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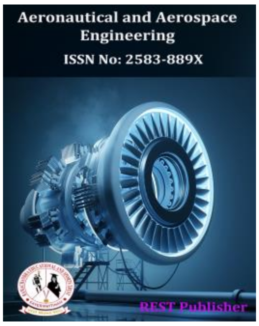

Fixed-Wing RC Plane Equipped with Acoustic Detection System

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Abstract: *With the rise in popularity of drones, their use in anti-social activities has also proliferated. Nationwide police increasingly report the appearance of drones in unauthorized settings such as public gatherings and also in the delivery of contraband to prisons. Detection and classification of drones in such environments is very challenging from both visual and acoustic perspective. Visual detection of drones is challenging due to their small size. There may be cases where views are obstructed, lighting conditions are poor, the field of view is narrow, etc. In contrast, acoustic-based detection methods are omnidirectional, however, they are prone to errors due to possible noise in the signal. This paper presents a method of predicting the presence (detection and classification) of a drone using a single microphone and other inexpensive computational devices. A Support Vector Machine classified the spectral and temporal features of pre- segments generated using a sliding window for the audio signal. Additionally, spectral subtraction was used to reconstruct the magnitude spectrum of drone sounds to reduce false alarms. To increase the accuracy of predictions, an added confidence script is proposed based on a queue-and-dump approach to make the system more robust. The proposed system was tested in real time in a realistic environment with various drone models and flight characteristics. Performance is satisfactory in a quiet setting, but the system generates excessive false alarms when exposed to lawn equipment.*

Keywords: *Sound Detection, Fixed wing RC plane, UAV, Aircraft object detection, Aerial Acoustic Sensing, Signal Processing.*

1. INTRODUCTION

This mini project report details the development of a fixed-wing RC (Remote Controlled) plane equipped with an acoustic system aims to integrate advanced sensory technology for enhanced navigation and environmental monitoring. This innovative design leverages a fixed-wing airframe, offering superior flight stability and longer endurance compared to traditional rotary- wing systems, making it ideal for a range of applications including surveillance, wildlife monitoring, and search-and-rescue operations. The embedded acoustic system is capable of detecting and analyzing sound frequencies, enabling the plane to locate specific sound sources or monitor environmental noise. This combination of aerodynamics and acoustics provides a versatile tool for research and real-time data collection in areas where traditional methods may be limited.

- Surveillance operations play a pivotal role in maintaining public safety, safeguarding national security, and protecting various commercial interests.
- Enabling more efficient and effective data collection.
- Fixed-wing drones, characterized by their aerodynamic design and extended flight endurance.
- The acoustic signatures picked up by the microphones can be compared to a database of known signatures in order to identify the type of drone threat.
- Algorithms may also be used to detect acoustic features and aid in classification

FIGURE 1.

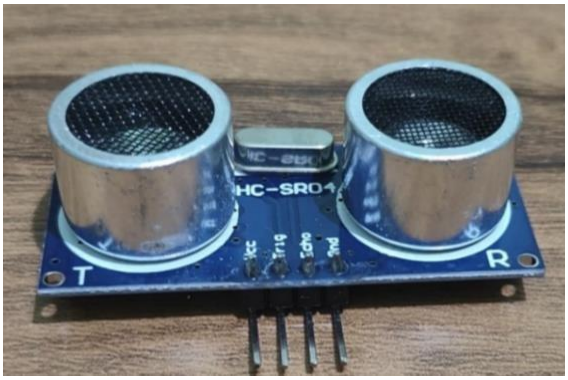

FIGURE 2.

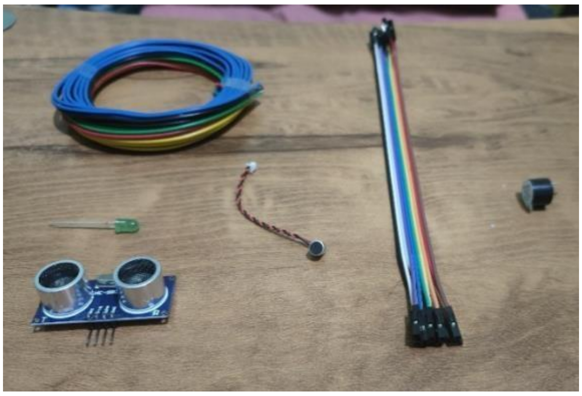

FIGURE 3.

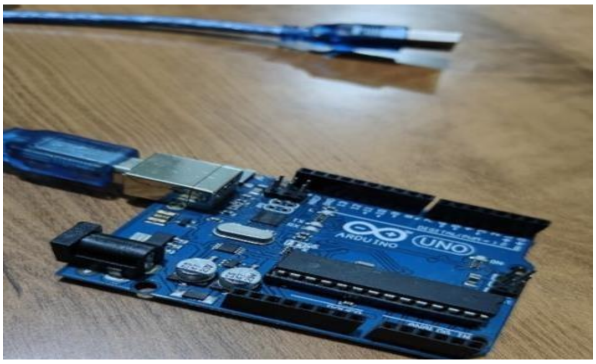

FIGURE 4.

Required Parts:

1. Arduino (UNO)
2. Ultrasonic Detector
3. LED Red, LED Green, Echo PIN, Trig PIN, Buzzer

2. ACOUSTIC DETECTION APPROACHES

Acoustic detection offers another sensing approach by analyzing the sound signals emitted from the drone's motor, which can be used to either identify or localize the sound source. investigated the use of a neural network to detect the presence of drones based on recorded sound events. Mel-frequency cepstrum coefficients and Mel-spectrogram are selected as the acoustic features for model input, and the output is a binary classification of the existence of a drone. In terms of sensor configuration, microphone arrays are more popular acoustic detection approaches. due to their advantages over a single microphone. The array leverages the signals from multiple channels captured at different positions, which contribute to estimating the direction of sound arrival as well as reducing the total SNR. The uses Doppler shift and direction of arrival (DOA) estimation of the target to provide a total least square estimate of the target trajectory under the assumption of constant target height, direction, and speed. The uses a tetrahedral microphone array to detect a military class I UAV with a beamforming algorithm within a selected frequency passband, achieving the best performance with a 99.5% probability of detection at ranges below 600 m. The several distributed microphone cluster nodes, each with a pyramid structure composed of 4–5 microphone units similar The relative 3D position of the target can be estimated by calculating the time difference of arrival between each pair of sensors and using the results for pairwise triangulation. The drawback of acoustic-based detection approaches is their low detection precision, limited 3D localization accuracy, and susceptibility to various environmental noises, which may impact the system effectiveness in more complex environments. Furthermore, conventional microphone arrays used in these methods also face hardware challenges. Insufficient elements in the arrays limit detection range and resolution. To improve resolution with a larger aperture in a uniform array, the number of elements needs to increase quadratically; otherwise, side lobe problems may arise which can deteriorate detection performance.

3. CONCLUSION

Deploying a fixed-wing aircraft equipped with an acoustic sensor requires meticulous testing and calibration to ensure reliable data collection in a challenging, noise-rich environment. Key considerations include sensor alignment, in-flight noise filtering, synchronization with telemetry, and regular re-calibration. By carefully characterizing and mitigating noise from the aircraft's engine, structure, and aerodynamic flow, one can achieve a balance between accurate sound detection and effective filtering of ambient noise. The result is an optimized system capable of capturing precise acoustic data, making it suitable for diverse applications in environmental monitoring, wildlife tracking, and defense. Through proper calibration and iterative testing, the fixed-wing platform can offer a discreet, efficient solution for long-range acoustic monitoring. This is particularly valuable in military operations where ground access may be limited or dangerous. By maintaining high fidelity in sound detection, fixed-wing aircraft with acoustic sensors provide strategic support in real-time intelligence gathering, enhancing situational awareness and allowing for timely responses in dynamic operational environments.

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