ISSN 2522-3488 Vol. 8, Issue 4: 70-77, DOI: 10.25236/IJNDES.2024.080409

# Application Analysis of Wireless Network Remote Sensing Image and Video Processing Technology in Smart City Design and Planning

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***Abstract:*** *This article analyzes the potential application of wireless network remote sensing image and video processing technology in smart city design and planning. Through a comprehensive analysis of existing research, this article explores how to use these technologies to improve the accuracy and efficiency of urban planning and management, thereby enhancing the quality of life of urban residents. This article provides a detailed analysis of the application of wireless network remote sensing image and video processing technology in smart city design and planning through three experiments. Firstly, in the experiment of urban green space monitoring and optimization, the optimization measures aim to achieve a green coverage rate of 40% in all regions. Secondly, in the traffic flow monitoring and diversion experiment, the optimized traffic flow increases by an average of about 10%. Finally, in the emergency response optimization experiment, the emergency response time of each region is significantly shortened. In the above data conclusions, optimization techniques have shown excellent application value in improving the accuracy of urban planning, optimizing traffic management, and accelerating emergency response.*

***Keywords:*** *Smart City, Wireless Network, Remote Sensing Image Processing, Video Monitoring*

## 1. Introduction

With the acceleration of global urbanization, the complexity and population density of cities continue to increase, and traditional urban management and planning methods face many challenges. Especially in key areas such as green space management, traffic diversion, and emergency response, existing methods often fail to meet the efficient operational needs of modern cities. Wireless network remote sensing image and video processing technology provides new solutions for the design and planning of smart cities due to its advantages of timely data acquisition and precise processing. These technologies not only help improve the scientific and real-time nature of urban planning, but also effectively enhance the intelligence level of urban management.

This article explores the specific applications of wireless network remote sensing image and video processing technology in urban green space optimization, traffic flow management, and emergency response improvement through three experiments. The experimental results show that these technologies can effectively identify problems in different urban management fields and achieve scientific resource allocation and intelligent management processes through optimization measures. Research has shown that the method proposed in this article has important practical application value in improving the overall operational efficiency of smart cities.

The structure of the article is as follows: Firstly, the application background and current status of wireless network remote sensing image and video processing technology in smart cities are introduced; next, the experimental design and application methods of related technologies are described in detail; finally, based on the experimental results, the technical application effects in various fields are analyzed and discussed, and future research directions and possible application prospects are proposed.

## 2. Related Works

In recent years, many scholars have carried out research on the application of remote sensing image and video processing technology of wireless network in urban management. For example, Liu T et al. constructed a nighttime light index based on nighttime light data and established a remote sensing eco-index model by combining four indexes: greenness, humidity, dryness and heat. The results of the study are of reference value for future urban planning and environmental protection in Guilin [1]. Tolegen Z Z et al. aimed to identify existing environmental problems and propose corresponding conceptual solutions using the city of Almaty as an example. They focused on architectural and design approaches to cope with the problems related to natural and climatic features of the urban environment [2]. Lin A et al. proposed a step-by-step identification framework based on remotely sensed imagery and point-of-interest data, through which the accuracy and completeness of the identification was improved [3]. Wiatkowska B et al. analyzed land use and land cover changes in 2000, 2005, 2010, 2015 and 2020 through remotely sensed imagery techniques [4]. Abutaleb K et al. assessed and compared the urban green space index of the affluent Rosebank suburb in the northern part of the city of Johannesburg with the impoverished Soweto township in the southern part of the city in order to determine the differences in the environmental quality of the two places [5]. Globally, urbanization-induced land use and cover changes are rapidly increasing and the impacts of urban sprawl have been widely documented. To counter its negative impacts, continuous monitoring and sustainable planning is essential. Dhanaraj K suggested to map land use and cover and monitor the spatial and temporal dynamics of Mangaluru urban agglomeration in India from 1972 to 2018 [6]. Urban vegetation inventory is costly and time-consuming, therefore, the development of new remote sensing techniques for mapping and monitoring vegetation has become an important topic of academic interest. Neyns R reviewed the major approaches for mapping urban vegetation using high-resolution remotely sensed data through a comprehensive literature survey [7]. However, most of these studies focused on the application of a single technique and lacked a systematic analysis of the integrated application of multiple techniques. In addition, many studies failed to effectively address the real-time and accuracy issues in the data processing process, which also limited the further application of the techniques in smart city planning.

To address the above challenges, some researchers have attempted to improve the efficiency and accuracy of remote sensing image and video processing by fusing multi-source data and optimizing algorithms. For example, Kuras A et al. introduced the principles and key features of airborne hyperspectral imaging, LiDAR, and their fusion techniques, and explored their applications in urban land cover classification [8]. With the rapid development of UAV platforms and small sensor technologies, multi-sensor remote sensing approaches for urban tree classification have become more feasible. Hartling S et al. aimed to develop a multi-sensor data fusion technique for urban tree species classification with limited training samples [9]. With the development of remote sensing and geostatistics, their applications in urban water resources monitoring have become increasingly widespread. Liu Z et al. explored how remote sensing and geostatistics can be utilized to enhance urban water resources monitoring capabilities, focusing on the classification of related techniques and equipment and their applications in urban surface water and groundwater monitoring [10]. However, these methods still have the problems of high consumption of computational resources and high complexity of algorithms when dealing with massive data. In order to solve these shortcomings, this paper will adopt wireless network remote sensing image and video processing technology to improve the real-time and accuracy of data processing.

## 3. Methods

### *3.1. Wireless Network Remote Sensing Image Acquisition*

Remote sensing image quality and collection efficiency largely depend on the type and arrangement of the equipment used. In this study, we primarily employ drones and low-earth orbit satellites for data collection. Drones offer high flexibility and resolution, ideal for detailed monitoring and data collection in localized areas; satellites, on the other hand, provide broader coverage, suitable for city-wide data acquisition. These devices transmit collected data to processing centers in real-time via wireless networks, independent of fixed base stations.

During data collection, drones fly in grid patterns while satellites orbit to capture remote sensing images periodically. These platforms use sensors to gather spectral data across various bands, including visible light and infrared, essential for physical analysis. Real-time data transmission is enabled via wireless networks to ground stations, improving efficiency and reducing data loss [11].

The collected data undergoes initial pre-processing at edge computing devices to enhance clarity through denoising, geometric, and radiometric corrections. Afterward, it is sent to the cloud for storage and further analysis. Cloud computing provides extensive storage and powerful processing capabilities, facilitating swift and expansive data analysis.

### *3.2. Video Surveillance Data Processing*

In smart city management systems, video surveillance plays a key role in maintaining urban safety and efficiency. High-definition cameras monitor critical areas, including traffic, public safety, and environmental conditions, facilitating intelligent decision-making.

The surveillance system employs a city-wide network of cameras that stream video to data centers through both wireless and wired connections. It uses low-latency protocols and data compression to optimize transmission and minimize bandwidth use. Encryption safeguards the security of the video data against unauthorized access or tampering.

Collected video data is stored in a distributed storage system, characterized by high capacity and redundancy, ensuring long-term preservation and fast access to extensive video archives. Video segmentation and indexing technologies allow for quick location and retrieval of surveillance data from specific times or places. Simultaneously, a pre-processing module enhances video quality by optimizing frame rates, denoising, and improving image quality, setting the stage for subsequent analytical tasks [12].

### *3.3. Multi-source Data Fusion*

The core of data fusion lies in integrating different types of data into a unified analytical framework in order to extract meaningful and comprehensive information from them. In this study, we adopt a fusion algorithm based on weighted averaging to generate a comprehensive dataset by overlaying different data sources weighted according to their importance. With this comprehensive dataset, city managers can obtain a more comprehensive view of the city's operational status. For example, by combining remote sensing images and video data, managers can analyze the correlation between traffic congestion and building density; by fusing data from IoT sensors, they can monitor the air quality of a certain area in real time and analyze its correlation with traffic flow. Where the fused and integrated data $D_{fused}$ can be expressed by equation (1):

$$\mathrm{D_{fused}} = \sum_{i=1}^{n} w_i \cdot D_i \tag{1}$$

In equation (1), the selection of weights $w_i$ can be adjusted based on the importance or quality of the data source.

Table 1 demonstrates the comprehensive indicators derived from the analysis of a city region through the fusion of data from multiple sources at different time periods, and the data in the table are used to illustrate the presentation and application scenarios of the fused data.

*Table 1: Comprehensive indicator situation*

| Time Period | Traffic Flow (vehicles/hour) | Air Quality Index (AQI) | Green Coverage (%) | Traffic Congestion Index (0-1) | Composite Environmental Index (0-100) |
|---|---|---|---|---|---|
| 08:00 | 1200 | 85 | 25 | 0.7 | 65 |
| 12:00 | 900 | 75 | 25 | 0.4 | 70 |
| 17:00 | 1500 | 95 | 25 | 0.9 | 60 |
| 22:00 | 600 | 60 | 25 | 0.2 | 80 |

In Table 1, "Traffic Flow" reflects the movement of vehicles in different time periods, "Air Quality Index" shows the degree of pollution in the environment, "Green Space Coverage" indicates the proportion of green space in the urban area, "Traffic Congestion Index" is the degree of traffic smoothness calculated based on video surveillance and sensor data, and "Comprehensive Environmental Index" is a comprehensive index combining all these data through a multi-source fusion algorithm to evaluate the state of the urban environment in general. The "Comprehensive Environmental Index" is a comprehensive index that combines these data through multi-source fusion algorithms, and is used to evaluate the state of the urban environment at that time.

Through multi-source data fusion technology, city managers are able to understand and manage the operation of the city from a more comprehensive perspective, providing solid data support and technical guarantee for the development of smart cities. With the continuous progress of technology, multi-source data fusion will play a role in a wider range of urban management fields in the future, and promote the intelligent and sustainable development of cities.

### *3.4. Edge Computing Combined with Cloud Computing*

Edge computing reduces the distance and time of data transmission by decentralizing some of the data processing tasks to edge devices close to the data source. This approach is particularly suitable for application scenarios with high real-time requirements, such as traffic management and emergency response. For example, in traffic flow monitoring, edge devices can quickly process video data locally, identify traffic congestion or accidents, and adjust the timing of traffic signals in real time without uploading all video data to the cloud. This not only improves the response speed, but also significantly reduces the bandwidth consumption and computational load on the cloud [13].

Although edge computing has obvious advantages in real-time and local processing, its computing power and storage capacity are limited after all, and it is difficult to handle complex global tasks. Cloud computing, with its powerful computing capabilities and large-scale data storage advantages, can handle more complex tasks in smart cities, such as overall traffic pattern analysis, big data mining, and machine learning model training.

The combination of edge computing and cloud computing is not a simple task assignment, but requires efficient collaboration between the two. The hierarchical processing and transmission of data is the core of this collaborative architecture. In our study, by designing a layered processing mechanism, we achieve a reasonable distribution of data: data with high real-time requirements are first processed on the edge devices and only the processed key data are uploaded to the cloud instead of all the raw data. The cloud then uses these key data for large-scale analysis and modeling, and feeds the analysis results and optimization instructions back to the edge devices. This synergistic mechanism ensures the overall efficiency of the system and maximizes the respective advantages of edge computing and cloud computing.

Table 2 shows the performance of edge computing and cloud computing in different types of data processing. The table lists the processing time, bandwidth consumption, and computational resource usage, which helps us visualize and understand the advantages and disadvantages of both in different application scenarios.

*Table 2: Performance performance status*

| Data Type | Processing Location | Processing Time (ms) | Bandwidth Usage (Mbps) | CPU Usage (%) | Storage Usage (MB) |
|---|---|---|---|---|---|
| Traffic Video Feed | Edge | 50 | 5 | 40 | 10 |
| Traffic Video Feed | Cloud | 200 | 50 | 20 | 50 |
| Air Quality Data | Edge | 10 | 1 | 15 | 2 |
| Air Quality Data | Cloud | 100 | 10 | 10 | 5 |
| Emergency Response | Edge | 30 | 2 | 30 | 8 |
| Emergency Response | Cloud | 150 | 20 | 25 | 15 |

From the table data, it can be seen that edge computing has obvious advantages in processing time and bandwidth usage, especially in traffic video and emergency response scenarios with high real-time requirements, the processing time of edge computing is much lower than that of cloud computing. When dealing with relatively simple and small amounts of air quality data, the performance advantages of cloud computing are not obvious, but its advantages in storage and long-term analysis capabilities cannot be ignored.

ISSN 2522-3488 Vol. 8, Issue 4: 70-77, DOI: 10.25236/IJNDES.2024.080409

## 4. Results and Discussion

### *4.1. Urban Green Space Monitoring and Optimization Experiment*

The purpose of this experiment is to evaluate the application effect of wireless network remote sensing image processing technology in urban green space monitoring and optimization. The experiment collects green space coverage data from five urban areas, analyzes the gap between current coverage and planning goals, and simulates the effect of improving green space coverage by proposing optimization plans. During the experiment, image processing techniques were used to extract green space area, and the green coverage of each area was compared before and after optimization to verify the effectiveness of the optimization measures. The specific data situation can be seen in Figure 1:

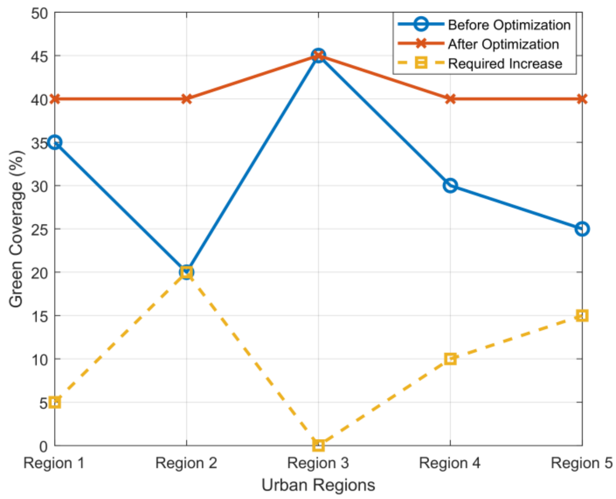


*Figure 1: Monitoring and optimization evaluation of urban green spaces*

In Figure 1, the green coverage rates of the five areas in the city before optimization are 35%, 20%, 45%, 30%, and 25%, respectively, with three areas failing to reach the planning target of 40%. Through optimization measures, the green coverage of regions 1, 2, 4, and 5 has increased by 5%, 20%, 10%, and 15% respectively, achieving the planning standard of 40% for all regions. The experimental results show that the use of wireless network remote sensing image processing technology can effectively identify areas with insufficient green space, and improve the coverage of urban green space through scientific optimization schemes, thereby enhancing the rationality and sustainability of urban planning.

### *4.2. Traffic Flow Monitoring and Diversion Experiment*

In the response speed evaluation experiment, the application effect of video surveillance and data analysis technology in alleviating urban traffic congestion was evaluated. The experiment simulates the traffic flow and congestion situation of five main road sections to analyze the impact of current signal timing on traffic flow. Then, based on the data, a plan to optimize the timing of signal lights was proposed in the experiment, and the improvement in traffic after optimization was verified through simulation. The focus of the experiment is to compare the changes in traffic flow and congestion index before and after optimization, in order to evaluate the actual effectiveness of the adopted technology. The specific data situation can be seen in Figure 2.

Figure 2 (a-b) shows the distribution of traffic flow and congestion index before and after optimization. In Figure 2, the traffic flow of the first five main optimized road sections is 800, 1200, 1500, 600, and 1000 vehicles per hour, corresponding to congestion indices of 0.7, 0.9, 1.0, 0.5, and 0.8. After optimization, the traffic flow increases to 900, 1300, 1600, 700, and 1100 vehicles per hour, respectively, and the congestion index decreases to 0.5, 0.7, 0.8, 0.4, and 0.6. The experimental results show that by optimizing the timing of traffic signals, the traffic flow of each road section has been improved, and the congestion index has been significantly reduced, especially in Region 3, which is the most congested area. The congestion index has decreased from 1.0 to 0.8, and the improvement effect is significant.

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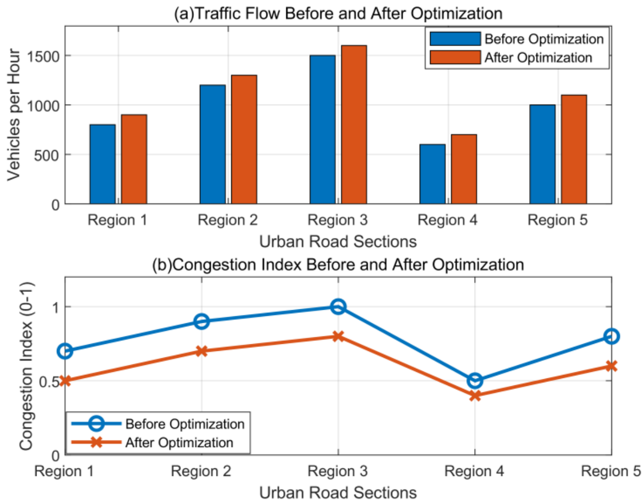


*Figure 2: Traffic flow monitoring and diversion evaluation*

### *4.3. Emergency Response Optimization Experiment*

The aim of this experiment is to investigate how to optimize urban emergency response time through wireless network remote sensing image and video processing technology. We simulated emergencies in five areas of the city, recorded the existing emergency response time, and applied technological means to optimize the response plan based on this. By comparing the response time before and after optimization, evaluating the potential application of these technologies in reducing emergency delays and improving urban emergency management efficiency. The experiment mainly focuses on the practical effects of technology in emergency response in different regions. The specific data situation can be seen in Figure 3:

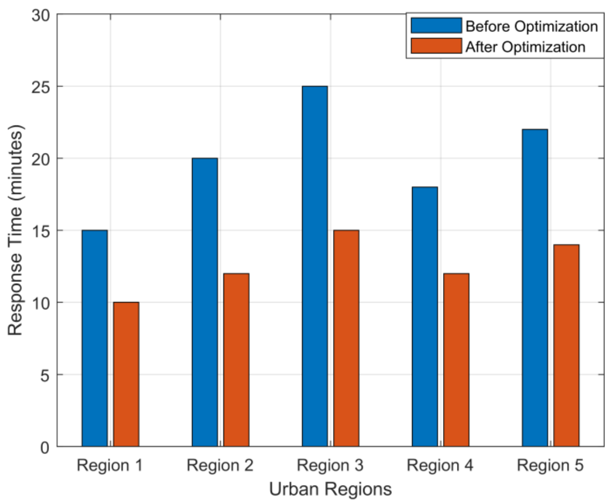


*Figure 3: Emergency Response Optimization Evaluation*

In Figure 3, the emergency response times for the first five optimized regions are 15 minutes, 20 minutes, 25 minutes, 18 minutes, and 22 minutes, respectively. By applying wireless network remote sensing image and video processing technology, the optimized response time has been reduced to 10 minutes, 12 minutes, 15 minutes, 12 minutes, and 14 minutes. Especially in Region 3, where the initial response time was the longest, the time was significantly reduced from 25 minutes to 15 minutes. Overall, the optimization measures have effectively reduced the emergency response time in various regions, improved the efficiency of emergency handling, and demonstrated the significant advantages of this technology in practical applications.

### *4.4. Experimental Summary*

Through comprehensive analysis of three experiments, namely urban green space monitoring and optimization, traffic flow monitoring and diversion, and emergency response optimization, it can be seen that advanced wireless network remote sensing image and video processing technology has significant effects in improving urban management efficiency and optimizing urban planning. All experiments have shown that these technologies can not only accurately identify problem areas, but also improve green space coverage, alleviate traffic congestion, and accelerate emergency response speed through effective optimization measures, thereby comprehensively enhancing the management level and response capabilities of smart cities.

## 5. Conclusion

This article explores in detail the application of wireless network remote sensing image and video processing technology in smart city design and planning through three experiments. By using these technologies reasonably, the experiment effectively improved the coverage of urban green spaces, alleviated traffic congestion, and accelerated emergency response speed. These achievements indicate that combining remote sensing images and video surveillance technology can not only achieve precise data collection in urban management, but also play an important role in optimizing resource allocation and management processes. However, this study also has certain limitations, such as the high equipment resource requirements that may be faced during data collection and processing, as well as the need for further validation and optimization in practical urban environments. Future research directions should focus on the fusion of multi-source data and the improvement of real-time processing technology to further enhance the management level of smart cities and explore more practical application scenarios in various fields of cities.

## Acknowledgement

This work was supported by Research on the Path of Promoting Regional Coordinated Development in Xiangyang City through the Construction of New Urbanization (HJZKYBKT2024060).

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