Vasco Caretta (The Hybrid)

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Abstract− **In the face of the limitations posed by conventional surveillance methods in monitoring challenging terrains, a pressing need arises for an innovative solution to safeguard national security. Illicit activities in difficult-to-reach areas demand a technology capable of traversing diverse landscapes seamlessly. The answer to this challenge lies in the deployment of a Hybrid Robot. By merging drone and rover mechanisms enhanced with advanced features, the Hybrid Robot offers a groundbreaking solution to improve reconnaissance, data gathering, and monitoring in a variety of difficult terrains. The adaptability of the hybrid robot is a standout feature, enabling it to navigate through terrains that pose significant challenges for traditional surveillance methods. Its hybrid mechanism seamlessly integrates aerial and ground operations, ensuring versatility in surveillance scenarios. The incorporation of advanced intelligence empowers the Hybrid Robot with autonomous decision-making capabilities, allowing it to dynamically respond to changing environments and identify potential threats. Beyond national security, the Hybrid Robot finds applications in disaster response, environmental monitoring, and scientific study. In essence, the Hybrid Robot emerges as a comprehensive solution, addressing the limitations of current surveillance methods and ushering in a new era of adaptable and intelligent robotic systems**

Keywords− ***Surveillance; Exploration Hybrid Robot; National Security; Illicit Activities; Challenging Terrains; Drone; Rover; water splashing Wheel; Defence; 4-wheel driver; Image recognition; Adaptability; Versatility; Autonomous Decision-Making; Reconnaissance; Data Gathering; Disaster Response; Environmental Monitoring; Rescue operations; Scientific Study;***

I. INTRODUCTION

In today's dynamic and fast changing landscape, the introduction of new technologies has created remarkable progress in a number of sectors. Combining rovers and drones into a single system represents paradigm shift innovation in this area. In sectors such as surveillance, exploration, agriculture, environmental monitoring, disaster management and infrastructure inspection, this integration has given rise to new frontiers.

The convergence of aircraft and ground-based capabilities has facilitated unprecedented advancements, empowering industries to overcome longstanding challenges. The combined drone and rover system represents a pivotal leap forward in the realms of automation, data collection, and remote sensing. By harnessing the complementary strengths of both aerial and terrestrial platforms, this integrated approach offers a versatile, dependable, and highly adaptable solution to complex real-world problems. Furthermore, in infrastructure inspection, the system streamlines assessment processes by combining aerial surveys with ground-level inspections, ensuring thorough evaluation. In essence, the integration of rovers and drones represents a transformative leap forward, ushering in a new era of innovation and efficiency across a myriad of industries. By leveraging the synergies between aerial and terrestrial platforms, this integrated approach holds immense promise for addressing the complex challenges of today's world and shaping a more sustainable and resilient future.

A bioinspired multi-finger robot system (MFRS) has been developed to mimic the grip of eagle claws, allowing a rotary-wing unmanned aerial vehicle (RUAV) to land on uneven terrain. The robot can pick up objects and rotate three rotary joints with a single motor. The MFRS's hardware architecture and control system layout have been determined, and it can successfully land on slopes and stairs [1].

The research and development community is increasingly interested in unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) due to their potential in high-risk operations. However, coordination and communication between these vehicles can hinder mission completion. This paper proposes a hierarchical cooperative control system for UAV/UGV platforms, utilizing a top-level mobile mission controller for efficient planning, system-level decision-making, and optimizing mission completion time and resource utilization [2].

Technology has advanced significantly from internal combustion to electric propulsion, from landlines to cell phones, and many more. The discovery of a tried-and-true technique or item does not signal the end of progress in any field. Similar advancements have been made by unmanned ground vehicles and even unmanned aircraft systems. These days, they could be used for military or space research among other things. The main objective of this project is to develop an unmanned ground and airborne vehicle, much like concepts for all-terrain drones that we've seen before [3].

Traditional agriculture uses rovers and drones for tasks like weeding, fertilizer application, and pesticide spraying. These technologies offer affordable monitoring and scanning, enabling precision agriculture. However, drones have limited flying time due to cargo limitations. To address these challenges, an autonomous hybrid drone rover vehicle is proposed, combining the advantages of both rovers and drones. The prototype can navigate obstacles, pluck weeds, and spray pesticides, meeting the demands of different terrains and vertical farming [4].

The United States Department of the Interior and National Forest Service are increasingly concerned about wildfire reconnaissance and mitigation, particularly due to the extended fire seasons and worsening conditions caused by climate change. The National Forest Service anticipates allocating over half of its budget to firefighting within the next decade. To aid firefighters in assessing wildfire risks safely, Team DRIFT, comprised of undergraduate Aerospace Engineering Sciences students at the University of Colorado Boulder, is developing a Mother Rover-Child Drone Firetracker System. This system will gather environmental data from at-risk locations and transmit it to a ground station, allowing firefighters to assess the fire's intensity, severity, and extent from a safe distance. The Mother Rover, equipped to carry the Child Drone, features an internal levelling jack system to ensure the landing platform remains within a safe angle for drone operations on sloped terrain. The engineering challenge lies in balancing the Mother Rover's weight while ensuring it can traverse rough terrain securely. The paper will detail the design solution for this innovative system [5].

This paper introduces a novel invention for Disaster Rescue Management (DRM): a multi-role UAV with an integrated Rover. DRM operations are inherently challenging, especially in adverse weather conditions. This hybrid UAV-Rover system addresses these complexities by providing image and thermal data capture capabilities. In scenarios where Rover deployment is hindered by debris or landslides, the UAV initiates operations until a clear path is established for the Rover. Equipped with GPS, the system sends location data to a central station upon detecting heat signatures via thermal imaging. Additionally, a secondary backup system deploys sensors markers in case of GPS failure, aiding remote tracking. The primary goal of this invention is to enhance DRM effectiveness, reduce search and rescue time, and minimize human casualties during disaster response efforts [6].

II. OBJECTIVES

This hybrid system unveils an innovative concept to meet the rising demand for versatile robotic systems tailored for surveillance and exploration in various terrains. Our mission is to unveil a hybrid robot system to integrates both drone and rover functionalities, empowered with advanced intelligence features. This hybrid system aims to amplify capabilities in reconnaissance, data collection, and monitoring across challenging landscapes. Our main objective is to tackle the pressing need for efficient surveillance and exploration, particularly in regions where traditional approaches fall short. By fusing aerial and ground-based capabilities, this hybrid system promises a revolutionary solution to safeguard national security and combat unlawful activities spanning diverse landscapes.

III. PROPOSED SYSTEM

Our innovational method, born from a deep dive into current systems, introduces an innovative rover-drone hybrid that breaks free from traditional limitations. This system represents a fusion of innovative technologies, carefully crafted to tackle unique challenges and push the boundaries of robotics. Our approach starts with a thorough examination of existing frameworks, allowing us to identify areas for improvement and fuel innovation. The resulting rover-drone hybrid transcends the constraints of conventional methods, offering unmatched versatility and adaptability across different environments. Central to this breakthrough is the seamless integration of state-of-the-art technologies, each tailored to address specific challenges encountered in surveillance and exploration. Through meticulous design and engineering, our hybrid system seamlessly blends the strengths of both aerial and ground platforms, delivering unparalleled flexibility and functionality. Furthermore, our methodology prioritizes precision and efficiency, ensuring that every component of the system is optimized for peak performance. From refining the rover's mobility, each aspect has been carefully crafted to enhance overall effectiveness and usefulness. By pushing the boundaries of traditional robotics, our method opens doors to new applications, spanning from disaster relief to environmental monitoring. With its transformative capabilities, our rover-drone hybrid is poised to revolutionize the field, setting a new standard for innovation and excellence.

A. Rover: Navigating Challenging Terrains

Conventional rovers often encounter difficulties when traversing challenging terrains such as slick surfaces, mud, or shallow water bodies. In response to this, our proposed system integrates an innovative water splashing wheel. This pioneering feature equips the rover with the capability to navigate shallow water streams effortlessly. Consisting of specialized wheels engineered with hydrodynamic properties, the rover maintains exceptional traction and stability, rendering it an ideal solution for tasks requiring operation in watery conditions. This technological advancement not only enhances the rover's versatility for industrial and scientific applications but also positions it as a dependable choice for missions in previously inaccessible environments. By incorporating the water splashing wheels, the rover gains the ability to traverse terrains that were once considered impassable, thus expanding its operational reach and effectiveness. Moreover, the incorporation of this advanced feature underscores our commitment to overcoming the limitations of traditional rovers and pushing the boundaries of exploration and research. With its enhanced capabilities, the rover is poised to tackle a wide range of tasks with increased efficiency and reliability, opening up new avenues for exploration and discovery in challenging environments. the integration of the water splashing wheel represents a significant leap forward in rover technology, offering unprecedented adaptability and performance in navigating challenging terrains, including shallow water bodies. This innovation not only expands the rover's utility across various industries but also unlocks opportunities for exploration and scientific discovery in previously inaccessible landscapes.

B. Integration with Drone System: Extending Capabilities

Incorporating a drone system into the rover marks a significant advancement, enhancing its versatility and effectiveness. This integration introduces a range of advanced features that revolutionize mission execution and broaden operational capabilities. This is particularly useful in remote or hazardous environments where human intervention may be challenging or unsafe. Moreover, the drone component brings auto-tracking capabilities to the system, allowing the rover to autonomously track and follow targets. This is valuable for tasks like monitoring moving objects or individuals, such as wildlife or during search and rescue missions. Additionally, the drone system introduces loitering capabilities, enabling the rover to hover or stay stationary in one place for extended periods. This is crucial for tasks requiring prolonged observation or surveillance, allowing detailed data collection without constant movement. The integrated drone system also offers low-altitude flying capabilities, allowing access to areas inaccessible to the rover alone, like dense forests or steep terrain. This extends the rover's operational range, enhancing adaptability in navigating challenging environments. The collaboration between the rover and drone creates a synergistic partnership, combining the strengths of aerial and terrestrial platforms. While the rover excels at ground-based tasks such as navigation, the drone provides aerial reconnaissance and surveillance capabilities. Whether it's environmental monitoring, search and rescue missions, or disaster assessment, the combined abilities of the rover and drone enable effective solutions with precision and efficiency. the integration of a drone system takes the rover to new heights, unlocking unparalleled versatility and effectiveness. With autonomous mission execution auto-tracking, loitering, and low-altitude flying capabilities, the rover is empowered to navigate complex terrains and environments with ease, while also enhancing data collection and surveillance capabilities.

C. Hybrid Locomotion Capabilities: Comprehensive Aerial and Terrestrial Operations

The combination of the rover's hybrid locomotion abilities with ground-based movement serves as the foundation of the system's holistic approach to handling diverse tasks. This integration enables the rover to smoothly shift between aerial and terrestrial operations, presenting a distinctive array of benefits. The inclusion of weight lifting and delivery capabilities through the drone component amplifies the system's effectiveness in scenarios necessitating payload transport. With the rover's advanced speed control system ensuring precise adjustments, it can deliver optimal performance tailored to the requirements of different tasks. This versatility positions the rover-drone hybrid as an invaluable resource across a wide range of applications, spanning from industrial activities to disaster response efforts.

IV. DESIGN REQUIREMENT ANALYSIS

Designing a drone integrated with a rover, considering future upgrades for a boat and submarine module, involves several parameters. Below are key considerations with a focus on mobility and adaptability:

A. Weight distribution (WD):

- Define the overall weight capacity (w_cap) of the integrated system.
- Distribute the weight between the drone (WD_drone), rover (WD_rover)

$$W_{cap} = WD_{drone} + WD_{rover}$$

B. power -to- weight ratio (PWR):

- Calculate the power-to-weight ratio for each module.
- Ensure that the power generated by the propulsion systems is sufficient for the weight of each module

$$PWR_{drone} = \frac{Power_{drone}}{WD_{drone}}$$

$$PWR_{rover} = \frac{Power_{rover}}{WD_{rover}}$$

C. Mobility requirements:

- Define the required speed (v) for each module.
- Incorporate considerations for different terrains

$$V_{rover} \leq Vmax_{rover}$$

D. Battery capacity (BC):

- Estimate the required battery capacity for each module based on the mission duration(t).
- Consider the power consumption (PC) of each module during operation.

$$BC_{drone} = PC_{drone} \times t_{drone}$$

$$BC_{rover} = PC_{rover} \times t_{rover}$$

1) Drone Parameters:

a) *Center of gravity (CoG)*:

- The CoG must be carefully positioned for stability

$$CoG_{drone} = \frac{\sum(m_i \times x_i)}{\sum m_i}$$

- Where m_i is the mass of individual components and x_i is their respective distances from the reference point.

b) *Thrust(T):*

- Calculate the thrust required for the drone's lift.

$$T_{drone} = m_{drone} \times g$$

- Where m_{drone} is the mass of the drone, and g is the acceleration due to gravity.

c) *weight lifting capacity (WLC):*

- Determine the maximum payload the drone can lift

$$WLC_{drone} = T_{drone} - m_{drone}$$

d) *Maximum payload (MP):*

- Define the maximum additional weight the drone can carry.

$$MP_{drone} = WLC_{drone} - m_{current\_payloads}$$

e) *symmetric frame requirements:*

- Choose an symmetric frame design or another suitable frame based on payload and stability

f) *electronic speed controller (ESC):*

- Select ESCs based on motor specifications
- Ensure each motor has a dedicated ESC for individual control.

$$ESC_{drone} = 4 \times ESC_{per\_motor}$$

2) Rover parameters:

a) Torque(τ):

- Calculate the torque required for rover movement.

$$T_{rover} = r_{wheel} \times F_{rover}$$

- Where r_{wheel} is the wheel radius and F_{rover} is the required force

b) speed(V):

- Determine the desired speed for rover movement.

$$V_{rover} = \frac{Trover}{rwheel}$$

c) weight loading (WL):

- Assess the maximum weight the rover can carry

$$WL_{rover} = \frac{Trover}{g}$$

d) wheels dimensions:

- Choose wheel dimensions based on torque requirements and terrain considerations.

e) Water splashing wheel's water resistance:

- Assess the water resistance of wheels for efficient movement.

$$R_{hydro\_wheel} = f \times v_{water}$$

- Where f is the drag coefficient and v_{water} is the water velocity.

f) Balancing:

- Optimize the rover's weight distribution for stability

g) power supply requirements:

- Calculate power requirements based on motor specifications and rover dynamics

V. WORKING PRINCIPLE

The integrated quadcopter and rover system, featuring an symmetric frame design, showcases a sophisticated synergy of aerial and ground-based functionalities. The symmetric frame architecture serves as the backbone, promoting stability and efficient weight distribution. The symmetric frame configuration is a widely adopted design for quadcopters, featuring two parallel arms extending horizontally from the center of the frame. This layout ensures stability during flight, even weight distribution for efficient payload handling, and versatility across various applications. The straightforward design facilitates easy assembly and maintenance, while advanced flight control systems enable precise maneuverability. With its aesthetic appeal and adaptability, the symmetric frame remains a popular choice for building reliable and effective quadcopter platforms for both recreational and professional use. This versatile system seamlessly transitions between aerial and ground modes, for compact transportation. The aerial drone utilizes a Pixhawk flight controller for precision flight, The rover, driven by Arduino, employs specialized water splashing wheels for optimal movement in shallow waters, ensuring resilience against water currents and stability across challenging terrains.

A. Quadcopter (Aerial Mode)

Quadcopter working : A quadcopter operates on the principle of aerodynamic lift generated by four rotors. The quadcopter's flight controller adjusts the speed of each rotor to control pitch, roll, yaw, and altitude. By varying the rotational speeds of the rotors, the drone can achieve stable flight and perform maneuvers. Gyroscopes and accelerometers provide real-time data on the quadcopter's orientation, allowing the flight controller to make rapid adjustments to maintain stability. This closed-loop control system enables precise and responsive flight control, making quadcopters versatile for applications ranging from aerial photography to surveillance and recreational flying.

B. Rover (Ground and Water Modes)

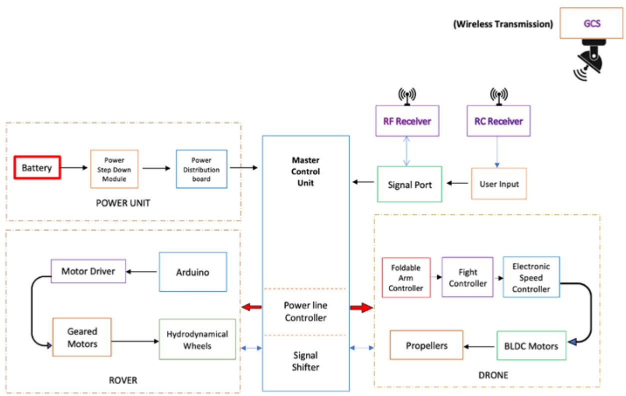
Water splashing Wheels: The rover's water splashing wheels are tailored for efficient movement in shallow water, demonstrating a remarkable ability to resist water current impact. This feature expands the system's applicability to aquatic environments.

1) *Arduino-Based Control:* The rover's terrestrial movements are governed by an Arduino controller, providing a robust and customizable platform for ground-based operations
2) *MCU Coordination:* The Master Control Unit (MCU) serves as the central intelligence hub, analyzing signals from the Arduino controller, ensuring seamless coordination between the aerial and ground components

C. Integration and Communication

1) *Pixhawk Flight Controller*: Responsible for managing the flight dynamics of the quadcopter, the Pixhawk flight controller ensures precise and stable aerial maneuvers.
2) *Nano Controller Subsystem*: Organizes the arm mechanism, offering a dedicated control system for efficient deployment of arms and stability.
3) *Arduino-Based Rover Control:* The Arduino controller governs the rover's movements, with the MCU serving as the bridge for effective communication and coordination between the aerial and ground systems.

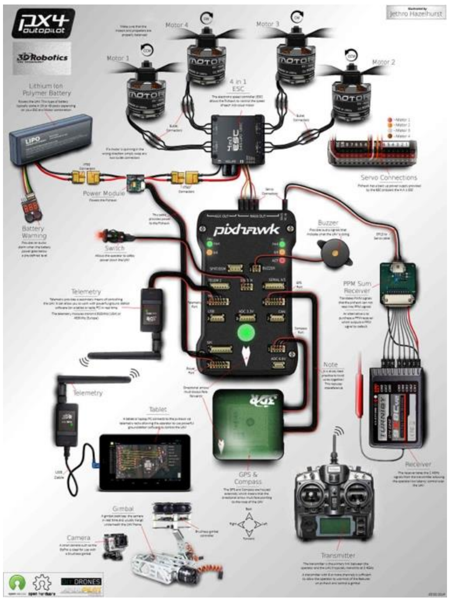
VI. BLOCK DIAGRAM



VII. METHODOLOGY

The hybrid robot is designed with the overarching goal of leveraging the strengths of both aerial and land-based mobility, ensuring optimal performance in diverse environments. Its key features revolve around achieving seamless transitions between flight and ground movement, enhancing maneuverability, and enabling the execution of a variety of tasks. To realize these objectives, the robot employs a sophisticated control algorithm that facilitates smooth transitioning between flight and ground modes.

The core methodology driving this seamless transition involves sensor fusion, a process that integrates data from



multiple sensors to create a comprehensive and accurate understanding of the robot's surroundings. This sensor fusion allows the hybrid robot to adapt dynamically to changing environments, a crucial capability for efficient and effective operations. By continuously receiving and analyzing data from sensors such as cameras, GPS, barometers, altimeters, pressure and ultrasonic sensors, and environmental sensors, the robot gains real-time insights into its surroundings.

A. Requirement analysis

In the requirement analysis, it's crucial to identify specific application needs for both terrestrial and aerial functionalities. For terrestrial operations, considerations may include efficient maneuverability on diverse terrains. Aerial functionalities might require features like stable flight and obstacle avoidance. Performance criteria, including payload capacity, speed, range, and autonomy, must be defined. Payload capacity ensures the robot can carry required equipment, while speed and range impact mission efficiency. Autonomy is vital for independent task execution. Clear identification of these criteria forms the foundation for designing a versatile and high-performance hybrid robot.

B. Drone system integration

The drone system is meticulously designed for seamless integration with the rover, ensuring effective coordination. Advanced communication protocols are implemented to facilitate real-time data exchange between the rover and drone. This integration enables features such as autonomous mission execution, allowing the drone to perform predefined tasks independently. Auto-tracking capabilities enhance target following, and low-altitude flying capabilities are incorporated for detailed observations. The synergy between the drone and rover, coupled with these advanced features, enhances the system's versatility and efficiency in addressing a myriad of tasks in diverse environments**.**

C. Rover system development

The four-wheeled rover is intricately designed with a water splashing wheel structure, ensuring optimal mobility in diverse environments, including shallow waters. A robust speed control system is integrated to facilitate precise maneuvering, adapting to different terrains efficiently. Payload management features are implemented, allowing the rover to carry additional equipment for various applications. This design emphasizes versatility, providing the rover with the capability to navigate challenging terrains while accommodating the necessary tools and instruments for a wide range of tasks in fields such as exploration, research, and industrial applications.

D. Wheel structure design

Hydrodynamic studies are conducted to comprehend water resistance, crucial for designing an efficient wheel structure for shallow water navigation. The rover's wheels are tailored to minimize resistance, ensuring optimal movement through water. Additionally, an acrimonious technique is implemented on the wheel surface, enhancing traction on wet and slippery terrains. This approach increases the rover's stability, enabling it to navigate challenging environments effectively. The combination of hydrodynamic studies and the acrimonious technique ensures the rover's adaptability to various surfaces, emphasizing its capability to navigate both terrestrial and aquatic terrains with enhanced performance**.**

E. Hybrid locomotion & weight lifting

Algorithms are developed to ensure seamless coordination between the rover's ground-based movement and the drone's aerial capabilities, allowing the hybrid system to efficiently navigate diverse environments. The integration of weight lifting and delivery mechanisms on the drone enhances the system's versatility by enabling it to lift and transport objects. This feature expands the system's functionality, making it capable of performing tasks such as object retrieval or delivery in varied scenarios. The harmonious collaboration between the rover and drone, coupled with these advanced capabilities, establishes the system as a versatile tool for a wide range of applications, from industrial tasks to exploration mission.

VIII. IMPLEMENTATION

A. Drone configuration

1) *Frame:* The symmetric frame design ensures stability and optimal space utilization, providing a sturdy foundation for payload integration. This design choice is crucial for maintaining balance during both aerial and terrestrial operations.
2) *Flight Controller:* The Pixhawk flight controller, renowned for reliability and versatility, serves as the brain of the drone. Its open-source nature allows for customization and integration with various sensors, enhancing the overall autonomy of the system.
3) *Transmitter:* The 6-channel transmitter not only enables manual control but also facilitates mission planning. This feature is essential for adapting the system to dynamic environments and diverse tasks, allowing for real-time adjustments during operations.

B. Rover configuration

1) *Chassis:* The rover's robust chassis is designed to accommodate the water splashing wheel structure and payload. It acts as a protective housing for internal components, ensuring durability in challenging terrains.
2) *Controller*: Utilizing Arduino as the rover's controller provides a real-time control interface and facilitates sensor integration. Arduino's versatility allows for seamless communication with various sensors and components, making it a suitable choice for managing the rover's movements and tasks.

C. Water splashing wheel design

1) *Specialized wheels:* The water splashing wheels are tailored for efficient movement in shallow water, slippery surfaces, and challenging terrains. Their unique design minimizes resistance and enhances the rover's adaptability to different environments.
2) *Traction Enhancement*: Implementing an acrimonious technique on the wheel surface significantly improves traction and stability. This feature is particularly valuable when navigating through rough or uneven terrain, ensuring the rover can maintain control and stability.

D. Sensors

1) *Comprehensive Sensor Suite*: Both the rover and drone are equipped with an array of sensors, including cameras, GPS, barometer, altimeter, pressure, ultrasonic sensors, and environmental sensors. This comprehensive sensor suite enables the system to collect diverse data for terrain mapping, obstacle detection, and environmental monitoring.
2) *Wireless Data Transmission*: The collected data is transmitted wirelessly to the PC-Interfaced Ground Control Station (GCS) in real-time. This seamless communication ensures that operators have up-to-date information for decision-making and system control.

E. Pc-interfaced ground control station (gcs)

1) *User-Friendly Interface* : The GCS features a user-friendly graphical interface for centralized monitoring and control. Operators can visualize data, set waypoints, and monitor the system's status in real-time, enhancing situational awareness and control efficiency.
2) *Real-Time Communication*: The GCS enables real-time communication with the hybrid system, allowing operators to intervene or modify mission parameters as needed. This two-way communication ensures a responsive and adaptable system.

F. Hybrid locomotion algorithms:

1) *Coordinated Movement*: The implemented algorithms facilitate seamless coordination between the drone and rover during hybrid locomotion. This coordination is essential for the drone to effectively assist the rover in overcoming obstacles, provide aerial surveillance, and enhance overall mobility.
2) *Adaptability*: The algorithms allow the system to dynamically adapt to the environment, adjusting the balance between aerial and terrestrial components based on the terrain and mission requirements.

G. Autonomous mission execution:

1) *Predefined Tasks*: The drone is programmed with autonomous mission execution capabilities, allowing it to perform predefined tasks without constant manual control. This autonomy is

particularly valuable for efficiency in data collection and exploration missions.

2) *Waypoint Navigation*: Waypoints and actions are defined through the GCS, enabling the system to follow a predetermined path and execute specific actions autonomously. This feature streamlines complex missions and minimizes the need for constant human intervention.

IX. HARDWARE

A. Motors

In the symmetric frame configuration, each arm typically integrates a Brushless Direct Current (BLDC) motor, and the selection of these motors is critical to the drone's performance, taking into consideration its size and payload capacity. BLDC motors are preferred for their efficiency, reliability, and precise control, making them suitable for quadcopters. The size and power rating of the BLDC motors must align with the dimensions and weight-carrying capabilities of the drone. Larger drones with higher payload capacities may require more powerful motors to ensure optimal lift and stability. Conversely, smaller drones may benefit from compact and lighter BLDC motors to maintain an appropriate power-to-weight ratio. The careful selection of BLDC motors for each arm of the symmetric frame is fundamental to achieving the desired flight characteristics and overall performance of the drone.

B. ESC

In the Quadcopter configuration, the integration of an Electronic Speed Controller (ESC) for each motor is essential to govern the speed and direction of the Brushless Direct Current (BLDC) motors. The ESC acts as a crucial intermediary between the flight controller and the motors, translating electronic signals into precise motor control. By adjusting the voltage and current supplied to each motor, the ESC enables dynamic control of motor speed, allowing for precise maneuvers, stability, and responsiveness during flight. Each ESC is tailored to its corresponding BLDC motor, ensuring synchronous operation across all arms of the symmetric frame. This individualized control not only enhances the drone's overall performance but also contributes to its agility and adaptability, making it well-suited for diverse aerial applications.

C. Flight controller

The Pixhawk flight controller is a sophisticated and widely used component that exemplifies the pinnacle of drone control systems. As the heart of the drone, the Pixhawk flight controller goes beyond managing stability and flight characteristics—it encompasses a comprehensive set of features and capabilities. Equipped with advanced sensors such as accelerometers, gyros, and GPS, the Pixhawk precisely interprets environmental data to ensure accurate positioning and navigation. Its open-source architecture facilitates customization, enabling users to fine-tune control parameters and algorithms to suit specific mission requirements.

The Pixhawk also supports a variety of flight modes, including autonomous waypoint navigation and stabilized manual control. Its integration with the Electronic Speed Controllers (ESCs) allows seamless coordination of motor outputs, ensuring optimal performance.

In summary, the Pixhawk flight controller is not just the brain of the drone; it represents a versatile and powerful control system that enhances the drone's overall functionality and adaptability for a wide range of applications.

D. Propellers

Incorporating two pairs of propellers, with both clockwise and counter clockwise rotations, is a critical optimization strategy for the chosen BLDC motors within the H-frame quadcopter configuration. This careful pairing is essential to achieve balanced thrust, stability, and precise maneuverability. By countering torque effects through the strategic coordination of propeller rotations, this configuration ensures efficient and controlled flight across a range of operational scenarios. The size, pitch, and material composition of the propellers are meticulously chosen to align with the power rating of the motors, contributing to optimal lift efficiency and minimized power consumption for enhanced overall aerodynamic performance.

E. Battery

The LiPo (Lithium Polymer) battery serves as the primary power source for both the drone and rover components in the integrated drone frame. This battery, selected with appropriate voltage and capacity considerations, ensures reliable and consistent power to drive the BLDC motors in the drone and the rover motors on the ground.

The battery's compatibility with both the Electronic Speed Controllers (ESCs) for the drone and the motor drivers for the rover guarantees seamless integration and optimized performance, maintaining stability, endurance, and responsiveness across a variety of terrains and operational scenarios.

X. SOFTWARE

A. Firm Ware

Pixhawk firmware, a key element of the Pixhawk flight controller, is a sophisticated software that governs the operation of the drone. This open-source firmware provides a robust foundation for the Pixhawk flight controller, enabling precise control and stability during flight. It incorporates advanced algorithms and customizable settings, allowing users to tailor the drone's behaviour to specific needs. Regular firmware updates enhance performance, introduce new features, and address any issues, ensuring the Pixhawk-equipped drone operates with the latest optimizations and capabilities. The Pixhawk firmware plays a pivotal role in the reliability and adaptability of the drone across various applications.

B. Mission Planner

Mission Planner is a powerful ground control station software designed for unmanned aerial vehicles (UAVs) and drones. Serving as a comprehensive planning and monitoring tool, Mission Planner allows users to program autonomous flight missions, configure vehicle parameters, and monitor real-time telemetry data. Compatible with various flight controllers, including Pixhawk, Mission Planner provides an intuitive interface for mission planning, waypoint navigation, and managing vehicle settings.

Its rich set of features includes map overlays, 3D modelling, and a built-in flight simulator, making it an indispensable tool for both hobbyists and professionals in the drone community. Mission Planner significantly enhances the user's ability to plan, execute, and monitor missions with precision and efficiency.

C. Telemetry

Telemetry refers to the communication link between the Pixhawk flight controller and a ground control station, enabling real-time transmission of crucial data during drone operations. Using telemetry modules, such as radio telemetry or digital transmission systems, Pixhawk provides continuous updates on flight parameters, sensor readings, and system status. This bidirectional communication allows users to monitor and control the drone remotely, providing essential information for mission planning, navigation, and troubleshooting. Pixhawk telemetry enhances situational awareness, enabling operators to make informed decisions and ensuring a seamless and responsive connection between the drone and the ground control station.

D. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a user-friendly software platform that facilitates the programming of Arduino microcontrollers. With a simple and intuitive interface, Arduino IDE allows users to write, compile, and upload code to Arduino boards effortlessly.

It supports a vast community of developers and provides access to a rich library of pre-written code, making it an ideal environment for both beginners and experienced programmers. Arduino IDE plays a pivotal role in the widespread adoption of Arduino boards, enabling users to bring their creative projects to life through seamless code development and microcontroller programming

E. User interface

The user interface of a ground control station (GCS) serves as the central dashboard for interacting with and managing unmanned aerial vehicles (UAVs) or drones. It provides an intuitive and visual representation of critical flight information, including real-time telemetry data, GPS coordinates, battery status, and more. The GCS user interface typically includes interactive maps, flight logs, and mission planning tools, allowing operators to monitor and control the drone's behaviour. With user-friendly features and controls, the GCS interface enhances situational awareness and empowers users to make informed decisions during drone operations. It acts as a command center, providing a comprehensive and accessible platform for efficient drone management and mission execution.

XI. CONCLUSION

A revolutionary invention with enormous potential in a variety of scientific, industrial, and recreational domains is the suggested hybrid robotic idea, which combines an integrated drone system with a four-wheeled rover with a water splashing wheel construction. By addressing the shortcomings of conventional models, the rover's water splashing wheel construction makes it possible to navigate difficult terrains including muddy, slippery, and shallow water bodies with ease. The rover becomes a multipurpose hybrid marvel as a result of the drone system's integration, raising the notion to new and metaphorical heights. The drone's hybrid locomotion capabilities enhance the rover's ground-based mobility, and it also offers autonomous functions including auto-tracking, task execution, loitering, and low-altitude flight. Tasks requiring both airborne and ground activities are comprehensively solved as a consequence of this complementary effort.

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