Dean&Francis
ISSN 2959-6157

Discussion on the Feasibility of Applying Unmanned Aerial Vehicle Remote Sensing Technology in Urban Road Traffic Congestion

Junhuan Liu[1],

Zhengye Xie[2,*]

[1]School of Nanjing Tech University, Nanjing, China
[1]School of Guangzhou Maritime University, Guangzhou, China
Corresponding author:xiezhengye@fsu.edu.pa

Abstract:
Frequent traffic jams occur in cities, affecting commuting efficiency and citizens' health. At present, based on the existing unmanned aerial vehicle remote sensing technology, it can be conducive to alleviating traffic congestion. This paper mainly compares the efficiency, frequency and cost of aerospace remote sensing and unmanned aerial vehicle (UAV) remote sensing in monitoring objects, and finds that UAV remote sensing can better match the scenarios of monitoring commuter vehicles. This paper also proposes that according to the complexity of urban road surfaces, corresponding remote sensing methods should be adopted to obtain traffic flow information for road sections with different complexity levels. It can be concluded from this that unmanned aerial vehicle remote sensing can achieve high-frequency monitoring over a large area in a short period at a relatively low cost. By coordinating with the transportation department to regulate vehicles, the function of predicting and alleviating traffic congestion can be well achieved. This brings a new problem solving idea for urban road segments with similar dilemma in the world.

Keywords: Unmanned aerial vehicle, Remote sensing, Traffic

1.Introduction

In recent years, ground transportation in Chinese cities has developed rapidly, which has led to frequent traffic jams in many central urban areas. According to data reports from China, in some large cities, the average speed of motor vehicles has dropped to 12 kilometers per hour during peak commuting hours[1]. In the city center, the speed of motor vehicles is only 8 to 10 kilometers per hour[1]. Fixed cameras have only a small range of monitoring functions for traffic jams, so they cannot predict upcoming traffic jams. Therefore, it is very necessary to explore new methods for predicting and reporting traffic congestion.

The inspection efficiency of unmanned aerial vehi-

ISSN 2959-6157

cle remote sensing has the advantages of high efficiency and good economy compared with the existing manual inspection. For instance, there was a study that utilized unmanned aerial vehicle remote sensing technology to replace manual inspection and identify and inspect the Jiukuhe Station and its sections of Chongqing Rail Transit Line 6 in China[2]. For road traffic conditions, drones can conduct rapid inspections along the prescribed routes, thereby achieving the prevention, control and monitoring of traffic congestion. In addition to the high efficiency of regional inspection, unmanned aerial vehicle remote sensing also has the characteristics of wide image detection coverage, real-time and objective information, and low cost. At present, high-resolution remote sensing data technology has huge development potential in fields such as transportation and even disaster monitoring. The cases of developed countries such as the United States and France developing real-time road network disaster monitoring technologies (such as Qinetiq's MaST system in the United States) using remote sensing data have affirmed the application prospects of remote sensing technology in the transportation industry[3].

The existing remote sensing technology can distinguish vehicles from roads by taking advantage of the different radiation gray values of roads and vehicles[4]. By layering the dark car image and light color car image and radiation-enhancing processing, the *OTSU* algorithm can be used to recognize the cars and roads in the layer. This provides a technical basis for unmanned aerial vehicle remote sensing to quickly identify multi-vehicle sections and slow-vehicle sections, and thereby predict traffic congestion and determine its degree.

This paper aims at the problem of urban road traffic congestion and studies the cities within the scope of China. Based on the existing remote sensing technology combined with unmanned aerial vehicles, it is proposed to use UAV remote sensing to predict and monitor congestion in urban traffic-dense areas, so as to achieve the goal of alleviating congestion. This method has a larger patrol range compared to fixed cameras. Compared with satellite remote sensing, it can achieve timely data feedback and can better predict and alleviate urban traffic congestion.

2.Impact of urban traffic congestion

With the rapid development of the economy, people's income level generally increases and their ability to purchase cars increases, more and more people choose to buy cars as a means of transportation. And, as the urbanization rate increases year by year, people's demand for urban transportation is also increasing. However, at the same time, the urban population and motor vehicle ownership rate are also growing rapidly, more people choose to drive to and from work, the demand for transportation commuting is increasing, and many cities are facing the increasingly serious problem of traffic congestion. This section analyzes the impacts associated with urban traffic congestion from the socio-economic and environmental health pollution perspectives.

2.1 Socio-economic impacts of urban traffic congestion

Table 1 Top 10 Cities in Congestion Index (Source: Baidu Map Traffic and Travel Big Data Platform in2024)

rankings	cities	congestion index	Average vehicle speed (km/h)	Compared to 2023
1	Beijing	2.073	23.86	-2.46%
2	Chongqing	2.026	23.60	+1.55%
3	Guangzhou	1.995	26.69	+2.00%
4	Wuhan	1.931	24.05	+0.22%
5	Shanghai	1.904	24.63	-1.28%

In Table 1, the congestion index is the ratio of the actual travel time to the unimpeded travel time, and the higher the congestion index, the higher the degree of congestion. 1.5 or more is considered severe congestion. As can be seen from Table 1, the time wasted due to traffic congestion greatly affects socio-economic development, and the excessively long traffic time may weaken the public's desire to go out to travel or spend money, thus slowing down the development of commercial activities and the efficiency of the normal operation of the city[5].

In addition, traffic congestion for the driver's physical and mental health also has a more serious impact, traffic congestion drivers and passengers are prone to anxiety, stress and even "road rage" and other emotions, seriously endangering physical and mental as well as driving safety.

2.2 Environmental impacts of urban traffic congestion

During urban traffic congestion, vehicles travel slowly and spend most of their time at idle speed. During traffic congestion, vehicles emit more harmful gases (e.g., carbon dioxide CO2, nitrogen oxides NOx, and particulate matter PM2.5, etc.) compared to non-congested periods[5]. The air quality is severely degraded, and people exposed to harmful polluted air for a long time will have serious respiratory and cardiovascular health problems. Long-term exposure to NO_2 may lead to chronic bronchitis, cause decreased lung function, and increase the risk of asthma and chronic obstructive pulmonary disease (*COPD*). Long-term exposure to PM2.5[6] will lead to chronic bronchitis, decreased lung function. Increased risk of cancer: (PM2.5 is classified as a group 1 carcinogen by the International Agency for Research on Cancer (*IARC*) of the World Health Organization). Long-term exposure to high levels of PM2.5 may lead to an increase in the incidence and mortality of cancer in general and certain specific cancers such as prostate cancer and female breast cancer[7].

Meanwhile, frequent starting and braking during traffic congestion consumes more gasoline fuel and wastes a lot of energy resources[8].

To summarize, urban traffic congestion has become a global problem, and long-time traffic congestion seriously restricts the healthy development of the city, which is contrary to the concept of green development [9]. Therefore, it is urgent to solve the problem of urban traffic congestion.

3. The application of Remote Sensing technology in transportation

Traffic cameras have been widely used in road traffic in China. In 2012, there were already studies using fixed-point remote sensing to recognize vehicle license plates and measure vehicle speeds, with an accuracy of up to 96.5%[10]. However, the drawback of traffic cameras lies in the small image coverage area of a single device and the concentrated distribution area of the devices. For sections where traffic cameras are scarce or under maintenance, it is difficult to effectively achieve the expected data collection to predict and regulate traffic congestion. In 2023, based on the existing remote sensing technology, some people have proposed using intelligent transportation systems to predict and alleviate traffic congestion[5]. This section mainly introduces the application of remote sensing technology in transportation through two aspects: aerospace remote sensing and unmanned aerial vehicle remote sensing.

3.1 Aerospace remote sensing

Satellite remote sensing technology has achieved rapid development in the 21st century, with such a wide coverage that it is sufficient to realize global navigation services[11]. In a satellite remote sensing study on road traffic in Shanxi, China in 2024, existing technology can complete road recognition in megapixel-level images within 1 minute[12]. Nowadays, some researchers have utilized remote sensing technology to locate ships at sea. This study utilized the *GAM-YOLOv8* model to analyze satellite images, achieving 0.957 and 0.942 respectively in terms of recall rate and average accuracy[13]. These studies represent that the existing aerospace remote sensing technology can accurately identify the observed targets and can judge and predict road congestion.

In sum, the existing aerospace remote sensing technology has high positioning accuracy and strong recognition ability. However the operation logic of aerospace remote sensing cannot provide real-time images for a long time. This is because the movement of satellites around the Earth relies on the Earth's rotation, and there is a delay of 1 to 3 days for capturing images of the same area[14].

Due to the intermittent nature of individual satellite observations and the fact that there are currently not enough satellites capable of achieving high-frequency earth observations. Therefore, aerospace remote sensing cannot well meet the prediction and monitoring requirements of urban traffic congestion.

3.2 Unmanned aerial vehicle aerial remote sensing

UAV refers to a class of unmanned aircraft, equipped with power modules and navigation capabilities, according to a designated program or by radio control of the flight. Unmanned aerial vehicles can be classified into two types based on their wings: one is fixed-wing, and the other is rotary-wing. Fixed-wing unmanned aerial vehicles can cruise rapidly over a large area, while rotorcraft UAVs have higher safety in complex airspace and are less difficult to take off and land vertically. The scenarios studied in this article are mainly densely populated urban areas. Considering safety, the type of unmanned aerial vehicle referred to is rotorcraft unmanned aerial vehicle.

There are already precedents of using unmanned aerial vehicles for exploration and inspection in the current research of aerial remote sensing. This provides the possibility for road traffic to use aerial remote sensing to

ISSN 2959-6157

collect information for prediction and prevention of traffic congestion. During the construction of the Sichuan-Tibet Railway in China in 2020, unmanned aerial vehicle remote sensing was utilized to explore key sections and areas with poor geological conditions[15]. This is due to the fact that UAV aerial remote sensing can work regardless of the geographical environment. In addition, compared with aerospace remote sensing, unmanned aerial vehicle aerial remote sensing can provide information more frequently and precisely for regional exploration at a lower cost.

Another advantage of unmanned aerial vehicle aerial remote sensing lies in the wide range of captured images. A study in 2017 captured 0.37 square kilometers of railway images by using unmanned aerial vehicle remote sensing. The flight altitude is 250 meters, the heading overlap is 85%, and the lateral overlap is 65%[2]. In this study, unmanned aerial vehicle remote sensing has improved the accuracy of inspections and reduced the input of human resources. In a 2024 study, unmanned aerial vehicle remote sensing technology was used to inspect the rail transit in Shanghai, China[16]. In the study, the UAV collected 43km orbital images through 10m intervals, and the number of photos reached 5680, which took a total of 4 hours[16]. According to this study, it can be seen that the efficiency of UAV remote sensing in monitoring large-scale road conditions has obvious advantages over traffic cameras in terms of working efficiency.

In 2017, existing studies have utilized UAV remote sensing technology to achieve the capture and tracking of moving vehicles. In this study, the image processing conditions under various factors such as different lighting conditions and different distances were compared[17]. The image is processed by *VEDAI* algorithm, and the illumination invariant characteristics are obtained by extracting image LSH technology, which can automatically and accurately capture small targets. For the complex situation of road surface traffic, in 2014, there was a study that could accurately determine the traffic road based on the gray value of the road surface[4]. The image is divided into the target and the background through the gray-scale characteristics. In this kind of remote sensing image processing, the discrimination rate of light-colored vehicles exceeded 80%, while that of dark-colored vehicles exceeded 75%. Thus, on some complex road surfaces, UAV aerial remote sensing still can complete the identification of road vehicles and judge congestion situations, providing data support for predicting and alleviating traffic congestion.

It can be seen from this that UAV remote sensing technology can be well adapted to the monitoring of traffic flow and congestion prediction on key traffic sections. In the peak period, using some technologies such as *PID*(control mechanism) and *LiDAR*(positioning technology) are used to frequently inspect the sections with large traffic flow[18]. Visual remote sensing is adopted for sections with a single route. Radiation remote sensing is adopted for complex road sections to provide highly accurate traffic flow data for traffic management in real-time. Traffic management can make reasonable adjustments to traffic lights and on-site personnel based on such data. This will reduce the degree of traffic congestion and improve the efficiency of urban commuting.

4.Difficulties in UAV remote sensing application

4.1 Unmanned aerial vehicle range

Urban traffic congestion is usually characterized by wide range and long duration. However, consumer-grade drones usually last only 20-40 minutes. For example, *DJI* drone official parameters: *dji mini4oro* with standard battery life can realize 34 minutes of endurance, with long battery life can only realize 45 minutes of endurance. Compared to the traffic jam time of several hours, the range time is far from enough. The short endurance time cannot support the UAV to use remote sensing technology to effectively identify, transmit and analyze the relevant congestion data, which greatly reduces the feasibility of UAV remote sensing technology in the field of transportation. At the same time, if the UAV is allowed to take off and land frequently for charging, it will also increase energy consumption during this period and reduce the efficiency of its monitoring of traffic congestion.

When applying UAV remote sensing technology to urban transportation, high-resolution photography is required. Therefore the UAV will be flying at low altitude for a long time. This means that the UAV will face more air resistance, making it consume power rapidly. At the same time, drones need to transmit real-time remote sensing images to data centers while monitoring, a process that adds to the power consumption.

Using drones outdoors also means that they will always be exposed to extreme weather conditions such as strong winds and low temperatures, which can seriously deplete their energy. In Harbin, China, for example, the outdoor temperature is <20°C for part of the year, in which case the capacity of the Li-ion battery will be greatly reduced. At the same time, the drone needs extra power to compensate for strong winds, a move that also increases power consumption significantly.

4.2 Solutions for UAV Range Technology

To improve the endurance of UAVs, it is possible to use high-efficiency batteries, such as hydrogen fuel cells, by increasing the energy density of the batteries, which are fueled by hydrogen carried as fuel and oxygen naturally inhaled to generate electrical energy to drive the UAVs to fly under the action of a platinum catalyst. The endurance of such hydrogen-powered UAVs can reach 3-10 hours (typical application cases such as the *FC-30* composite wing UAV developed by the Civil Aviation Flight Academy of China, with a maximum endurance of 4 hours).

At the same time, the design of the UAV can be optimized by using high-strength and lightweight materials (e.g. carbon fiber composites) to manufacture the UAV, reducing the mass of the UAV under the guarantee of its stiffness and strength, lowering energy consumption, and improving endurance. It is also possible to improve the efficiency of the UAV motor and optimize the propeller design, so that the UAV can complete longer flight, hovering, remote sensing transmission and other tasks under the same power consumption. The corresponding program is written to optimize the flight path, calculate the shortest flight route, and reduce the flight distance. At the same time, the hovering time should be reduced to reduce the flight energy consumption, which can also greatly improve the endurance.

The development of drone apron is also a good way to improve the endurance of the drone, automatic charging apron can realize the automatic charging of the drone, and without manual intervention, after the drone runs out of power, it automatically flies to the nearest charging apron for automatic charging, and at the same time implements the handover with the drone that has been fully charged to ensure that the remote sensing inspection work is carried out 24 hours uninterruptedly (such as the *DJI Dock2* drone, which supports unattended operation).

4.3 Unmanned aerial vehicle control and management

Drones have risen rapidly in recent years, but in many regions, it is difficult to synchronize information such as the flight routes and flight permits of drone lines with the management departments and other drone users on time. Take China as an example. Due to the inability to effectively control and for safety reasons, the regulations issued in 2016 have relatively strict requirements for the flight airspace of unmanned aerial vehicles[19]. The control of a large number of unmanned aerial vehicles in a relatively limited airspace requires a unified information platform and effective obstacle avoidance measures. Take *UTM* in the United States as an example. This control framework adopts distributed management. Suppliers of unmanned aerial vehicles coordinate with each other, share data from the *Flight Information Management System* (*FIMS-FAA*), and coordinate information such as flight plans with the *National Airspace System* (*ATM*). Through the *UTM* framework, managers do not need to directly control the drones. They can issue relevant instructions in the system and configure the airspace. Only when such systems are mature enough can the application of unmanned aerial vehicles be realized in daily traffic.

5.Conclusion

For the problem of urban traffic congestion, the application of UAV remote sensing technology can alleviate urban traffic congestion by realizing the monitoring of the main traffic sections in the city and combining it with the urban intelligent transportation technology, transmitting the traffic section congestion data to the data center in real time for analysis, and realizing the prediction of traffic congestion. At the same time, let the drone remote sensing technology into the people can improve the popularization rate of science and technology, so as to stimulate the enthusiasm of the people's learning, and promote the benign cycle of science and technology application, and the drone remote sensing technology can also provide more new jobs for the society. But at the same time, in order to better apply UAV remote sensing technology in the field of transportation, it is necessary for technology companies, urban transportation authorities, the government and the public to work together, in the application of UAV remote sensing technology continues to improve, continue to develop, so that the UAV remote sensing technology is better, more efficient, and more economical solution to the problem of urban traffic congestion.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Fan Xiaoke. Research on Urban Traffic Congestion [J]. Public Safety in China (Academic Edition),2007,(01):48-51.

[2] Nie Xinlu, Tang Feifei, Zhu Qianhong. The Application of Unmanned Aerial Vehicle Remote Sensing Technology in Urban Rail Transit Inspection [J]. Modern Urban Rail Transit,2017,(10):58-61.

[3] Song Chenxi, Zou Tongyuan, Wang Jian, et al. The Application and Prospect of High-Resolution Remote Sensing Technology in the Transportation Industry [J]. Satellite Applications,2014,(06):55-59.

[4] Cao Tianyang, Shen Li. Vehicle Target Recognition Method

ISSN 2959-6157

Based on Traffic Remote Sensing Image Processing [J]. Computer measurement and control,2014,22(01):222-224.
[5] Wang Lei, Li Zhixuan. Research on Traffic Congestion Prediction and Mitigation Strategies Based on Intelligent Transportation Systems [J]. Transport Manager World,2023,(36):77-79.
[6] Research progress on the mechanism of PM2.5-induced respiratory system damage and its mitigating substances
[7] Qin Xiaojian, Wan Fangning, Zhang Hailiang, et al Relationship between PM2.5 concentration in air pollution and cancer [c]// Chinese anticancer association, oncology branch of Chinese Medical Association Compilation of papers of the 8th China Cancer academic conference and the 13th cross strait cancer academic conference Department of Urology, Fudan University Cancer Hospital; Department of oncology, Shanghai Medical College, Fudan University; , 2014:84
[8] Zhang Yibo, Wang Can. Research and suggestions on the development of Intelligent Transportation System -- Taking Hong Kong's public transport system as an example [j]. urban architecture, 2023,20 (20): 99-103.doi:10.19892/j.cnki.csjz.2023.20.25
[9] Hejunhao Application of green transportation concept in urban transportation planning [j]. urban architecture, 2025,22 (06): 83-86.doi:10.19892/j.cnki.csjz.2025.06.22
[10] Xu Zheng, Wang Yichao, Huang Xuan, et al. License Plate Recognition and Speed Measurement Based on Traffic Camera Videos [J]. Jiangxi Science,2012,30(04):528-531. DOI:10. 13990/j. issn1001-3679. 2012. 04. 019.
[11] Liu Jian, Cao Chong. Current Situation and Trend of Global Satellite Navigation System Development [J]. Journal of Navigation and Positioning,2020,8(01):1-8. DOI:10. 16547/j. cnki. 10-1096. 20200101.
[12] Zhang Jiapeng. Research and Application of Remote Sensing "One Map" for High-Speed Transportation Infrastructure in Shanxi Province [J]. Automation application,2025,66(04):80-82.
[13] Yang Xiaotian, Tan Jinlin, Yu Xin, et al. Ship Target Tracking in Remote Sensing Images Based on GAM-YOLOv8 [J]. Journal of Jilin University (Earth Science Edition),2025,55(01):328-339. DOI:10. 13278/j. cnki. jjuese. 20240305.
[14] Ma Huiyuan. Research on the Operating Mechanism of Satellite Remote Sensing for Earth Observation [C]// Space Exploration Professional Committee of the Chinese Society for Space Sciences. Proceedings of the 15th Academic Conference of the Space Exploration Professional Committee of the Chinese Society of Space Sciences The 54th Research Institute of Electronics, Ministry of Information Industry;,2002:296-301.
[15] Huang Yong. Research on Comprehensive Investigation Technology of Traffic Safety Corridor of Sichuan-Tibet Railway [J]. Journal of Railway Engineering,2020,37(10):16-21.
[16] Yang Ming. Application of Air-Ground Integrated Remote Sensing Technology in the Inspection of Rail Transit Safety Protection Zone [J]. Surveying and Mapping Bulletin,2024,(S2):178-181+186.
[17] Li Dawei. Automatic Detection and Tracking of Ground Vehicle Targets by Fixed-Wing Unmanned Aerial Vehicles [D]. University of Chinese Academy of Sciences (National Space Science Center, Chinese Academy of Sciences),2017.
[18] Shao Guiwei, Liu Zhuang, Fu Jing, et al. Research Progress on Unmanned Aerial Vehicle Inspection Technology for Overhead Transmission Lines [J]. High Voltage Technology,2020,46(01):14-22.
[19] Quan Quan, Li Gang, Bai Yiqin, et al. Overview and Suggestions of Low-altitude Unmanned Aerial Vehicle Traffic Management [J]. Acta Aeronautica et Astronautica Sinica,2020,41(01):6-34.