Usage of Police Surveillance Drone for Public Safety

Donna Mariya David[a], Abdul Adnan[b] and Abhishek H[c]
Department of Electrical and Electronics Engineering, Dayananda Sagar College of Engineering, Bengaaluru, Karnataka, India

Keywords: Autonomous, Public Safety, Law Enforcement, Emergency Response, Real Time Data Processing, Machine Learning.

Abstract: This paper presents a framework for utilizing autonomous drones to enhance public safety. The proposed system leverages advanced methodologies in autonomous navigation and real-time data processing to address critical challenges in law enforcement and emergency response. The drone operates independently, capturing high-resolution images of crime scenes, conducting surveillance over vast areas, and detecting suspicious activities such as theft. By integrating machine learning algorithms, the drone is capable of identifying and tracking individuals or objects of interest, providing actionable insights to authorities in real time. This work outlines the system's architecture, operational workflow, and key technologies, emphasizing its adaptability to dynamic environments and diverse applications. The paper also discusses the societal implications, potential challenges, and future directions for deploying autonomous drones in public safety scenarios. Through rigorous analysis and experimental validation, this study demonstrates how autonomous drones can serve as a transformative tool in modern law enforcement, promoting safety and security across communities.

1 INTRODUCTION

In an era where public safety concerns are increasingly paramount, especially in both urban and rural set- tings, the need for rapid and effective response mechanisms have been more critical. Traditional emergency response systems often face challenges in reaching crime scenes promptly, leaving communities vulnerable in times of crisis. To address these challenges, our project introduces an innovative solution: an autonomous drone designed specifically for public safety applications. This drone not only enhances surveillance capabilities but also integrates seamlessly with a dedicated protection application. The proposed drone system operates autonomously to monitor and traverse various environments, providing real-time aerial support to law enforcement agencies. In situations where individuals feel threatened or are in danger, the accompanying mobile application allows users to alert authorities with a simple press of a button. This action triggers the drone to navigate directly to the user's location ensuring a swift response. Upon arrival the drone captures high- resolution imagery of the scene. facilitating immediate assessment and documentation of potential threats. A key feature of our system is the integration of machine learning techniques to analyse video feeds and sensor data for identifying suspicious behaviours or activities. By training algorithms on diverse datasets, the drone can recognize patterns indicative of potential threats, enabling proactive intervention and enhancing situational awareness for law enforcement. This capability not only aids in crime scene documentation but also facilitates real- time decision- making by providing actionable insights. In this paper, we will explore the methodologies underpinning our autonomous drone system, focusing on its operational framework and the critical role of machine learning in enhancing safety. Through this approach, we aim to contribute to safer environments by harnessing the power of technology and data driven insights in public safety initiatives.

[a] https://orcid.org/0009-0001-2469-8090
[b] https://orcid.org/0009-0006-7013-2481
[c] https://orcid.org/0009-0009-4457-3234

Mariya David, D., Adnan, A. and H, A.
Usage of Police Surveillance Drone for Public Safety.
DOI: 10.5220/0013652700004639
In *Proceedings of the 2nd International Conference on Intelligent and Sustainable Power and Energy Systems (ISPES 2024)*, pages 171-177
ISBN: 978-989-758-756-6

2 REVIEWS OF EXISITING MODELS

The incorporation of drones into public safety initiatives has significantly transformed the landscape of law enforcement and emergency response. Models such as the JOUAV CW Series and Height Technologies SAMS exemplify the cutting- edge advancements that enhance surveillance and operational effectiveness. The JOUAV CW Series is particularly notable for its extensive range and impressive flight duration, making it well-suited for monitoring large areas, such as borders or critical infrastructure. In contrast, the SAMS drone system operates autonomously, allowing for continuous surveillance without requiring constant human supervision. This capability not only improves situational awareness but also facilitates quicker responses to incidents, thereby bolstering com safety. Skydio drones can be quickly launched from patrol vehicles, providing immediate aerial perspectives on developing situations. This real-time visibility is crucial for law enforcement to assess incidents effectively before arriving on the scene. Similarly, GAO Tek's drones utilize advanced sensors and machine learning algorithms to monitor suspicious activities and gather critical data efficiently, showcasing how technology can enhance crime prevention efforts.

3 GAP ANALYSIS

The current landscape of drones designed for public safety includes a range of models with each offering unique features tailored to specific operational needs. While these established models excel in areas like autonomous navigation, high-resolution imaging, and real-time data transmission, they often lack comprehensive user engagement mechanisms that empower citizens to actively participate in their own safety. Most existing systems are primarily designed for law enforcement use and do not provide a direct interface for the general public to alert authorities in emergencies. In contrast, the proposed drone model is paired with a mobile application that allows anyone to utilize its capabilities for public safety. In situations where in- dividuals feel threatened or are in danger, they can simply press a button on the app to send an immediate alert along with their location to the drone. Upon receiving an alert from the app, the drone can autonomously navigate to the user's location and analyze the environment for potential threats. This proactive approach allows law enforcement to assess situations more effectively upon arrival, ultimately improving public safety outcomes. By integrating user engagement through our app with advanced drone technology, our model represents a significant advancement over current offerings in the public safety drone market. This user-friendly feature addresses a significant gap in existing models by enabling rapid response from the drone without requiring prior training or specialized knowledge. The integration of this app not only enhances community engagement but also ensures that help can be dispatched quickly and efficiently

4 METHADOLOGY

This section outlines the design and assembly of a drone system that integrates essential hardware components, including motors, electronic speed controllers, and a Raspberry Pi as the central processing unit. The second part talks about the programming phase which incorporates machine learning algorithms and advanced image processing techniques using OpenCV and TensorFlow Lite

4.1 Design and Assembly of Hardware

Once the frame is established, we proceed to assemble the essential components, including motors, electronic speed controllers (ESCs), propellers, and a power distribution board. Each motor is paired with a propeller to generate sufficient lift, while the ESCs regulate power delivery based on input from the flight controller. In addition to these core components, several auxiliary elements are integrated into the drone system. The Raspberry Pi acts as the central processing unit, managing data from various sensors, including the GPS module for location tracking and ultrasonic sensors for obstacle detection. This configuration allows for autonomous navigation and real time decision-making, critical for effective operation in dynamic environments. Communication is facilitated through a GSM module, which connects the drone to a mobile application used by individuals in distress, allowing them to send alerts with their location. The telemetry module enables real-time data transmission between the drone and ground control, providing operators with live video feeds and sensor information. The onboard camera captures high-resolution images and video for surveillance purposes, with image processing handled by OpenCV to enhance data quality. Together, these components create a cohesive system that enhances situational awareness and enables rapid responses to emergencies.

4.2 Programming and Integration

The subsequent phase focuses on programming the flight controller, which acts as the central processing unit for the drone's operations. The flight controller is configured to interpret data from the GPS module and various sensors, enabling autonomous navigation and obstacle avoidance capabilities. Machine learning algorithms are implemented to enhance the drone's ability to analyze sensor data in real time for detecting suspicious activities. These algorithms are are trained on diverse datasets to improve their accuracy in identifying potential threats.A crucial aspect of this research is the development of a dedicated mobile application that allows users to engage with the drone system directly. In emergency situations, individuals can alert authorities by pressing a button within the app, which sends their location to the drone. Upon receiving this alert, the drone autonomously navigates to the user's location while simultaneously analyzing its surroundings for any signs of danger. The mentioned are the key software components employed in the project OpenCV: For image processing.

TensorFlow Lite: For optimized deep learning models. YOLOv4-tiny or MobileNet: For real-time object detection

4.3 Block Diagram

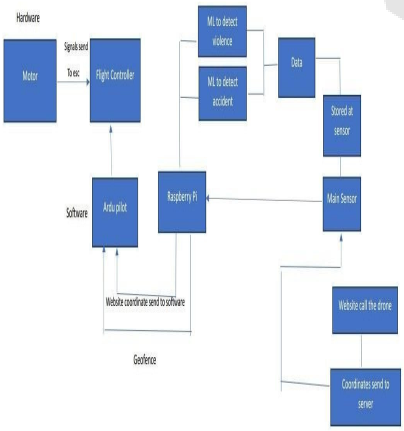

Figure 1: Block Diagram of the drone system.

4.3.1 Code Used for Facial Recognition

This code provides a straightforward implementation of a facial recognition system that leverages the capabilities of the face recognition library and OpenCV. It captures live video from a webcam, processes each frame to identify faces, and matches these faces against a predefined set of known encodings. This system can be applied in various contexts, including security monitoring, user verification, and automated attendance systems.

```
Import face_rec
ognition
import
cv2
video_capture = cv2.VideoCapture(0)
known_face_encodings = [] # Add your
known faces' encodings here
known_face_names = []  # Add the
corresponding names for the known faces
while True:
ret, frame =
video_capture.
read()
rgb_frame =
frame[:, :, ::-1]
# Find all face locations and
encodings in the current frame
face_locations =
face_recognition.face_locations(rgb_frame)
face_encodings =
face_recognition.face_encodings(rgb_frame,
face_locations)
for (top, right, bottom, left), face_encoding in
zip (face_locations, face_encodings): matches
=
face_recognition.compare_faces(known_face_
encodings, face_encoding)
```

It implements a basic facial recognition system using the face recognition library and OpenCV. It initializes video capture from the webcam and continuously reads frames in a loop. Each captured frame is converted from BGR to RGB format, which is necessary for face detection.

The code detects faces in the frame and computes their encodings, which are numerical representations of the faces. It then compares these encodings against a predefined list of known face encodings to identify matches.

4.3.2 Machine Learning Data

The dataset will comprise a diverse collection of video clips and images that depict various scenarios, including physical confrontations, aggressive gestures, and peaceful interactions, enabling the model to learn the key characteristics that differentiate these categories. Dataset encompasses a wide range of scenarios depicting violence, non-violence, accidents etc.

4.3.3 Data for Violence

Figure 2: Machine Learning data for violence.

4.3.4 Data for Non-Violence

Figure 3: Machine Learning data for non-violence.

4.3.5 Data for Accidents

Figure 4: Machine Learning data for accidents.

4.3.6 Design of the App

i. User Login:

Upon launching the app, users must log in to their accounts for security and personalization .After successful login, users are presented with the main interface of the app.

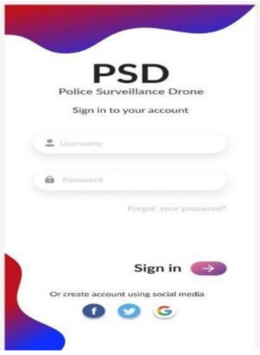

Figure 5: Main interface of the app.

ii. Initiating the call

Users will see a prominent button labeled "Call Drone.", When the button is pressed, the.app sends the user's current GPS location to the drone

Figure 6. Emergency button to call the drone.

iii. Visual Feedback:

The app displays a notification indicating "Calling the Drone," confirming that the request has been successfully transmitted.

iv. Emergency Response:

The drone receives the location and begins it's autonomous navigation to assist the user in distress.

Fig 7. Feedback of the Emergency Response

5 WORKING AND WORKING MODEL

Figure 8: Working Police Surveillance Drone Model.

The process begins when a user interacts with the mobile plication designed specifically for public safety. In the event of an emergency or when an individual feels threatened, they can activate an alert by pressing a button within the app. This action sends a notification that includes the user's current GPS coordinates to the drone. The communication is facilitated through the GSM module integrated into the drone, ensuring swift and reliable transmission of the alert. Once the drone receives the alert, its flight controller initiates the autonomous navigation process. The GPS module determines the exact location of the user and transmits this information to the Raspberry Pi, which processes it to establish the most efficient route to reach the user. The drone employs pre-programmed flight algorithms to navigate its environment while utilizing ultrasonic sensors to detect and avoid obstacles in real time. This capability allows the drone to maneuver safely through complex urban or rural settings. As the drone approaches the user's location, it activates its onboard camera to capture high-resolution images and video footage of the area. This data is crucial for documenting any incidents or potential threats present at the scene. Concurrently, machine learning algorithms running on the Raspberry Pi analyze data from various sensors, including video streams from the camera and readings from ultrasonic sensors. These algorithms are designed to identify suspicious activities based on specific behavioural patterns, enabling effective assessment of potential risks. Throughout it's mission, the drone maintains continuous communication with ground control via its telemetry module. This connection allows for real-time transmission of video feeds and sensor data back to monitoring personnel or law enforcement agencies. Operators at ground control can evaluate live footage and sensor information to make informed decisions regarding further actions or resource allocation. If suspicious behaviour is detected or if additional assistance is deemed necessary, ground control can initiate an appropriate response based on insights provided by the drone. This may involve dispatching law enforcement officers to investigate further or implementing other emergency protocols as required.

6 RESULTS

6.1 Real-Time Navigation and Obstacle Avoidance

The drone exhibited proficient autonomous navigational abilities across diverse environmental contexts. The ArduPilot framework facilitated dependable flight regulation, permitting the drone to sustain stability throughout its operational phases. The incorporation of ultrasonic sensors markedly improved the drone's capacity for obstacle detection. These sensors furnished instantaneous distance assessments, empowering the drone to identify proximate objects and modify its trajectory as necessary.

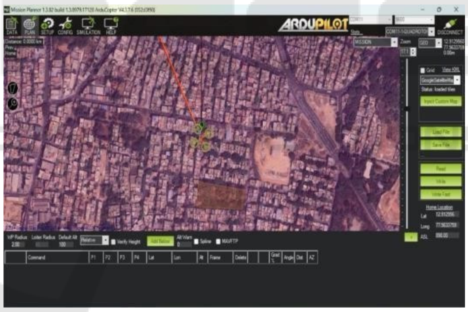

Figure 9 Visual output from ArduPilot 1.

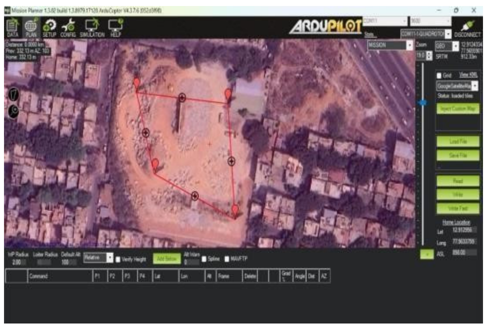

Figure 10 Visual output from ArduPilot 2.

6.2 Facial Recognition

The integration of facial recognition technology into the drone's operational framework markedly improved its proficiency in recognizing individuals instantaneously. The system underwent training utilizing a comprehensive dataset comprising identifiable facial images. This functionality is of paramount importance for applications pertaining to public safety, as it empowers the drone to swiftly detect potential threats or individuals in urgent need

6.3 Data Collection and Analysis

The drone's onboard camera successfully captured high-resolution images and video footage during its operations. These visual data were processed using OpenCV for image enhancement and analysis, allowing for effective monitoring of public spaces. The integration of machine learning algorithms enabled the drone to detect suspicious activities in real-time, providing actionable insights for law enforcement and emergency responders. The data collected during test flights will serve as a valuable resource for refining future models and improving detection accuracy.

6.4 User Interaction and Application Functionality

The mobile application developed for user interaction proved effective in facilitating communication between individuals in distress and the drone system. Users reported a positive experience with the app's interface, which allowed them to easily send alerts and track the drone's location in real time. The notification feature indicating "Calling the Drone" provided reassurance to users during emergencies, confirming that their request for assistance had been successfully transmitted

7 CHALLENGES & FUTURE IMPROVEMENTS

Several challenges were identified during testing the accuracy of facial recognition decreased in low- light conditions or when subjects wore accessories that obscured facial features. Additionally, variations in environmental factors such as wind speed affected flight stability during certain operations. Future work will focus on expanding the dataset used for training facial recognition algorithms to include diverse environmental conditions and enhancing navigation algorithms to improve robustness against external factors. One major constraint was budget limitations, which impacted our ability to procure higher-quality components that could enhance performance and reliability. With a larger budget, we could have integrated more advanced sensors, improved processing units, and better cameras, ultimately resulting in a more robust drone capable of overcoming many of the challenges faced during this project.In future improvements, we plan to invest in better and more expensive components that can enhance the drone's capabilities significantly. Upgrading hardware such as high-resolution cameras, advanced obstacle detection sensors, and more powerful processors will not only improve facial recognition accuracy but also enhance navigation stability under varying environmental conditions.

8 CONCLUSION

The advancement of the autonomous drone model designated for public safety signifies a pivotal progression in the enhancement of emergency response capabilities and situational awareness frame work through the amalgamation of sophisticated technologies, including machine learning algorithms, real-time data analytics, and high-resolution imaging, the drone is proficiently equipped to meticulously monitor diverse environments, discern potential threats, and assist first responders in critical scenarios. Its capacity equ- ipped to meticulously monitor diverse environments, discern potential threats, and assist first responders in critical scenarios, navigate complex terrains autonomously while simultaneously collecting and analyzing data in real time accentuates its potential as an indispensable asset for law enforcement and public safety agencies. The deployment of drones in public safety operations offers numerous advantages, including rapid coverage of large areas and the provision of critical information before personnel arrive on the scene. This capability not only aids in informed decision-making but also enhances the safety of responders by allowing them to assess potentially hazardous situations from a distance. The versatility of drones enables their use in various applications, such as surveillance, search and rescue missions, and infrastructure assessments, demonstrating their effectiveness across different public safety scenarios. The autonomous drone model has the potential to transform public safety operations by enhancing situational awareness and improving response times while minimizing risks to personnel.

REFERENCES

E. Sanchez, T. Hsu, M. Goodman (2022) - "Autonomous Drones for Urban Surveillance: A Review": This paper reviews the deployment and challenges of using autonomous drones for urban surveillance, focusing on their potential for improving security and public safety.

J. Lee, A. Khan, R. Patel (2021) - "Machine Learning Algorithms for Real-Time Surveillance and Anomaly Detection in Drones": This study explores the application of machine learning algorithms in enhancing the real-time surveillance and anomaly detection capabilities of drones.

L. Chen, Y. Li, C. Zheng (2020) - "Facial Recognition and Surveillance Systems in Law Enforcement: A Comprehensive Survey": The paper provides an extensive survey of facial recognition technologies used in conjunction with drones for law enforcement surveillance.

R. Sharma, H. Wei, K. Nair (2023) - "Real-Time Communication and Data Transmission in Autonomous Drone Systems": This research investigates the methods and technologies used for real-time communication and data transmission in autonomous drone systems.

P. Gupta, E. Adams, F. Zheng (2021) -"Advanced Obstacle Avoidance Techniques for Drones in Urban Environments": This paper discusses the development and implementation of advanced techniques for obstacle avoidance in drones, particularly in complex urban settings.

Roggi, G., Meraglia, S., & Lovera, M. (2023) "Leonardo Drone Contest Autonomous Drone Competition: Overview, Results, and Lessons Learned from Politecnico di Milano Team." This paper provides an overview of an annual competition focused on autonomous drone design and navigation in GNSS-denied environments