serial.available()>0)
  {
    char a = (char) Serial.read();
    lora.write(a);
  }
}
```

12.2 PYTHON PROGRAM

```
import tkinter as tk

import serial

import threading

import folium

from openpyxl import Workbook

from datetime import datetime

SERIAL_PORT = 'COM6'

BAUD_RATE = 9600

ser = serial.Serial(SERIAL_PORT, BAUD_RATE, timeout=1)

wb = Workbook()

ws = wb.active

ws.append(['Latitude', 'Longitude', 'NPK1', 'NPK2', 'NPK3'])

live_location = {'latitude': 0, 'longitude': 0}  # Initial
live location

sensor_data = {'NPK1': 0, 'NPK2': 0, 'NPK3': 0}  # Initial
sensor data

data_log = []  # Initialize data log

my_map = folium.Map(location=[live_location['latitude'],
live_location['longitude']], zoom_start=10)

livelocationmarker =
folium.Marker(location=[live_location['latitude'],
live_location['longitude']], popup='Live
Location').add_to(my_map)

def display_map_with_data():

    if live_location['latitude'] == 0 and
live_location['longitude'] == 0:

        print("Waiting for satellite connection...")

        return
```

```
    livelocationmarker.location=[live_location['latitude'],
live_location['longitude']]
    my_map.fit_bounds([[live_location['latitude'],
live_location['longitude']]])
    my_map.save('live_map_with_sensor_data.html')
def disable_buttons():
    for button in [forward_button, reverse_button,
left_button, right_button]:
        button.conFigure(state=tk.DISABLED)
def enable_buttons(event=None):
    for button in [forward_button, reverse_button,
left_button, right_button]:
        button.conFigure(state=tk.NORMAL)
def read_serial(ser):
    while True:
        if ser.in_waiting:
            received_data = ser.readline().decode().strip()
            print("Received data:", received_data)
            if received_data[0] == 'g':
                received_data = received_data.split(",")
                live_location['latitude'] =
float(received_data[1])
                live_location['longitude'] =
float(received_data[2])
                display_map_with_data()
            if received_data[0]=='n':
                received_data = received_data.split(",")
                sensor_data['NPK1'] = float(received_data[1])
                sensor_data['NPK2'] = float(received_data[2])
```

```
                sensor_data['NPK3'] = float(received_data[3])
                ws.append((live_location['latitude'],
live_location['longitude'], sensor_data['NPK1'],
sensor_data['NPK2'], sensor_data['NPK3']))
                wb.save('AGER_Data.xlsx')
                popup_html = '<b>Sensor Data:</b><br>'
                for key, value in sensor_data.items():
                    popup_html += f'<b>{key}:</b> {value}<br>'
folium.Marker(location=[live_location['latitude'],
live_location['longitude']], popup=popup_html).add_to(my_map)
                my_map.save('live_map_with_sensor_data.html')
            if received_data=='k':
                enable_buttons()
def forward(event=None):
    ser.write('w'.encode())
def reverse(event=None):
    ser.write('s'.encode())
def left(event=None):
    ser.write('a'.encode())
def right(event=None):
    ser.write('d'.encode())
def middle(event=None):
    ser.write(b'l')
    disable_buttons()
def stop(event=None):
    ser.write('m'.encode())
root = tk.Tk()
root.title("Controller")
```

```
button_frame = tk.Frame(root, bg="#f0f0f0")

button_frame.pack(pady=10)

# Color scheme

button_bg = "#4caf50"  # Green

button_fg = "white"    # White

button_active_bg = "#388e3c"  # Dark green

button_font = ("Arial", 12)   # Font size 12

forward_button = tk.Button(button_frame, text="Forward",
width=10, height=10, font=button_font, bg=button_bg,
fg=button_fg, activebackground=button_active_bg, bd=0,
relief=tk.RIDGE)

forward_button.grid(row=0, column=1, padx=5, pady=5,
sticky="ew")

forward_button.bind("<ButtonPress>", forward)

forward_button.bind("<ButtonRelease>", stop)

reverse_button = tk.Button(button_frame, text="Reverse",
width=10, height=10, font=button_font, bg=button_bg,
fg=button_fg, activebackground=button_active_bg, bd=0,
relief=tk.RIDGE)

reverse_button.grid(row=2, column=1, padx=5, pady=5,
sticky="ew")

reverse_button.bind("<ButtonPress>", reverse)

reverse_button.bind("<ButtonRelease>", stop)

left_button = tk.Button(button_frame, text="Left", width=10,
height=10, font=button_font, bg=button_bg, fg=button_fg,
activebackground=button_active_bg, bd=0, relief=tk.RIDGE)

left_button.grid(row=1, column=0, padx=5, pady=5, sticky="ew")

left_button.bind("<ButtonPress>", left)

left_button.bind("<ButtonRelease>", stop)
```

```
right_button = tk.Button(button_frame, text="Right", width=10,
height=10, font=button_font, bg=button_bg, fg=button_fg,
activebackground=button_active_bg, bd=0, relief=tk.RIDGE)

right_button.grid(row=1, column=2, padx=5, pady=5,
sticky="ew")

right_button.bind("<ButtonPress>", right)

right_button.bind("<ButtonRelease>", stop)

middle_button = tk.Button(button_frame, text="Get Data",
width=10, height=10, font=button_font, bg="#e91e63",
fg=button_fg, activebackground="#c2185b", bd=0,
relief=tk.RIDGE)  # Pink color for middle button

middle_button.grid(row=1, column=1, padx=5, pady=5,
sticky="ew")

middle_button.bind("<ButtonPress>", middle)

# ConFigureure row and column to expand

button_frame.grid_columnconFigureure((0, 1, 2), weight=1)  #
columns 0, 1, and 2

button_frame.grid_rowconFigureure((0, 2), weight=1)       #
rows 0 and 2

button_frame.grid_rowconFigureure(1, weight=1)           # row
1

button_frame.pack(fill=tk.BOTH, expand=True)

def main():

    read_thread = threading.Thread(target=read_serial,
args=(ser,))

    read_thread.daemon = True

    read_thread.start()

    root.mainloop()

if __name__ == "__main__":

    main()
```

CHAPTER 13

RESULT & DISCUSSION

The Autonomous Geo-Exploration Rover (AGER) demonstrated robust performance in autonomously navigating fields, collecting real-time data and testing the nutrient levels of the soil using NPK sensor. Unit and integration testing confirmed the functionality and seamless integration of individual components.

Navigation testing showcased AGER's ability to navigate diverse terrains and environmental conditions accurately. Data collection and analysis testing validated the accuracy of collected data, providing meaningful insights for agricultural optimization.

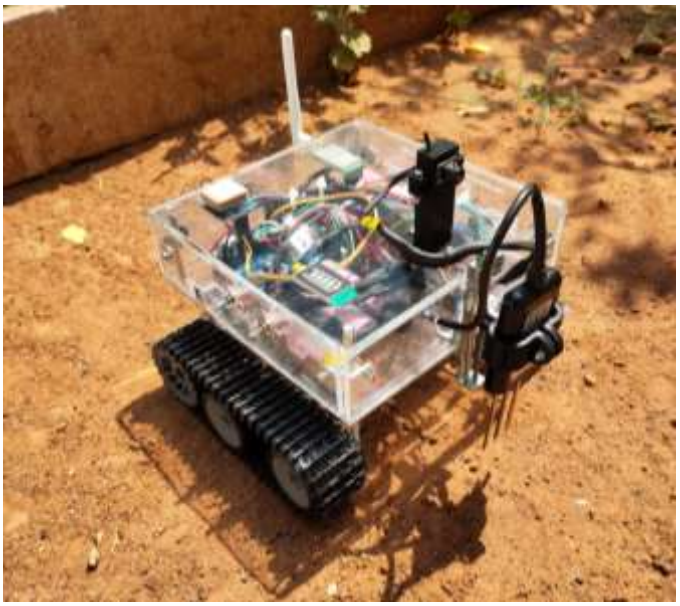

Figure 13.1 Autonomous Geo-Exploration Rover

Field testing revealed AGER's reliability and effectiveness in real agricultural environments, while endurance testing highlighted its long-term operational capability.

CHAPTER 14

CONCLUSION

The development of the Autonomous Geo-Exploration Rover (AGER) represents a significant advancement in geo-exploration and agricultural technology. By addressing the limitations of existing methodologies, AGER offers a versatile and efficient platform for optimizing agricultural practices and environmental monitoring.

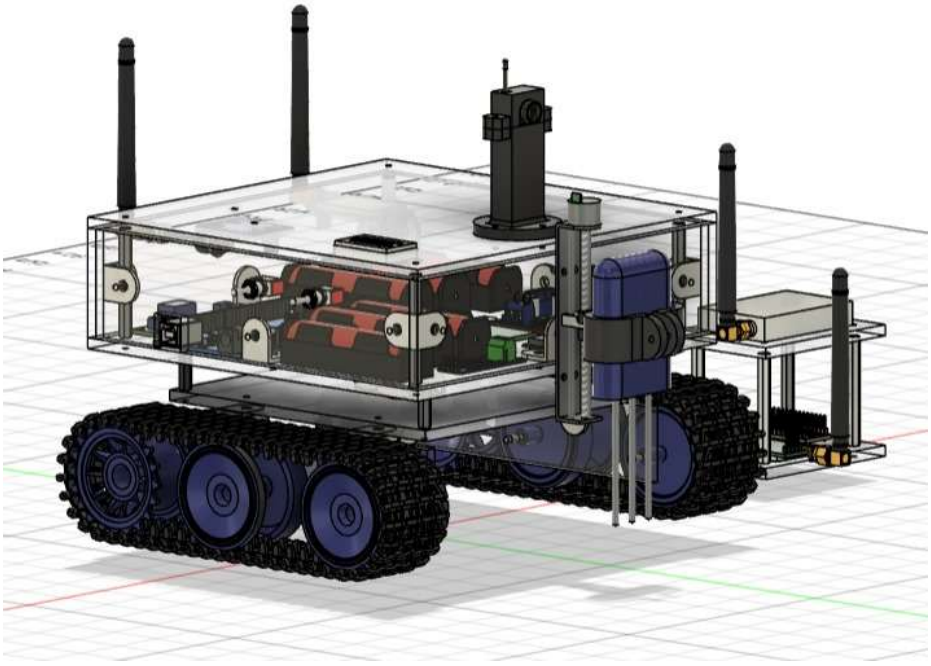

Figure 14.1 AGER and Receiver Unit

Its successful validation through various tests underscores its potential impact on improving crop yield, resource management, and scientific research in sandy environments. AGER holds promise for revolutionizing agricultural practices and contributing to sustainable agriculture and environmental conservation efforts.

CHAPTER 15

FUTURE SCOPE

The future scope of the AGER (Autonomous Geo-Exploration Rover) project encompasses a broad spectrum of advancements aimed at enhancing its capabilities in precision agriculture and environmental monitoring. Firstly, the project could focus on augmenting navigation systems to enable autonomous operations, leveraging advanced algorithms for obstacle avoidance and path planning. Concurrently, integrating additional sensors such as those for soil pH, temperature, and humidity would fortify the AGER's ability to assess soil health comprehensively.

Furthermore, the development of robust data fusion and analysis algorithms would facilitate the integration of diverse sensor data, empowering the AGER to generate actionable insights for optimizing agricultural practices and resource management. Additionally, seamless integration with precision farming systems and user-friendly interfaces would streamline data interpretation and decision-making processes, enhancing the AGER's practical utility in agricultural operations.

Finally, the project's scalability and adaptability are essential considerations, necessitating modular design principles to accommodate different agricultural environments and applications. Field trials and validation studies would be paramount to assess the AGER's performance and reliability in real-world settings, fostering collaboration with stakeholders to refine its functionality. Moreover, prioritizing sustainability and minimizing environmental impact would underscore the project's commitment to responsible innovation, ensuring that the AGER project contributes positively to sustainable food production and ecosystem stewardship.

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