# APPLICATION OF IOT IN SMART CITIES: UTILIZING STREETLIGHT-INTEGRATED DRONES FOR PRECISION WEATHER MONITORING AND REAL-TIME CROWD TRACKING

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**Group Number: 4**


| Name | E-mail |
| --- | --- |
| Gai Yifan | MarkfuGod@outlook.com |
| Li Ruihua | 1945458849@qq.com |
| Shang Siyu | 1172840160@qq.com |
| Shi Haojiang | 2491960452@qq.com |
| Li Zhuohang | 925798691@qq.com |


*(ORDER CONTRIBUTIONS BASED ON THEIR CONTRIBUTION LEVEL, FROM GREATEST TO LEAST.)*

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## Abstract

This paper proposes an innovative application of IoT in smart cities by integrating drones equipped with sensors atop streetlights. These drones will provide real-time, location-specific weather data and crowd density information through a dedicated app. The solution aims to enhance urban living by offering precise environmental data and improving crowd management in public spaces.

## Introduction

With the rapid urbanization of cities, there is a growing need for smart solutions to enhance the quality of life. Traditional methods of weather monitoring and crowd management are often inadequate due to their limited scope and real-time capabilities. By leveraging IoT and drone technology, we aim to provide more accurate and actionable data to urban residents, thus improving their daily experiences and decision-making processes.

## Statement of needs

1. **Inadequate Utilization of Streetlights**: Streetlights are an underutilized asset in urban infrastructure.
2. **Lack of Precise Weather Data**: City-wide weather reports often fail to capture microclimate variations within different urban areas.
3. **Inefficient Crowd Management**: Current crowd monitoring systems do not provide real-time updates, limiting their effectiveness in managing dense urban areas, especially during events or in high-traffic zones.

## Literature Survey

A review of current literature reveals several gaps in the existing smart city technologies:

- **Weather Monitoring**: Studies show the importance of localized weather data but lack scalable solutions for urban environments.
- **Crowd Management**: Existing solutions, such as satellite imagery and fixed camera systems, offer limited real-time capabilities and are often restricted to specific locations.
- **Traffic management:** Despite the development of intelligent transportation systems, there is still room for improvement in dealing with sudden traffic conditions and optimizing public transportation routes. The accuracy of traffic flow prediction models is challenged in complex urban environments.
- **Energy management:** Most urban energy monitoring systems are not refined enough to accurately assess energy consumption patterns in different areas and time periods. The integration of renewable energy also faces technical and infrastructure obstacles.
- **Environmental monitoring:** In addition to air quality and water quality monitoring, monitoring technologies for noise pollution and soil quality have not been fully developed, and the efficiency of data sharing and integration is low.

- **Public services:** In public service fields such as education and healthcare, the popularity of digital platforms is not high enough, and the levels of personalization and intelligence of services need to be improved.
- **Safety and emergency response:** Emergency response systems in cities have deficiencies in the timeliness and accuracy of information transmission and resource allocation, and there is a lack of efficient cross-departmental collaboration mechanisms.

## Description of Solution

We propose a dual-solution approach using drones integrated into streetlights:

1. **Precision Weather Monitoring**:
    - Equip drones with temperature and humidity sensors.
    - Collect real-time data at various altitudes within the urban environment.
    - Broadcast this data through streetlight-based signals to an app, providing users with precise local weather information.
2. **Real-Time Crowd Tracking**:
    - Use drones with camera sensors to capture real-time images of public spaces.

Figure 2.1 Drones with camera sensors

3.
    - Apply visual recognition technologies, such as Mediapipe, to anonymize and analyze crowd density.
    - Stream processed data to an app, helping users make informed decisions about navigating crowded areas.

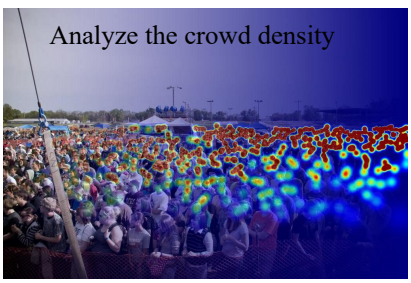


Figure 2.2 Analyze the crowd density

4. **Air Quality Monitoring**: Besides temperature and humidity sensors, add air quality sensors (e.g., PM2.5, CO2 sensors) to provide more comprehensive environmental data.

Figure 4.1 CO2 sensors

5. **Emergency Response Features**: Integrate emergency response capabilities into drones. For instance, if anomalies (e.g., fires, traffic accidents) are detected, drones can automatically fly to the site and transmit real-time data to emergency teams, facilitating quicker responses.

Figure 5.1 Drones can automatically fly to the anomalies site

## Implementation and Results

1. **App Development**:
    - **Basic Function:** Create an app with features for precise weather data and real-time crowd monitoring.
    - **Data Visualization**: Enhance the app with more data visualization options, such as historical data trends and forecasting features, allowing users to understand weather and crowd conditions more intuitively.

    - **User Feedback Mechanism**: Implement a user feedback mechanism to gather user experiences and needs, continuously improving and optimizing app features.
    - **Data Privacy Protection**: Ensure compliance with data privacy regulations (e.g., GDPR) when collecting and processing data, especially for crowd data, to anonymize and protect personal information.
    - **Drone Safety**: Develop a detailed drone flight and maintenance plan to ensure drones do not pose safety risks to pedestrians and vehicles during city flights.
2. **Sensor Integration**:
    - Install temperature, humidity, and camera sensors on drones mounted atop streetlights.
3. **Data Broadcasting and Analysis**:
    - Develop a system for real-time data transmission from drones to the app.
    - Implement visual recognition algorithms for crowd analysis.
4. **Drone Endurance and Charging**: Drone battery life and charging are challenges. Install wireless charging equipment on streetlights to ensure drones are always charged. Additionally, choose high-efficiency drones capable of long flight times.
5. **Data Transmission Stability**:Ensuring stable and reliable data transmission is crucial in complex urban environments. Utilize multiple communication technologies, such as 5G and LoRa, to guarantee stable data transmission under various conditions.

**Results**:

- **Enhanced User Experience**: Users receive accurate, localized weather updates and real-time crowd information, aiding in better decision-making.
- **Monetization Opportunities**: Revenue generation through in-app advertising, electronic billboard ads on streetlights, and special event decorations funded by vendors.
- **Partnerships**: Collaborate with local governments, transportation departments, and meteorological agencies to provide accurate data services. This not only enhances the credibility and coverage of your solution but also allows access to more resources and support through partnerships.
- **Subscription Services**: In addition to advertising revenue, we can offer subscription services for users, providing premium features and an ad-free experience, thereby generating a stable income stream.

## Conclusions

The integration of IoT and drone technology into streetlights represents a significant advancement in smart city infrastructure. This solution not only maximizes the utility of existing urban assets but also provides valuable real-time data to residents. Future developments could further enhance this system, replacing drones with more advanced technologies and expanding its capabilities.

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