Journal of
Aerospace Engineering & Technology
https://journals.stmjournals.com/joaet

ISSN: 2231-038X (Online)
ISSN: 2348-7887 (Print)
Volume 14, Issue 1, 2024
January–April
DOI (Journal): 10.37591/JoAET

Research JoAET

Multi-functional UAV for Disaster Response and Management

Abhishek S.[1,*], Anirudh K.K.[2], Gautham G. Lal[3], Faris Muhammed[4]

Abstract

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have become integral across diverse fields such as agriculture, surveillance, and defense, with expanding roles in critical operations like search and rescue and post-disaster management. Despite their versatility, current UAVs encounter challenges in disaster response due to limitations in flight time, costs, and accuracy, particularly in dynamic weather conditions. The UAV is equipped with features essential for disaster site surveillance, human detection, communication with isolated individuals, and the delivery of vital supplies such as medical aid or food packages. The hardware foundation comprises a standard F450 drone frame and an APM flight controller. For human detection, a cost-effective solution utilizing a pre-trained machine learning model, YOLOv8, in conjunction with an FPV camera is implemented. Additional sensors can be seamlessly integrated to enhance human detection capabilities. Computational tasks are managed through a ground control station, ensuring the efficient execution of algorithms. Communication with affected individuals is facilitated by a SIM800L GSM GPRS module, accompanied by dedicated microphone and speaker components. Future developments include incorporating a modular dropping mechanism to the drone for flexible deployment options. The prototype aims for semi-autonomous control, detecting humans at altitudes of 10-25 meters and facilitating communication or dropping packages at specified locations. As a future scope, a hybrid UAV with rover capabilities can further enhance operational efficiency. The successful implementation of this drone prototype promises significant advancements in disaster response capabilities, leading to improved situational awareness, efficient communication, and timely delivery of essential supplies to affected areas.

Keywords: YOLO, UAV, Mission Planner, Machine learning, Human detection

INTRODUCTION

Drones, or Unmanned Aerial Vehicles (UAVs), have emerged as versatile tools at the forefront of modern technological advancements. These aerial platforms, equipped with advanced telemetry systems, machine learning algorithms, and an array of sophisticated sensors [1], have transcended their initial role as flying robots to become indispensable assets across various sectors. Technically, the foundation of drone technology rests upon the convergence of engineering disciplines such as aerodynamics, propulsion systems, and materials science. Aerodynamic design principles coupled with lightweight yet durable materials like carbon fiber composites optimize flight efficiency and structural integrity, enabling drones to perform a myriad of tasks. Sensor fusion, another cornerstone of drone technology, integrates high-resolution cameras, LiDAR, thermal imaging, and multispectral sensors [1]. These sensors, enhanced by machine learning algorithms, empower drones with autonomous decision-making capabilities, facilitating tasks ranging from object detection and tracking to classification and delivery [2, 3]. In military and defense applications, drones revolutionize tactical

***Author for Correspondence**
Abhishek S.
E-mail: abhishekmanjeeram@gmail.com

[1-4]Student, Department of Electrical and Electronics Engineering, TKM College of Engineering, Kerala, India

Receiving Date: May 20, 2024
Accepted Date: June 04, 2024
Published Date: June 10, 2024

Citation: Abhishek S., Anirudh K.K., Gautham G. Lal, Faris Muhammed. Multi-functional UAV for Disaster Response and Management. Journal of Aerospace Engineering & Technology. 2024; 14(1): 1–6p.

operations by offering persistent surveillance, reconnaissance, and precision strike capabilities. Similarly, in humanitarian and disaster response contexts, drones expedite response efforts and optimize resource allocation through rapid damage assessment and situational mapping [4, 5]. Operating seamlessly in adverse conditions, drones equipped with advanced telemetry systems navigate rugged terrains and disaster zones, augmenting search-and-rescue missions and enhancing overall disaster preparedness [5]. However, challenges such as regulatory frameworks, airspace integration, and cybersecurity threats loom large, requiring collaborative efforts to ensure responsible and ethical deployment of drone technology. Despite these challenges, the evolution of drones promises to shape a safer, more resilient future across military, humanitarian, and disaster response operations.

METHODOLOGY

Hardware

The drone's framework comprises a standard F450 frame, an APM flight controller, and four 1000 KV BLDC motors, ensuring robust performance. Telemetry control is facilitated by a Flysky receiver-transmitter module, offering ample operational range. In the prototype configuration, an ESP-32 CAM module captures vital videos or images of disaster sites. To enhance maneuverability and aerodynamics, a custom 3D-printed frame, designed using SolidWorks, is employed, capable of accommodating the wheels necessary for the hybrid UAV model [6, 7]. Hybrid UAV showcases profound improvements in future scope, combining the advantages of both drone and rover. Unlike previous approaches [2] that relied on onboard processing of camera visuals, our strategy leverages a ground control station (computer) for machine learning tasks, mitigating issues such as high latency and low flight time. Communication is facilitated by a SIM800L module, providing 2G connectivity with provisions for microphone and speaker connections. Additional optimization options include incorporating boards like the Maduino Zero 4G, featuring 4G connectivity and higher internet speeds, for improved performance. Detailed representations of the drone are depicted in Figure 1 and Figure 2.

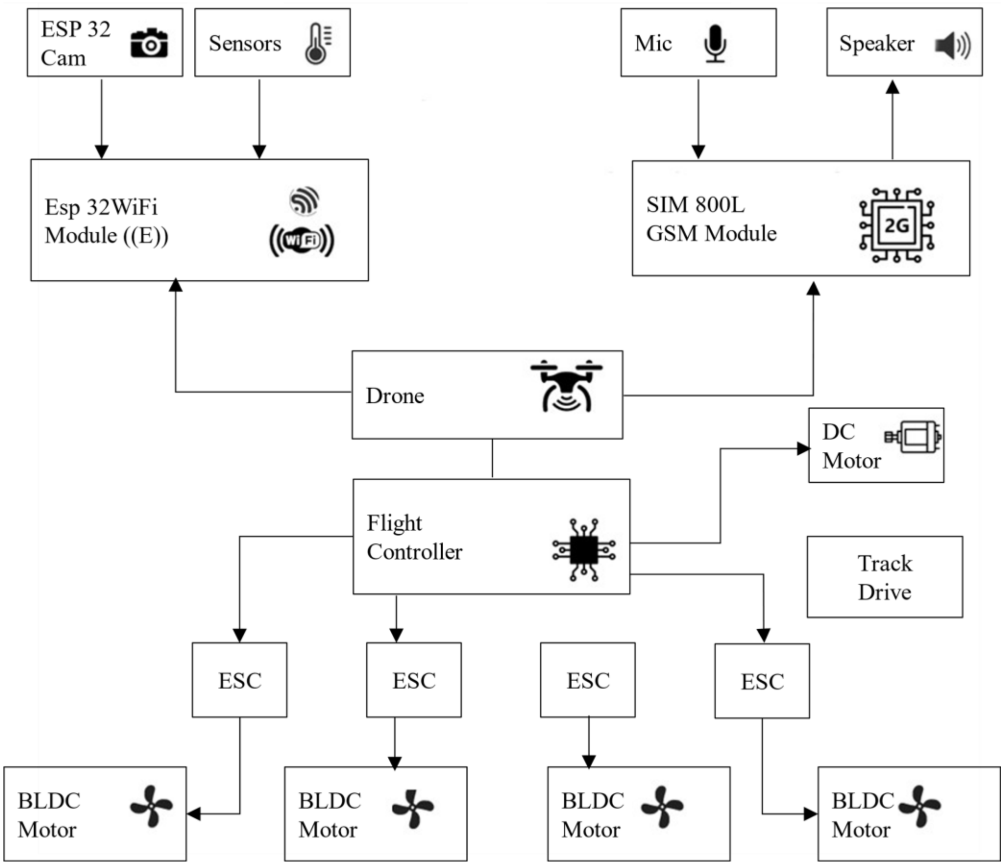

Figure 1. Block diagram.

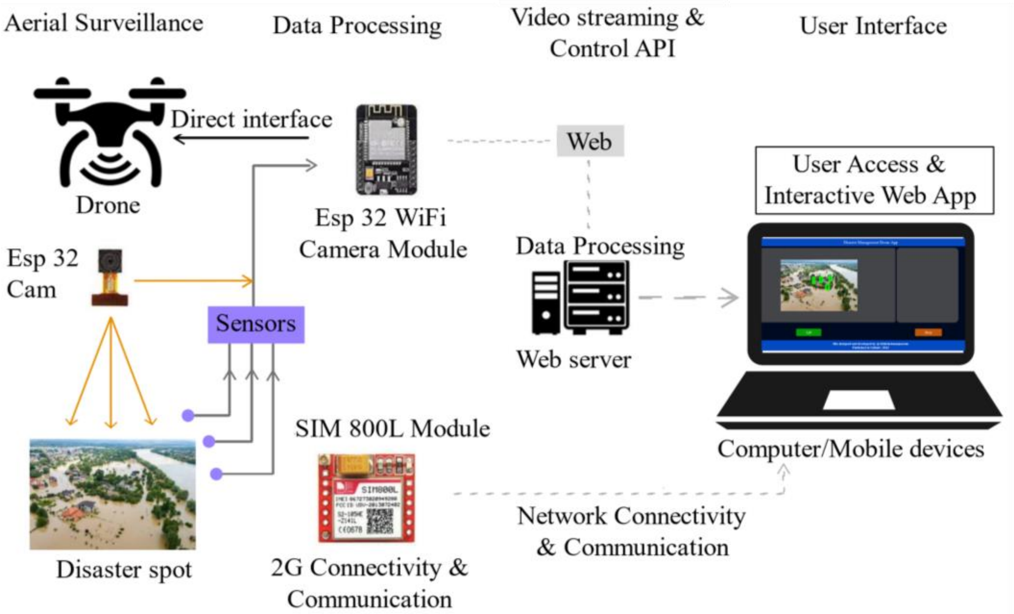

Figure 2. Functional diagram.

Software

The development process of the drone involves several crucial steps to ensure its effectiveness in disaster management scenarios. Calibration and firmware uploading are essential tasks performed using Mission Planner software, which serves as a comprehensive ground control station. Mission Planner enables not only the configuration of the drone but also dynamic control, allowing for autonomous operation based on predefined parameters such as viewpoints and flight paths. This capability is particularly valuable in disaster situations where precise and autonomous navigation is vital for effective response efforts. In order to detect humans amidst disaster debris and chaos, a sophisticated machine learning model is developed using Python. The model relies on YOLOv8, the latest iteration of the YOLO (You Only Look Once) algorithm series, renowned for its efficiency in object detection and classification within Computer Vision [2]. While YOLOv8 comes pre-trained to recognize various objects, including humans, our project aims to optimize its performance by fine-tuning it with the VisDrone dataset. This dataset consists of labeled aerial images, providing valuable training data specifically tailored to detecting survivors in disaster scenarios. [8] focuses on utilizing thermal datasets to distinguish between injured and uninjured individuals, our project prioritizes the identification of survivors without such discrimination. This approach is crucial for quickly locating and assisting individuals in need of rescue and medical attention. By deploying the machine learning model in the ground station, rather than on board the drone itself, we address potential challenges related to computational power and flight time constraints. This setup allows the ground station's computer to process video footage captured by the drone's FPV (First Person View) camera in real-time, enabling rapid and accurate human detection in disaster areas. [9] present advancements in human detection using customized datasets and deep neural networks, their applicability to disaster management contexts may be limited. Nonetheless, these developments contribute valuable insights and techniques that can enhance the performance of drones in non-emergency scenarios, further enriching the field of computer vision and machine learning.

Working

The drone serves as crucial surveillance equipment in disaster zones, functioning as the first responder in rescue operations. It navigates hard-to-reach areas like peaks and damaged buildings to search for missing individuals or animals. Autonomous control is facilitated through a ground control station, utilizing Mission Planner to set viewpoints and flight paths for surveillance operations as in Figure 3. In instances where the exact location is known, manual operation directs the drone to deliver essential supplies or establish communication with affected individuals [3]. Real-time video footage captured during flight is transmitted to the operator for analysis [4]. The ground control station employs machine learning algorithms to detect survivors shown in Figure 4, while for scenarios where visual data is unavailable, such as detecting individuals under rubble, alternative sensors like CO_2 [10] or proximity infrared sensors [1] are utilized. In areas inaccessible to drones, conversion to a rover extends battery life and enables access to precise locations. Moreover, the rover's functionality can be enhanced through modular conversion into a dropping mechanism, further augmenting the drone's versatility and operational efficiency [3].

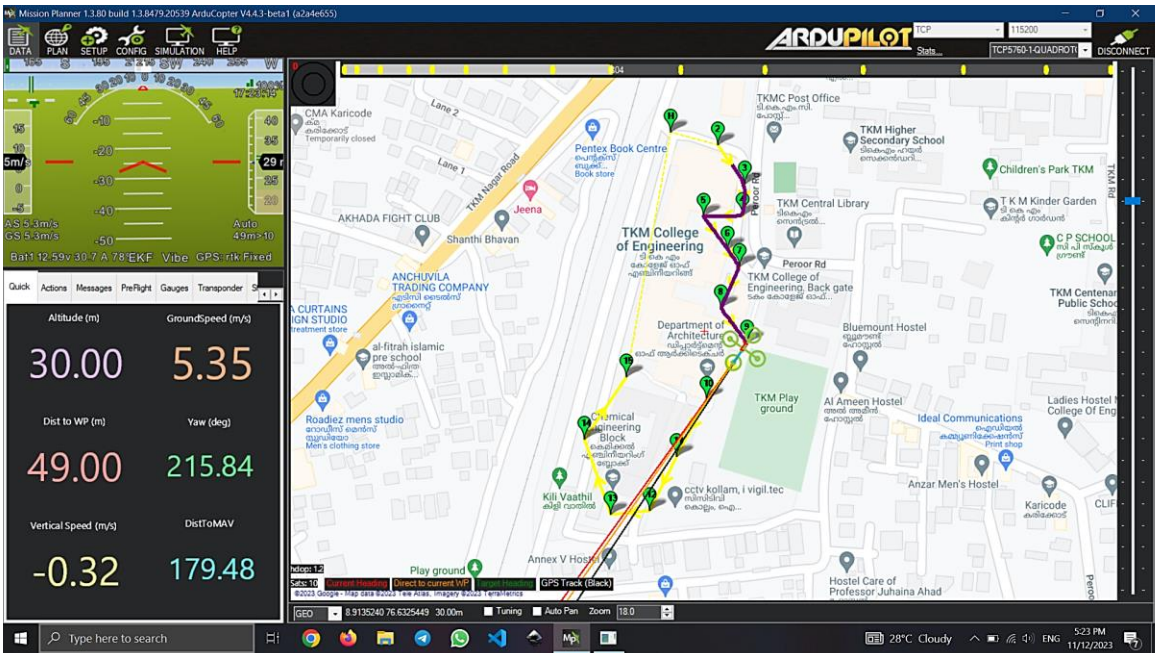

Figure 3. Flight path setup for autonomous mode.

Figure 4. Humans detected from drone footage after image processing using YOLOv8.

CONCLUSIONS

Incorporating a basic quadcopter outfitted with a communication module and camera holds promise for human detection in disaster zones, coupled with a specialized dropping mechanism for essential supplies delivery. To optimize flight performance, the computational burden of machine learning models can be offloaded to a ground control station, thereby enhancing accuracy and complexity while reducing onboard weight. Future endeavors could explore autonomous drone control via platforms like Mission Planner, offering seamless mission execution. Furthermore, addressing the challenge of limited flight time remains paramount, with potential solutions such as battery swapping warranting investigation to extend operational durations. Beyond disaster response, this technology extends its utility to encompass responsive mitigation measures and wildlife tracking, particularly in scenarios involving the encroachment of wild animals into human settlements. In conclusion, while current implementations showcase the efficacy of drones in disaster management, ongoing research and development efforts hold promise for further enhancements. Future scopes encompass advancements in autonomous control, battery technology, and expanded applications beyond human detection, underscoring the transformative potential of this technology in safeguarding lives and mitigating crises.

Acknowledgments

Deep thanks to TKM College of Engineering and Dr. Mathew P. Abraham for valuable guidance and technical support.

REFERENCES

1. S. Lee, D. Har and D. Kum. Drone-Assisted Disaster Management: Finding Victims via Infrared Camera and Lidar Sensor Fusion. *2016 3rd Asia-Pacific World Congress on Computer Science and Engineering (APWC on CSE)*, Nadi, Fiji. 2016. pp. 84-89. doi: 10.1109/APWC-on-CSE.2016.025.
2. J. Dong, K. Ota and M. Dong. UAV-Based Real-Time Survivor Detection System in Post-Disaster Search and Rescue Operations in *IEEE Journal on Miniaturization for Air and Space Systems*. 2021. vol. 2, no. 4, pp. 209-219. doi: 10.1109/JMASS.2021.3083659
3. K. -W. Chen, M. -R. Xie, Y. -M. Chen, T. -T. Chu and Y. -B. Lin. DroneTalk: An Internet-of-Things-Based Drone System for Last-Mile Drone Delivery. *IEEE Transactions on Intelligent Transportation Systems*. 2022. vol. 23, no. 9. pp. 15204-15217. doi: 10.1109/TITS.2021.3138432.
4. R. Tariq, M. Rahim, N. Aslam, N. Bawany and U. Faseeha. DronAID : A Smart Human Detection Drone for Rescue. *2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT)*, Islamabad, Pakistan. 2018. pp. 33-37. doi: 10.1109/HONET.2018.8551326.
5. N. Nikhil, S. M. Shreyas, G. Vyshnavi and S. Yadav. Unmanned Aerial Vehicles (UAV) in Disaster Management Applications. *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)*, Tirunelveli, India. 2020, pp. 140-148. doi: 10.1109/ICSSIT48917.2020.9214241.
6. L. T, K. V, A. K, R. N, and J. R. R, “Flying Rover”, *pices*, vol. 4, no. 5, pp. 98-111, Sep. 2020.
7. Swamy Shivakumara R., Sasnur, S. Sangamesh., Sai Prasanna G., Naga Srikanth B., & Kharvi, V. Sanketh. (2020). Design and Development of Unmanned Ground and Aerial Vehicle with The Concept of Integration of Drone and Rover. Journal of Emerging Technologies and Innovative Research, 7(8), 1629-1638.
8. M. -L. Tham, T. H. Cham and B. -H. Kwan, "Detecting Non-Injured and Injured Humans in Thermal Imaging using YOLOv8," *2023 International Conference on Computer and Applications (ICCA)*, Cairo, Egypt, 2023, pp. 1-5, doi: 10.1109/ICCA59364.2023.10401590.
9. M. -T. Do, M. -H. Ha, D. -C. Nguyen, K. Thai and Q. . -H. D. Ba, "Human Detection Based Yolo Backbones-Transformer in UAVs," *2023 International Conference on System Science and Engineering (ICSSE)*, Ho Chi Minh, Vietnam, 2023, pp. 576-580, doi: 10.1109/ICSSE58758.2023.10227141.

10. D. Garcia-Romeo, H. Fuentes, N. Medrano, B. Calvo, S. Celma and D. Antolin. An electronic interface for measuring CO2 emissions in embedded systems. *2012 IEEE International Instrumentation and Measurement Technology Conference Proceedings*, Graz, Austria. 2012. pp. 417-420. doi: 10.1109/I2MTC.2012.6229384.

