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Hybrid Quadcopter for Surveillance and Rescue Operations

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***Abstract*—The Hybrid Quadcopter for Surveillance and Rescue Operations is an innovative system designed for disaster-prone and remote areas, integrating an F450 quadcopter with an RC car for seamless air, land, and water surveillance. Controlled by an APM 2.8 flight controller, the quadcopter provides aerial monitoring while carrying an RC car equipped with temperature, humidity, gas, ultrasonic, and PIR sensors. The RC car can detach mid-flight to navigate challenging terrains, collecting real-time environmental data. Two HD night vision cameras, one on the quadcopter and another on the RC car, ensure high-quality live feeds for effective monitoring. A robotic arm facilitates medical kit delivery, offering immediate aid before rescue teams arrive. Additionally, an RF-based mic and speaker system enable real-time communication between victims and rescue teams, improving coordination. A telemetry system provides live location tracking and flight data for precise navigation. This hybrid system enhances search and rescue operations by offering multi-terrain adaptability, real-time surveillance, and rapid medical assistance, making it a crucial advancement in disaster response and emergency management.**

Keywords—Hybrid Quadcopter, Surveillance and Rescue, Real-Time Monitoring, Flight Controller (APM 2.8)

I. INTRODUCTION

The demand for efficient, versatile, and autonomous surveillance and rescue systems has significantly increased due to the growing frequency of natural disasters, security threats, and emergency response requirements. Traditional UAVs (Unmanned Aerial Vehicles) offer rapid deployment and aerial monitoring capabilities, but their limitations in endurance, energy efficiency, and maneuverability in confined or obstructed environments restrict their effectiveness in critical rescue operations. Similarly, UGVs (Unmanned Ground Vehicles) provide reliable ground navigation but lack the ability to traverse obstacles such as collapsed structures or flooded areas. To address these limitations, this research presents the design and implementation of a Hybrid Quadcopter for Surveillance and Rescue Operations, integrating the mobility of a quadcopter with the terrain adaptability of a ground vehicle. This hybrid system allows seamless transition between aerial and terrestrial movement, enabling it to overcome various environmental constraints that standalone UAVs or UGVs cannot handle efficiently. The proposed system is equipped with an advanced flight controller, brushless motors for aerial navigation, high-torque DC motors for ground mobility, and multiple sensors including GPS, IMU, ultrasonic sensors, and a real-time video transmission module for autonomous navigation and obstacle avoidance. A hybrid navigation algorithm governs the transition between flight and ground modes, ensuring optimal path planning and power efficiency. Unlike conventional UAVs, which are constrained by battery limitations and flight restrictions in urban areas, the hybrid quadcopter can land and continue operations on the ground, significantly extending operational time and mission feasibility. The primary applications of this system include search and rescue missions in disaster-stricken regions, real-time surveillance for security operations and reconnaissance in hazardous environments where human access is limited. Additionally, the integration of real-time video transmission and machine-learning-based obstacle detection enhances situational awareness for remote operators. Several real-world tests were conducted to validate the system's performance, demonstrating successful transitions between flight and ground navigation, efficient obstacle detection, and prolonged operational time compared to standard UAVs. The results indicate that the system can provide critical advantages in rescue missions by reducing response time and increasing coverage capabilities. Compared to traditional UAV-based surveillance, this hybrid approach significantly improves operational flexibility, making it a viable solution for modern search and rescue challenges. Despite its advantages, challenges such as energy consumption optimization, autonomous decision-making, and adaptability in extreme environments remain areas for further improvement. Future enhancements will focus on integrating AI-driven navigation for fully autonomous operation, implementing energy- efficient propulsion systems to extend battery life, and refining environmental mapping capabilities for more precise decision-making in complex terrains.

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Several studies have contributed to advancements in search and rescue (SAR) operations through AI-driven and UAV-based methodologies.

II. Literature Survey

Search and Rescue (SAR) operations have increasingly integrated intelligent systems such as UAVs, deep learning, and sensor networks to enhance operational effectiveness and reduce response times in disaster-affected areas. The following literature review outlines the recent advancements and methodologies that support automated detection, tracking, and coordination mechanisms in SAR environments.

Tohaemy (2021) proposed an "Automatic Person-in-Water Detection System" that employs deep learning models to detect human presence in maritime environments during SAR missions. The study focused on convolutional neural networks (CNNs) trained on visual datasets captured in challenging marine conditions, including varied water turbulence, lighting variations, and occlusions. The system showed significant promise with high detection accuracy and low false-positive rates, making it a valuable tool for real-time monitoring using UAVs and surveillance drones. The work demonstrated the feasibility of deploying AI-powered vision systems in maritime SAR applications, offering a critical edge in locating victims faster [1].

Neupane and Horan (2020) introduced an "Ensemble learning-based approach" to improve the accuracy of human detection in SAR operations. Their model integrated multiple classifiers such as random forests, support vector machines (SVM), and neural networks to form a robust ensemble framework. By combining the strengths of individual models, the ensemble approach reduced classification errors in complex SAR scenarios involving debris, low visibility, and irregular terrains. This study is pivotal in reinforcing the importance of hybrid models over standalone detection systems, particularly for improving detection reliability in real-world disaster conditions [2].

M. Rahmani, A. Nath, and S. Shaker (2020) conducted a "Comprehensive survey on UAV-based target tracking systems" for SAR applications, reviewing over 100 papers related to object tracking, UAV path planning, and multi-UAV coordination. The survey categorized tracking systems into vision-based, sensor-based, and hybrid systems. Key challenges identified included real-time processing limitations, occlusion management, energy constraints, and the integration of multi-modal data. The review emphasized the increasing use of deep reinforcement learning and Kalman filtering techniques or dynamic target tracking. It also underscored the role of UAV swarms in covering wider areas with greater autonomy and precision [3].

Al-Hourani (2020) addressed the "Air-to-Air wireless communication" needs of drone swarms by proposing an adaptive frequency allocation model to minimize interference and maximize bandwidth utilization. The study presented a detailed simulation-based model for signal propagation in UAV networks, accounting for drone altitude, mobility, and environmental constraints. This work is highly relevant to SAR operations involving multi-UAV systems, where coordination and information exchange are essential for synchronized mission execution. The adaptive approach supports the reliable deployment of autonomous UAV swarms in real-time rescue missions [4].

Munir et al. (2021) explored "Cognitive workload monitoring of drone operators" using machine learning algorithms trained on physiological signals such as EEG, eye-tracking, and heart rate data. The study aimed to adapt user interfaces based on the operator’s mental workload during SAR operations. By implementing cognitive models, the system could dynamically adjust visual and control feedback, reducing operator fatigue and enhancing situational awareness. This research is critical in human-in-the-loop UAV control systems, ensuring operator readiness and sustained performance during prolonged or high-stress rescue missions [5].

Sun et al. provided an 'Extensive review of on-road vehicle detection methods", focusing on vision-based techniques such as background subtraction, edge detection, and machine learning classifiers. Although primarily developed for urban traffic systems, many of these techniques are transferable to SAR applications where recognizing emergency vehicles or mobile assets in post-disaster zones is essential. The study detailed both monocular and stereo vision approaches and highlighted challenges related to cluttered backgrounds and object occlusion. The review also laid a foundational basis for subsequent advances in real-time object detection using AI [6].

Dollar et al. conducted a thorough evaluation of "State-of-the-art pedestrian detection algorithms", including deformable part models (DPM), integral channel features, and deep learning-based method. Their benchmark comparisons across multiple datasets revealed performance trade-offs in speed, accuracy, and robustness under varying lighting and occlusion conditions. Pedestrian detection is especially relevant to SAR operations in urban or collapsed-structure environments where locating survivors is the primary objective. This work provides an essential baseline for selecting and optimizing human detection models for field deployment in rescue scenarios [7].

III. Existing Methodology

The Surveillance and rescue operations traditionally depend on either aerial or ground-based robotic systems, each with inherent limitations. Drones are widely used for real-time monitoring, equipped with high-resolution cameras and thermal imaging to detect survivors in disaster-affected areas. However, their effectiveness is constrained by limited battery life, restricted payload capacity, and challenges in navigating complex environments. On the other hand, ground-based robots excel in traversing difficult terrains and carrying essential supplies but lack the speed and accessibility of aerial drones. Conventional payload delivery systems, such as fixed compartments or winch mechanisms, are often inefficient, as they lack precision in drop-offs and retrievals. Additionally, the communication and control of these systems often rely on short-range or unstable connections, which can hinder rescue operations. Furthermore, drones and robots operate independently, making coordinated missions challenging. These shortcomings highlight the need for an integrated hybrid solution that combines aerial mobility with ground-based stability. A hybrid quadcopter system that seamlessly transitions between flying and driving modes can address these issues by offering enhanced flexibility in surveillance and rescue missions. By incorporating a robotic arm, such a system can efficiently pick and drop medical supplies, improving response time in critical situations. This hybrid approach not only extends operational range but also ensures adaptability in varied terrains, making it a more effective tool for disaster management, military applications, and emergency response scenarios. Thus, the development of an advanced hybrid quadcopter that integrates both aerial and ground functionalities can significantly enhance the efficiency, accuracy, and reliability of surveillance and rescue operations, overcoming the limitations of existing methodologies.

IV. PROPOSED METHODOLOGY

The proposed system aims to develop a hybrid Quadcopter that can operate seamlessly across land, air, and water, enhancing its versatility for various surveillance and rescue operations. This innovative drone-car hybrid is designed to tackle challenges in remote or hazardous environments, providing critical support in situations such as natural disasters, security monitoring, and victim assistance. By integrating advanced technologies and multiple sensors, the system seeks to improve response times and operational efficiency in emergency scenarios incorporating features such as a night vision camera, voice communication capabilities, and a compartment for carrying essential supplies, the hybrid quadcopter is tailored for effective performance in low-light conditions and during complex rescue missions. The integration of sensors for motion, temperature, humidity, flame, and gas detection further enhances its functionality, allowing for comprehensive data collection and decision-making in critical situations. This proposed system represents a significant advancement in the field of aerial and ground- based rescue operations, aiming to save lives and improve safety in various applications.

Fig. 1 represents a motor control system using a NodeMCU ESP8266 microcontroller, a motor drive unit, four motors, and a battery. The ESP8266 acts as the main controller, sending signals to the motor drive unit, which then regulates power to the motors. The battery supplies the necessary voltage and current to the motor drive unit, which distributes it to the four motors accordingly. The system enables precise motor control, likely for applications such as robotic vehicles, drones, or hybrid quadcopters. The ESP8266, with its Wi-Fi capabilities, allows for remote operation, making the system suitable for automation, surveillance, or rescue operations.

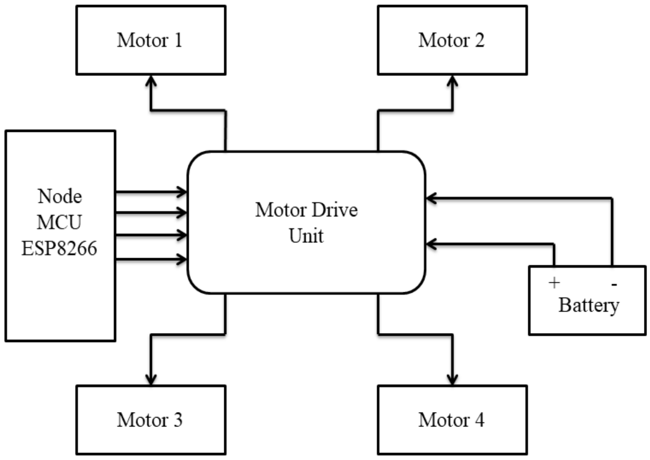

Fig.1. Block Diagram of RC Car

Fig. 2 represents the circuit diagram of the motor control of RC Car system using a NodeMCU ESP8266, an L298N motor driver, four DC motors, and a 18650 battery pack. The NodeMCU serves as the microcontroller, providing control signals to the L298N motor driver, which in turn controls the direction and speed of the motors. The L298N receives power from the 18650- battery pack which include two 3.7V 3.2Ah rechargeable batteries, supplying 7.4V to the motors and 5V logic power to the NodeMCU. The motors are arranged in an H- bridge configuration, allowing bidirectional movement. The motor driver's IN1, IN2, IN3, and IN4 pins are connected to the NodeMCU's digital output pins, enabling independent motor control. The enable pins on the L298N determine whether the motors are powered.

The ground (GND) connections of all components are linked to form a common reference point. The motors are wired in a differential drive configuration, commonly used in robotic vehicles, with crossed connections on one side to enable smooth turns. The 18650-battery pack provides the necessary current and voltage for efficient operation. This setup is ideal for remote-controlled robotic vehicles or automation projects where wireless control and efficient motor operation are required.

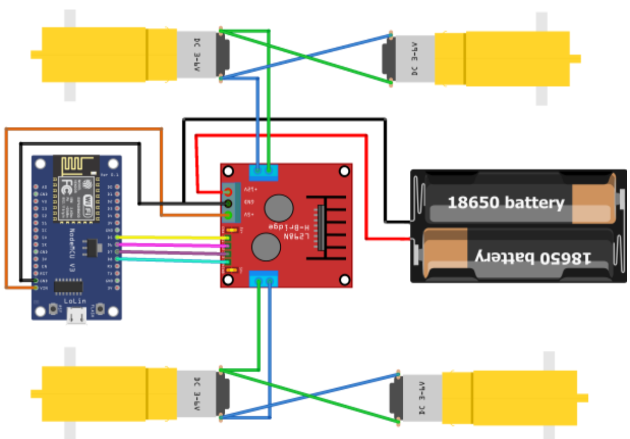

Fig. 2. Circuit Diagram of RC Car

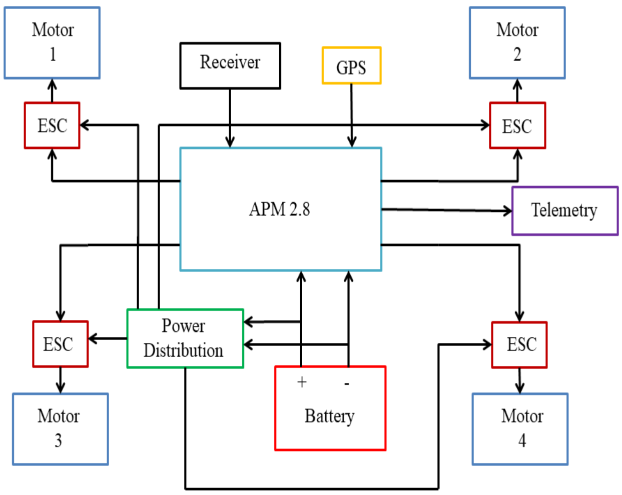

Fig. 3. Block Diagram of Quadcopter

Fig. 3 represents the block diagram that Symbolize the electronic architecture of a quadcopter, showcasing the integration of various components for stable and controlled flight. At the core is the APM 2.8 flight controller, which processes inputs from multiple sensors and the user to regulate motor speeds and ensure flight stability. The system is powered by a battery, which distributes energy through a power distribution board to four electronic speed controllers (ESCs) that control the speed of the four motors (Motor 1, Motor 2, Motor 3, and Motor 4). These motors generate the necessary thrust for lift and maneuverability. The receiver, connected to the APM 2.8, receives user commands from a remote control, enabling manual flight operations.

A GPS module provides real-time location data, allowing the quadcopter to perform autonomous navigation and waypoint tracking. Additionally, a telemetry module facilitates real-time data transmission to a ground station, enabling remote monitoring of flight parameters such as altitude, speed, and battery status. The APM 2.8 processes user inputs, GPS data, and sensor feedback to dynamically adjust the motor speeds through the ESCs, ensuring a stable and responsive flight. The power distribution board ensures a balanced power supply, maintaining efficiency across all components. With GPS integration and telemetry support, this setup enables a wide range of applications, including search and rescue missions, environmental monitoring, aerial surveillance, and automated inspections. This system design offers high precision, reliability, and adaptability, making it suitable for hybrid quadcopters that may integrate ground mobility features, further enhancing operational versatility beyond traditional aerial platforms.

Fig. 4 illustrates the integration of the APM 2.8 flight controller in a quadcopter system, highlighting its connection to Mission Planner software for configuration, monitoring, and control. The APM 2.8 functions as the central processing unit, receiving inputs from the receiver and GPS, and transmitting control signals to the electronic speed controllers (ESCs) that regulate the four brushless motors. The receiver processes flight commands, including roll, pitch, yaw, throttle, and auxiliary functions, with a 2.4 GHz RF module enabling real-time wireless communication with the transmitter. Powered by an 4s 2.2Ah 14.8V LiPo battery, the ESCs adjust motor speeds for stability, while a battery eliminator circuit (BEC) steps down the voltage to 5V, supplying power to the APM and receiver. The GPS module provides real time positioning data for navigation, autonomous flight, and position-hold capabilities, while the telemetry module transmits flight data to a ground station for live monitoring. Proper motor orientation, with synchronized clockwise and counterclockwise rotations, ensures balanced flight performance.

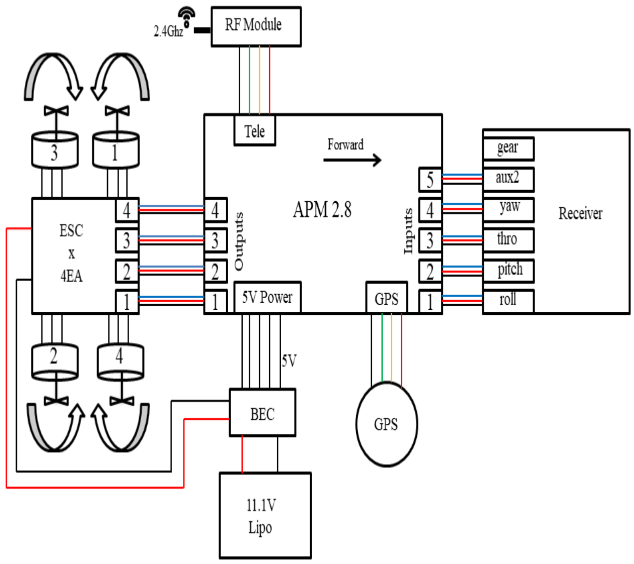

Fig. 4. Circuit Diagram of Quadcopter

Fig. 5. Mission Planner Software Interface

Fig. 5 shows the interface of mission planner software. Mission Planner software is integral for configuring and optimizing the quadcopter, offering a graphical interface for sensor calibration, flight mode adjustments, and autonomous mission planning using GPS waypoints. It provides real-time telemetry, GPS tracking, and battery monitoring, enabling users to track flight performance and enhance system stability. Additionally, Mission Planner supports pre-flight checks, log analysis, and firmware updates, ensuring the efficient operation of the APM 2.8. The software allows users to switch between manual and autonomous flight modes, making it ideal for applications such as aerial surveillance, search and rescue, and industrial inspections. Through real-time tracking, precise control, and customizable settings, Mission Planner enhances the reliability and adaptability of the APM 2.8 based quadcopter, optimizing performance across a variety of mission-critical applications.

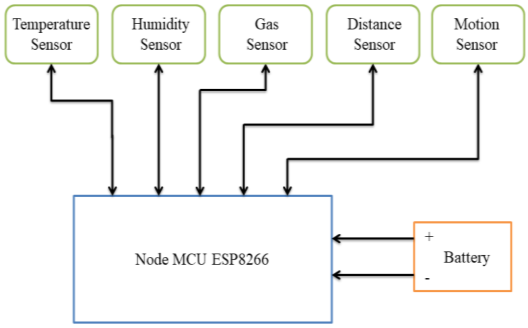

Fig. 6. Sensor System Block Diagram

Fig. 6 represents a functional block diagram of an IoT-based sensor system using the NodeMCU ESP8266 microcontroller, which collects data from multiple sensors and operates on battery power. The system consists of five sensors: a temperature sensor, humidity sensor, gas sensor, distance sensor, and motion sensor, each connected to the NodeMCU ESP8266, which processes the received data. The temperature and humidity sensors monitor environmental conditions, while the gas sensor detects harmful gases or air quality variations. The distance sensor helps in measuring object proximity or detecting obstacles, and the motion sensor identifies movement in the surroundings.

All these sensors provide real- time data to the NodeMCU, which can then transmit the information wirelessly to a cloud server or a user interface for monitoring and analysis. The entire system is powered by a battery, ensuring portability and continuous operation in remote areas. This setup is useful in applications such as smart home automation, environmental monitoring, security surveillance, and industrial safety. By leveraging the Wi-Fi capability of the ESP8266, the collected sensor data can be accessed remotely, enabling efficient decision-making and automation based on real-time environmental conditions.

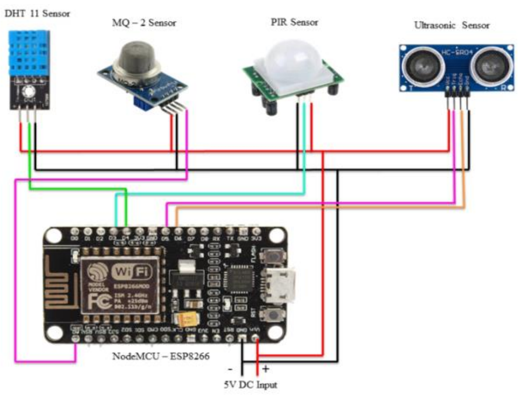

Fig. 7. Sensor System Circuit Diagram

Fig. 7 illustrates a sensor-based system utilizing the NodeMCU ESP8266 microcontroller, which is interfaced with four different sensors: the DHT11 temperature and humidity sensor, the MQ-2 gas sensor, the PIR motion sensor, and the HC-SR04 ultrasonic sensor. The DHT11 sensor, responsible for measuring temperature and humidity, is connected to a digital input pin of the ESP8266, enabling real- time environmental monitoring. The MQ-2 gas sensor, which detects gases such as smoke, propane, and methane, is wired to an analog input pin, allowing the microcontroller to process varying levels of gas concentration.

The PIR motion sensor detects infrared radiation emitted by moving objects, such as humans, and is linked to a digital pin of the NodeMCU, making it suitable for security applications. The HC-SR04 ultrasonic sensor, used for distance measurement, consists of a trigger and an echo pin connected to separate digital pins on the ESP8266 to send and receive sound waves, calculating the time delay to determine distance. Power is supplied through a 5V DC input, which is distributed to all components, ensuring stable operation.

The circuit is designed to collect data from all sensors and process it using the ESP8266, which, with its built-in Wi-Fi capabilities, can transmit the gathered information to a cloud server, mobile application, or other IoT platforms for remote monitoring and automation. This setup is ideal for applications in smart home automation, environmental sensing, security systems, and IoT-based real- time monitoring, offering a versatile and compact solution for various embedded projects.

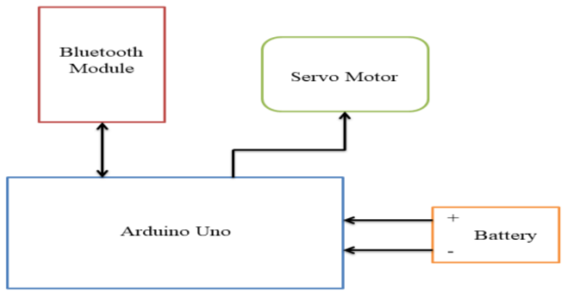

Fig. 8. Block Diagram of Robotic Arm

Fig. 8 represents the block diagram of robotic arm system, where an Arduino Uno controls a servo motor using a Bluetooth module. The Bluetooth module receives commands wirelessly and transmits them to the Arduino Uno. The Arduino processes these commands and adjusts the servo motor accordingly. A battery powers the Arduino Uno, which, in turn, supplies power to the servo motor and Bluetooth module. This setup is commonly used in remote-controlled.

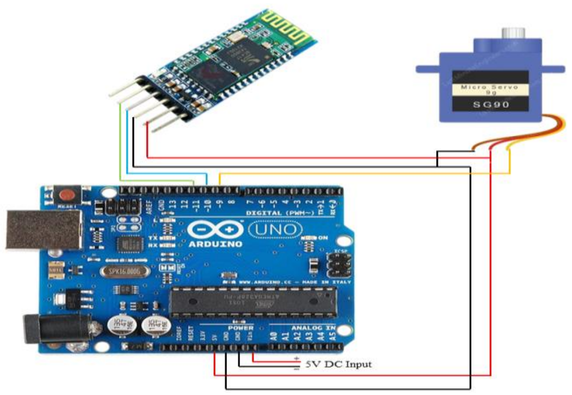

Fig. 9. Circuit Diagram of Robotic Arm

Fig. 9 illustrates an Arduino-based setup integrating an HC-05 Bluetooth module and an SG90 micro servo motor, powered by a 5V DC supply. The Arduino Uno serves as the central controller, receiving wireless commands via the HC-05 module, which is connected with its VCC and GND to the Arduino's power pins, while TX and RX interface with the Arduino's RX and TX for serial communication. The SG90 servo motor is powered by the Arduino's 5V and GND, with its signal wire connected to a digital PWM pin for precise control. An external 5V power supply ensures stable operation, preventing power constraints from the Arduino's onboard supply. This configuration allows remote control of the servo motor through Bluetooth, making it ideal for applications in robotics, automation, and IoT, where wireless interaction is essential for real-time motor adjustments.

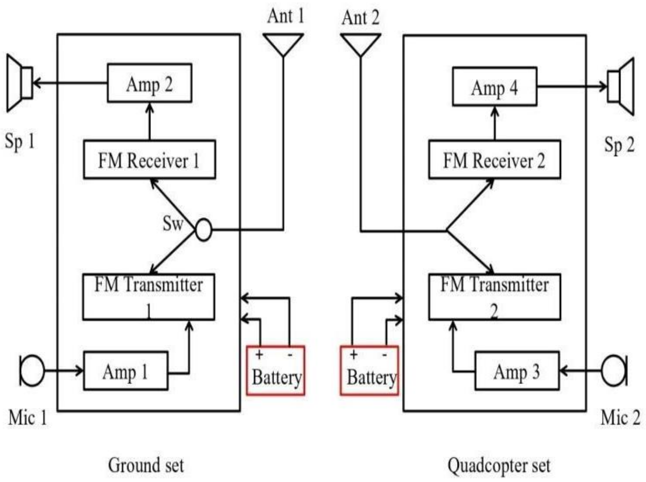

Fig. 10. Block Diagram of Voice Communication System

Fig. 10 represents the block diagram of the two-way FM communication system between a ground set and a quadcopter set, facilitating audio transmission and reception. The ground set comprises a microphone (Mic 1), an amplifier (Amp 1), an FM transmitter (FM Transmitter 1), a switch (Sw), an FM receiver (FM Receiver 1), an amplifier (Amp 2), and a speaker (Sp 1). The microphone captures audio signals, which are amplified by Amp 1 and transmitted via FM Transmitter 1 through an antenna (Ant 1). The quadcopter set features a corresponding system with a microphone (Mic 2), an amplifier (Amp 3), an FM transmitter (FM Transmitter 2), an FM receiver (FM Receiver 2), an amplifier (Amp 4), and a speaker (Sp 2). FM Receiver 2 on the quadcopter picks up the transmitted signal from the ground set through Ant 2, processes it via Amp 4, and outputs it via Sp 2. Similarly, Mic 2 captures audio on the quadcopter, which is amplified by Amp 3 and transmitted via FM Transmitter 2 through Ant 2. The ground set's FM Receiver 1 receives this signal, amplifies it using Amp 2, and outputs it through Sp 1. A switch (Sw) allows control over the transmission-reception mode at the ground station. Both sets are powered by separate batteries, highlighted in red. The system enables bidirectional communication between the ground station and the quadcopter, making it useful for applications such as aerial surveillance, remote communication, and real-time audio exchange between operators and airborne units. The FM transmission ensures efficient long-range communication without reliance on wired connections, providing flexibility in various operational environments.

V. System Analysis and Discussion

A. *Power Requirements and Supply Strategy*

The hybrid quadcopter system relies on multiple power sources to operate efficiently across various subsystems. The aerial unit is powered by a 4s 14.8V 2.2Ah Li-Po battery, providing sufficient energy to operate the APM 2.8 flight controller, brushless motors, GPS module, and telemetry system. For the RC car, a 7.4V 3.2Ah 18650 lithium-ion battery pack powers the NodeMCU ESP8266, motor driver, and onboard sensors. A Battery Eliminator Circuit (BEC) steps down voltages where necessary, ensuring all components receive stable power. These battery ratings allow for approximately 10–15 minutes of combined aerial and terrestrial operation per charge, depending on load and terrain.

B. *Environmental and Terrain Adaptability*

The system is designed to handle diverse environmental conditions. The quadcopter is capable of GPS-based flight navigation in open-air and moderate wind environments, while the RC car is fitted with all-terrain wheels and ultrasonic sensors to adapt to uneven ground, debris, or rubble often found in disaster zones. The system's robust frame ensures functionality during light rain and moderate dust exposure, though extreme weather such as heavy storms or high humidity may affect operational stability.

C. *Limitations and Mitigation Strategies*

The main limitations include limited battery life, signal interference, and sensor accuracy under extreme conditions. To mitigate these, modular batteries are used for easy replacement during extended missions, and signal repeaters or LTE modules can be added to extend communication range. Sensor fusion techniques are considered for future upgrades to increase reliability in poor visibility or unstable terrain.

VI. Results and Discussion

The hybrid surveillance system, which combines a quadcopter and an RC car, was successfully developed and tested. The results demonstrate the effectiveness of real-time data monitoring, remote control operation, and surveillance capabilities. The system can collect environmental data, navigating obstacles, and transmitting real-time video feeds, making it suitable for surveillance, disaster response, and search-and-rescue operations. The RC car is equipped with multiple sensors that continuously collect environmental data, which is displayed on the Blynk application. The data includes gas level, temperature, humidity, and distance measurement, along with a motion sensor status indicator. The Blynk application enables real-time monitoring of these environmental parameters, making the system ideal for hazardous environments such as disaster-struck areas, industrial zones, or areas with gas leaks. The RC car serves as the ground surveillance unit, equipped with an ESP8266 Wi Fi module for remote wireless operation, ultrasonic sensors for obstacle detection, motor driver circuits for smooth movement, and real-time data transmission capabilities via Wi-Fi.

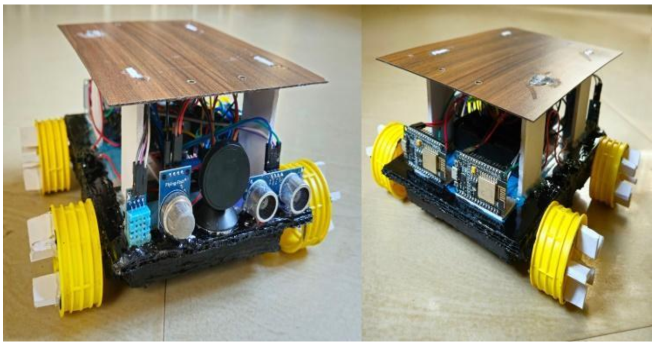

Fig 11. RC Car Front and Back View

Fig. 11 shows the front and back view of the RC car. The RC car is remotely controlled through a mobile application, allowing users to move it forward, backward, left, and right as shown in Fig. 12. It is designed to navigate through narrow passages and difficult terrain, making it useful for reconnaissance missions, military applications, and disaster response scenarios.

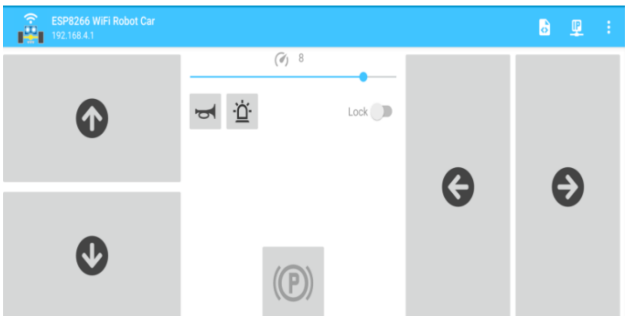

Fig 12. RC Car Control Application

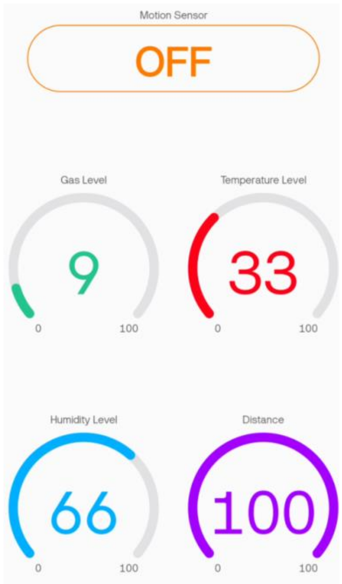

Fig 13. RC Car Sensor Output Using Blynk Application

Testing demonstrated that the RC car, equipped with various sensors, continuously collected environmental data that was displayed on the Blynk application as shown in Fig. 13. This included monitoring gas levels, temperature, humidity, and distance measurements, providing operators with vital information in hazardous environments. The ability to visualize this data in real-time allows for quick assessments and responses, making the system particularly effective in disaster-struck areas or industrial zones where immediate action is required.

In the project aimed at developing a hybrid quadcopter for surveillance and rescue missions, a key feature is the integration of a robotic arm controlled via a user-friendly interface. Fig. 14 shows the controlling of the robotic arm. This interface utilizes Bluetooth connectivity, allowing operators to manipulate the robotic arm wirelessly. Central to the control system is a prominent Bluetooth logo, symbolizing the wireless capabilities of the device.

Fig 14. Robotic Arm Control

The interface includes five angle presets—0, 45, 90, 135, and 180 degrees—enabling quick adjustments to the arm's position for various tasks such as reaching or grasping objects during rescue operations. Additionally, a green slider offers continuous control, allowing users to fine-tune the arm’s position beyond preset angles. This combination of preset buttons and a customizable slider enhances operational flexibility, ensuring that the robotic arm can respond effectively to the dynamic needs of surveillance and rescue missions.

Fig 15. RC Car mounted on Quadcopter

Fig. 15 shows the successful integration of the RC car mounted on the quadcopter, which enhances the hybrid system's operational capabilities. This innovative design allows the quadcopter to conduct aerial surveillance before deploying the RC car for ground-level monitoring, providing a comprehensive approach to situational assessment during rescue missions. The quadcopter's ability to transport the RC car to remote or hazardous locations significantly expands the range of operations, enabling emergency responders to access areas that may be difficult or dangerous to reach on foot.

The quadcopter is equipped with advanced navigation capabilities, including GPS and a flight controller, which facilitate precise positioning and stability during flight. The use of mission planning software further enhances the quadcopter's functionality, allowing operators to predefine flight paths and automate the surveillance process. This software enables users to set waypoints, adjust altitude, and configure specific tasks for the quadcopter, ensuring efficient coverage of the target area. For instance, during a search-and-rescue operation, the mission planning software can be programmed to conduct systematic aerial sweeps, maximizing the likelihood of locating victims or assessing damage.

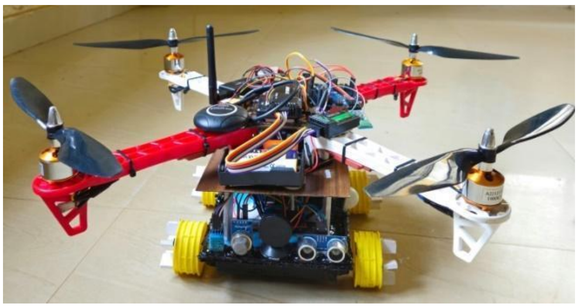

Fig 16. Final Prototype

Fig. 16 shows the final prototype of our project, showcasing a hybrid quadcopter designed for efficient surveillance and rescue operations. Equipped with advanced sensors and robust design, this drone can navigate various environments while capturing critical data for effective mission support.

VII. Conclusion

The hybrid quadcopter represents a significant advancement in surveillance and rescue operations, combining the capabilities of land, air, and water mobility. Its design incorporates a variety of sensors and communication tools, enabling it to perform effectively in diverse environments, whether urban, remote, or maritime. This versatility makes it an invaluable asset for emergency responders, enhancing their operational efficiency and situational awareness. Equipped with features such as night vision, GPS, and first-aid carrying capabilities, the quadcopter is well suited for critical tasks that require quick and reliable responses. Its ability to navigate challenging terrains and provide real-time data ensures that emergency teams can make informed decisions during crises. This technological innovation not only improves the effectiveness of rescue missions but also contributes to overall public safety. In summary, the hybrid quadcopter is a powerful tool that enhances the capabilities of emergency response teams. By integrating advanced technology and versatile functionality, it addresses the challenges faced in surveillance and rescue operations, ultimately leading to better outcomes in critical situations. The project underscores the importance of innovation in engineering and its potential to save lives and improve emergency management.

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