

Research on Urban Noise Pollution Monitoring and Tracking System Based on Quadcopter

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Abstract: Urban noise pollution has become a prominent issue affecting residents' health and urban livability. According to the China Noise Pollution Prevention and Control Report (2025), noise complaints in prefecture-level and above cities accounted for 59.2% of total environmental complaints in 2024, and the nighttime compliance rate of Class 4a functional zones remained low in 2025. Traditional monitoring methods are incompetent for refined needs. This paper proposes an intelligent noise monitoring and tracking system based on drones, integrating multi-sensor modules to achieve synchronous data collection and real-time transmission. Applied in practice, the system significantly improves the efficiency of noise source localization and tracing, providing technical support for the scientific control of urban noise pollution.

Keywords: Drone Technology; Urban Noise Pollution; Intelligent Monitoring System; Noise Source Localization; Real-Time Data Transmission.

1. INTRODUCTION

1.1 Research Background and Significance

With the rapid development of urbanization and social economy in China, urban noise pollution has become a prominent environmental problem affecting residents' physical and mental health and quality of life. According to the data from the China Noise Pollution Prevention and Control Report (2025) released by the Ministry of Ecology and Environment, there were about 5.895 million noise complaints and reports in 338 prefecture-level and above cities nationwide in 2024, an increase of 3.3% compared with 2023^[1]. Although the growth rate of complaints has slowed down, the huge base still reflects that the control of urban noise pollution is an important task urgently needed to be promoted in current urban management.

Traditional noise monitoring methods have obvious limitations: first, fixed-point monitoring

requires professional personnel to deploy on-site, with limited scope and insufficient flexibility^[2]; second, data processing is cumbersome, and large-scale monitoring is time-consuming and labor-intensive; third, data visualization is insufficient, making it difficult to provide intuitive noise distribution information^[3].

1.2 Current Status of Technological Development

In recent years, Quadcopter technology has developed rapidly, expanding from the military field to civil use, and achieving remarkable results in many fields such as smart policing and logistics distribution^[4]. It has shown advantages of high cost-effectiveness, strong mobility, and good safety in environmental monitoring, which can reduce labor costs and safety risks^[5].

At the same time, sensor technology has continued to progress. The sensitivity and accuracy of

modern sensors have been greatly improved, enabling accurate collection of noise signals and real-time transmission and analysis^[6]. However, there is currently no successful case of organically combining the two for the specific application of urban noise monitoring and tracking.

2. RESEARCH CONTENT AND OBJECTIVES

The urban noise monitoring and tracking system based on the Quadcopter platform integrates acoustic collection, visual recognition, and wireless communication technologies to construct an intelligent mobile monitoring solution. The research focuses on building a multi-sensor collaborative platform, developing microphone array sound source localization and deep learning noise recognition algorithms, and optimizing the processes of noise detection, autonomous tracking, and data return. The system aims to break through the limitations of traditional fixed-point monitoring, realize large-scale, high-precision dynamic noise monitoring and visualization, provide technical support for urban noise control, and help improve the urban acoustic environment and residents' quality of life.

3. SOUND DETECTION TECHNOLOGIES

The core advantages, main disadvantages, and Quadcopter adaptability of each detection technology are compared as shown in [Table 1](#).

3.1 Acoustic Array Detection Technology

Through a multi-microphone array, sound source localization and recognition are realized using the time difference or phase difference of sound waves, which has been successfully applied in Quadcopter detection^[7]. It has high positioning accuracy, strong anti-interference ability, and can realize sound field visualization, and can work stably in complex environments^[9]. However, the device position is fixed, with poor flexibility, and cannot effectively expand the detection range.

3.2 Laser Detection Technology

It is a non-contact long-distance voice detection technology that restores sound signals by irradiating

vibrating surfaces with lasers^[10]. It has a long detection distance but is easily affected by atmospheric conditions and the quality of reflective surfaces, and the system complexity and cost are relatively high^[11].

3.3 Voiceprint Recognition Technology

It extracts the unique acoustic features of speech to realize individual recognition, with convenient collection and low cost. It is sensitive to environmental noise and relies on long speech input, making it difficult to meet the demand for rapid positioning^[12].

3.4 Wireless Sensor Network Detection

Distributed sensor nodes collaboratively collect sound data, with a wide coverage range and flexible deployment. The node resources are limited, and the reliability of data transmission and fusion is insufficient, with poor adaptability^[13].

3.5 Audio Event Detection Technology

It identifies the event category of an audio segment and marks time information, with application potential in multiple fields. In complex acoustic environments, the recognition accuracy and generalization ability are insufficient, which cannot meet the demand for precise positioning^[8].

4. ADVANTAGES AND FEASIBILITY OF QUADCOPTER-BASED SOUND DETECTION

Quadcopter have outstanding mobility, can quickly reach complex areas to achieve three-dimensional sound data collection, and avoid ground interference. Meanwhile, the integration of miniaturized acoustic sensors has become increasingly mature^[7]. Combining technical characteristics and application requirements, the acoustic array detection technology is finally selected for the following reasons: first, the advantages of high positioning accuracy and sound field visualization are consistent with the three-dimensional detection needs of Quadcopter, with a positioning accuracy of up to 92.2%^[7]; second, the miniaturized array is suitable for the payload limitations of Quadcopter^[9]; third, it has stronger anti-interference ability, and the stability in complex

scenarios is improved through optimized algorithms, which is superior to other technologies^[9].

Table 1. Comparison of Detection Methods

Technology Type	Core Advantages	Main Disadvantages	Quadcopter Adaptability
Acoustic Array Detection Technology	High positioning accuracy, strong anti-interference ability, lightweight	Fixed position, poor flexibility	High
Laser Detection Technology	Long detection distance, no path noise interference	Affected by atmospheric conditions, high requirements for reflective surfaces, high cost	Medium
Voiceprint Recognition Technology	Convenient collection, low cost	Poor noise resistance, dependent on long speech input	Low
Wireless Sensor Network Detection	Wide coverage, flexible deployment	Limited node resources, low reliability of data transmission	Low
Audio Event Detection Technology	Great application potential in multiple scenarios	Low accuracy and poor generalization in complex environments	Medium

4.1 Overall System Design

The system takes Quadcopter and acoustic array technology as the core, supplemented by computer technology, control technology, information processing technology, etc., to realize the Quadcopter noise monitoring, sound-seeking tracking and recognition with multi-functional combination. It can be used for environmental noise monitoring in cities, with the advantages of convenient use, accurate tracking, and precise recognition. The hardware of the system consists of four parts: Quadcopter Control System Module, Microphone Array Module, Imaging Module, and Communication Module, and its overall block diagram is shown in Figure 1.

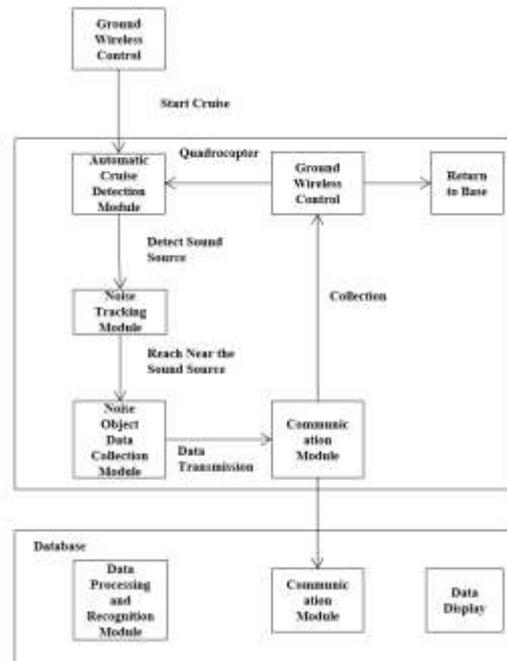


Figure 1. Design Block Diagram of Quadcopter Detection and Tracking System

The working principle of the system is roughly as follows: the Microphone Array Module and CCD camera are mounted under the Quadcopter, enabling the Quadcopter to start automatic cruising along a predefined route. Through Quadcopter flight, the monitoring range is expanded. During the flight, the

Quadcopter's recording noise reduction technology is used to separately reduce the propeller noise and wind noise, thereby accurately collecting environmental noise. When the Quadcopter's microphone array collects noise in a predefined specific frequency band, the Quadcopter starts tracking the noise source. When

it reaches about 5 meters away from the noise source, the Quadcopter takes photos and analyzes them through the CCD camera, and transmits the data back. The noise decibel data collected by the microphone is wirelessly transmitted to the database through the serial port to WIFI function of the Communication Module; the data processing system in the database can identify the photos, determine the cause of the noise, and finally summarize the noise pollution information and rate the noise pollution level.

4.2 System Hardware Architecture

The system is mainly composed of a flight control system, a power transfer board, and a TX2 artificial intelligence development board. The flight control system is connected to an M8N GPS module, a remote control receiver (RadioLink R9DS), a data link (Radio Telemetry), and an electronic speed controller (BL-30A). The TX2 artificial intelligence development board is connected to the power transfer board, the flight control system, and the camera. In addition, a low-voltage alarm is equipped.

On this basis, an additional serial port compatible with the Mavlink 2.0 protocol is configured in this control system by flashing the firmware, and an STM32F407VET6 is used as the control board. The system architecture is shown in Figure 2.

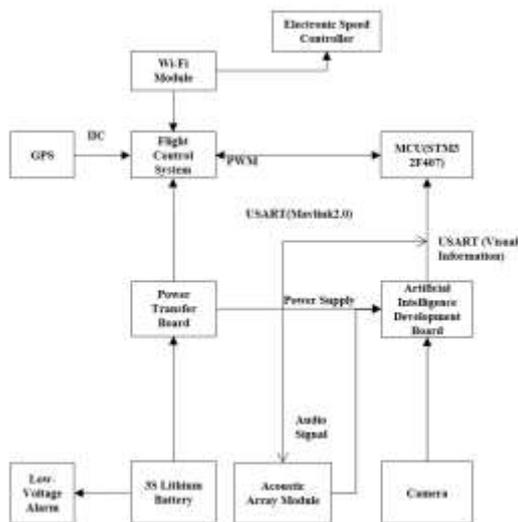


Figure 2 System Hardware Architecture

4.3 Data Collection, Processing and Analysis

The sound collection part uses a circular microphone array. This module has an effective sound pickup distance of 10 meters in all directions (360 degrees). After audio filtering and voiceprint screening, the real-time direction is output. Then, it is transmitted back to the MCU through the serial port, and finally transmitted to the database for integration. The returned data is shown in Figure 3, where "angle" represents the relative angle of the sound to the Quadcopter, and the figure shows that there is a sound source in the direction of 337°. The processing result of the collected original audio signal is shown in Figure 4. The lower part is the original audio with significant wind noise interference, and the upper part is the extracted specific sound signal after processing.

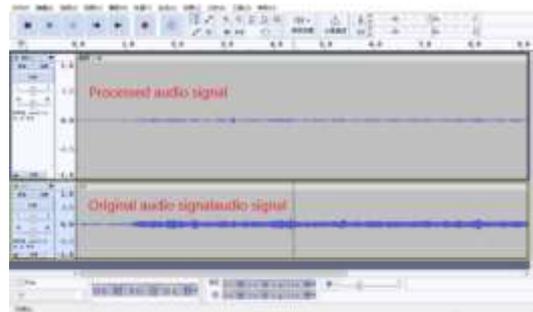


Figure 3. Direction Recognition Return Information



Figure 4. Comparison of Audio Signal Processing

By configuring the built-in chip of the camera, the CCD camera uses the YOLO algorithm to capture and frame suspected noise sources in the current environment, as shown in Figure 5. The recognition result shows that the confidence level for "crane" is 0.77, and the confidence levels for "shopping cart", "seashore" and "plow" are 0.26, 0.33 and 0.37 respectively. The collected original audio signals are

retained, and the target audio is screened out through filtering and voiceprint technology. The noise source is finally analyzed by combining visual and audio signals.



Figure 5. Recognition Result

5. CONCLUSIONS AND PROSPECTS

This paper designs and implements an urban noise pollution monitoring and tracking system based on Quadcopter. Through multi-sensor data fusion and advanced signal processing technology, the system realizes automatic identification, positioning and monitoring of urban noise sources. The system has shown good performance and reliability in practical tests, providing a new technical means for urban noise control.

Compared with traditional noise monitoring methods, the system has the following advantages:

- Larger monitoring range and stronger mobility;
- Faster response speed and real-time monitoring capability;
- More intelligent data processing and higher visualization level;
- Lower comprehensive cost and better economic benefits.

However, the system still has some areas that need further improvement:

- first, the effective monitoring distance of the microphone array needs to be further expanded;
- second, the anti-interference ability in complex environments needs to be strengthened;
- third, the accuracy of the noise recognition algorithm can be improved.

Future research directions include:

- Optimize the sound source localization algorithm to improve performance in complex environments;
- Extend the monitoring distance to enhance the practicality of the system;

- Improve the noise classification database to increase recognition accuracy;

- Explore the application of technologies such as 5G in the system to further improve system performance.

6. ACKNOWLEDGMENTS

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7. REFERENCES

- [1] Ministry of Ecology and Environment of the People's Republic of China. China Noise Pollution Prevention and Control Report (2025)[EB/OL]. 2025, 50(11).
- [2] Hou P P. Development Status and Trends of Environmental Noise Monitoring Technology[J]. Audio Engineering, 2023, 47(07): 140-142.
- [3] Wang Y J, Li Y, Fang R, Tang Z Z, Yan C Y, Men B. Research on the Optimal Utilization of Library Seats Based on Noise Monitoring Technology[J]. Fortune Today, 2022, (12): 198-199.
- [4] Li Y J. Industrialization Path of Quadcopter Based on Diversified Applications[J]. China Science and Technology Information, 2024, (17): 138-140.
- [5] Zhang S J, Hu J Y, Zhang K, Yin Y H. Advantages of Unmanned Aerial Vehicle in the Field of Environmental Monitoring[J]. Journal of Fujian Computer, 2021, 37(05): 127-129.
- [6] Han M, Li L, Liu Q Q. Research and Application of Real-Time Noise Monitoring Technology in High-Density Residential Areas[J]. Leather Manufacture and Environmental Technology, 2024, 5(16): 193-195.

- [7] Chen P, Chen Y, Wang W. A Review of Acoustic Positioning Technology for Unmanned Aerial Vehicles [J]. Journal of South China University of Technology(Natural Science Edition), 2022, 50(12): 109-123
- [8] Luo J X, Xiu Y. Multi-Sound Event Detection Based on Auditory Fusion Features [J]. Journal of Sichuan University (Natural Science Edition), 2024, 61(04): 231-237.
- [9] Ma C Y, Zhang J, Bao M, Chen Z F, Yang J H, Guo L. UAV Acoustic Detection Based on Non-Parametric Fusion of Spatial–Frequency Characteristics of Sound Field[J].Journal of Signal Processing, 2019,35(9):1590-1598.
- [10] Wang X F. Research on Several De-noising Methods in Laser Sound Detection [D]. Hefei University of Technology, 2019,03
- [11] Lu W, Bu W G. Feasibility Study of Long-distance Voice Pickup System [J]. Scientific and Technological Innovation, 2022 (20): 13-17.
- [12] Han X. Research on Speaker Method Based on RNN in Noisy Environment[D]. Harbin University of Science and Technology, 2019,08.
- [13] Peng X J. Research on Acoustic Signal Acquisition System Based on Wireless Communication[D]. North University of China, 2007,05.