Application of UAV aerial image in monitoring and maintenance of expressway green belt

Nan Zhong¹, Lingzhi Sang¹ and Tao Duan¹,²*
¹China Transport Telecommunications & Information Center, Beijing, 100011, China
²Institute of Geographic Sciences and Natural Resources Research Chinese Academy of Sciences, Beijing, 100101, China
*Corresponding author’s e-mail: duantaohao@126.com

Abstract. The function of highway greening project is mainly classified from three aspects of central separation belt greening, slope greening and road side greening, and the initial indexes of various highway greening evaluation will bring great workload to the post-maintenance work. High-throughput highway inspection and monitoring platform is of great significance to the qualitative and quantitative evaluation of highway greening project. The UAV platform monitors the population shape of the plant in the central green belt of the highway, has the advantages of higher flux, high reduction degree and low cost, and is an important development direction of highway greening project maintenance in the future. Based on the present situation of maintenance and repair of highway greening project, the information acquisition technology of plant population characteristics and the systematic summary of the function of highway green belt, this paper mainly discusses the application prospect of UAV quantitative remote sensing technology in the monitoring of functional index of highway green belt, which is the driving safety of highway, the design of green belt, structural optimization and maintenance management provide theoretical support.

1. Introduction
The development of expressway has promoted the development of China's economy and the progress of society, and greening engineering is an important guarantee for the operation, maintenance and use of expressway. China's highway line across a number of climatic zones, and at this stage most of the maintenance work of the highway green belt still depends on sampling inspection, mainly include patrol worker inspection, vehicle sorting. It not only can bring large workload but also the low accuracy. In the high-risk work environment, the personal safety of maintenance workers can't be guaranteed. UAV has the characteristics of remote operation, real-time access to high-resolution data and low cost, and the application of UAV quantitative remote sensing technology in the daily inspection and maintenance of road greening project will solve some difficulties, such as large maintenance workload, heavy manpower consumption and safety performance of highway greening project at present. In 2018, UAV Aerial survey had been included in the newly revised standard for quality inspection and evaluation of Highway Engineering (JTG F80/1-2017) for the recommended use of road greening engineering testing.

With the development of computer technology, on the basis of the research and application of high efficiency intelligent detection platform, a comprehensive evaluation method combining qualitative characteristics and quantitative analysis of highway greening is proposed. It can reflect the greening function intuitively, present situation and maintenance level of highway, and provide reference for the
development, management and improvement of highway greening work. At present, the study of highway greening belt only focuses on qualitative description and evaluation, and there is no quantitative parameter evaluation system. Based on the analysis of the present situation of highway green belt and the review of functional index evaluation of green belt, it is concluded that there is a lack of a quantitative monitoring platform in the industry at present. So researchers urgently need to explore efficient and non-destructive quantitative remote sensing technology, such as UAV and vehicle radar, to meet the needs of quantitative monitoring of highway greening functional indicators in the field of transportation.

2. Content and importance of highway greening project
In the evaluation system of highway operation and maintenance quality, the present situation of highway greening is an important evaluation index. Highway construction will bring the excavation of a large number of soil, which can change the original topography and the stability of the original ecosystem, resulting in a series of environmental problems, such as soil erosion, environmental pollution, biodiversity reduction and so on. After opening up traffic, it can will bring air pollution and noise pollution[1-2]. The ecological function of expressway greening is embodied in its ability to slow down the impact of highway construction on ecological environment, such as dust and noise prevention, air purification, soil and water conservation, reduction of pavement temperature, maintenance of biodiversity along the highway and so on to achieve the coordination and unification of highway construction and environment[3]. It is the landscape function of greening project that proper greening can make a rich landscape effect along the single highway relatively[4]. At the same time, it will improve the comfort and safety through reduce the surface area exposed by excavation of earthwork, so that the negative impact of highway construction on the landscape environment is reduced[5]. The traffic function of expressway greening mainly includes the anti-glare function of the central separator belt and the sight induction function of the green belt along the route[6]. The green isolation belt on both sides of the expressway can indicate the change of highway linearity, induce the driver's sight effectively and increase the safety of vehicle driving. Planting a certain height and crown of flower shrubs in the central separation zone of expressway can play the role of anti-glare shading effectively, finally to ensure the safety of driving[7].

3. Application of remote sensing imaging technology in plant structure characteristic monitoring
The morphological structure in the process of plant growth is closely related to its physiological characteristics, environmental conditions and many other factors. Conventional plant morphological parameters, such as plant height, size, etc., can be obtained by direct measurement of the instrument or by software analysis after photography. Three-dimensional digitization technology can be used to describe the geometrical morphology and spatial information of plants accurately[8]. Three-dimensional digital technology has high measurement accuracy, but heavy workload, and it is difficult to achieve non-interference determination of plant morphological structure. With the development of remote sensing platform, the application of spatial information acquisition technology has been further popularized, and many non-contact three-dimensional data acquisition instruments such as 3D radar imaging technology LIDAR gradually been applied. These methods can realize the non-destructive acquisition of three-dimensional information of plant structure and then extract its structural shape. However, due to the limitations of the operating environment and the high cost, these technologies are limited in their wider application greatly.

With the development of computer technology and the research and development of multi-source image processing software, the reconstruction of plant canopy space structure based on image sequence and the extraction of morphological characteristic parameters provide a cheap and accurate method for the acquisition of plant structure data[9]. Information interpretation from the multi-image sequence (RGB images and high-resolution wide-wave images) can be bulk extraction of plant characteristic parameters. From the present point of view, whether it is two-dimensional image method, stereo vision method or three-dimensional LIDAR technology, the individual acquisition of crop
morphological structure characteristics of information is subject to flux or limited to precision, so that it can’t meet the needs of scientific research and application fully. However, it is an important development direction to realize the quantitative measurement of plant structure characteristics through combining the sensor with the fully automatic loading platform.

4. Application of UAV aerial shooting in expressway greening project

4.1 Processing of UAV image set for expressway green belt
Monitoring scenes, UAV parameters, flight routes and other pre-preparation are the guarantee for the smooth conduct of aerial rackets. After exporting aerial images from UAV storage devices, mosaic images, three-dimensional point clouds, and digital surface models (DSM) can be generated by Agisoft PhotoScan software. The geographic information of the picture sequence is achieved by UAV carried the GPS positioning system. Firstly, the feature matching points between adjacent image pairs are found in the original image sequence, and the dense three-dimensional point clouds of the whole monitoring area are generated based on the key matching points, and the two-dimensional mosaic images and elevation digital surface models are carried with the color and elevation values of each reconstruction point respectively. The reconstructed three-dimensional point cloud (color and height) and ortho-mosaic image cover the entire scene in the flight area, thus further extracting the parameters of the plant population structure of the highway green belt (Fig. 1).

![Fig 1 Diagram of UAV image data processing process](image)

4.2 Quantitative study on plant morphological structure parameters based on UAV aerial image
In recent years, it has been applied to vegetation pixel calculation coverage, plant disease monitoring through the interpretation analysis of UAV image sequence[10]. Relevant studies have shown that the UAV has a significant advantage over the on-board platform when measuring speed and determination conditions (terrain or meteorological conditions) are limited. Exploring the comprehensive detection technology of terrestrial ecological quality in China, the relevant research team has coupled the UAV platform with the machine learning algorithm to evaluate the automatic classification and coverage of vegetation, and developed an open source platform (www.uav-hirap.org) for aerial image analysis.

With the great development of the function of image processing software, the plant growth characteristics based on UAV aerial image sequence can be carried out through two-dimensional
orthogonal splicing and three-dimensional point cloud reconstruction for large monitoring range. The plant characteristic analysis based on the reconstructed canopy can estimate the seedling deficiency rate, canopy coverage and so on of planting plants in the monitoring range. Accurate digital surface models (DSM) can be obtained through GPS collaborative positioning of the UAV platform. In addition, multispectral image data can be used to extract the canopy vegetation index of plants in the monitoring range, so that the growth state of vegetation can be evaluated more accurately. This plant morphological quantitative monitoring technique is used to monitor the plant in the green belt of Expressway, and then to provide technical support for the quantitative analysis of its functional evaluation index.

4.3 Application research prospect of expressway green belt based on quantitative remote sensing platform

Because plant growth is affected by growth season, environment, topography and other factors, and its group shape is variable, the corresponding functions of the existing green belt will be affected accordingly. Taking the central green belt of highway as an example, the larger spacing of adjacent plants caused by car accident milling, pests and diseases, seedlings will lead to glare and thus affect driving safety. The change of canopy height after plant ripening, such as the height of the green plant between the driver's point of view and the pair to the headlights of the vehicle, will lead to loss of green belt function, need to be trimmed in time. Although at the beginning of the configuration plant reached the spacing and height requirements, due to the poor planting conditions of the highway green belt caused by low plant survival rate, car accident collision and milling caused some plants to die, the need to replanting saplings, resulting in topping, high layer, canopy width and other plant morphological changes. In addition, indicators such as the degree of change in the greening design of the road intersection and the vegetation richness required on the landscape will affect the function of the green belt and need to be monitored regularly (fig. 2). The high-throughput highway green belt technology based on UAV platform can monitor the plant in a large range in real time, so as to find the change of its growth and survival situation in time, and make it easy for the industry department to carry out maintenance management in time.

![Fig 2 Example of the application of UAV quantitative remote sensing in highway greening](image)

5. Conclusion

According to the actual demand of highway greening project maintenance work, this paper gives a systematic qualitative description of the functional index of highway green belt, combined with the demand of quantitative analysis technology in post-maintenance work, and puts forward a quantitative monitoring method of highway green belt based on UAV quantitative telemetry platform. Based on the research of the method of acquiring the characteristic parameters of plant structure at home and abroad at present, the feasibility of the key technology of UAV aerial image in the research and application of greening vegetation of expressway is further determined. Combined with specific
quantitative indexes such as height, spacing, canopy width and landscape variation, the application direction and prospect of UAV platform in highway green belt are finally defined. In the future, based on the periodic monitoring of the target highway green belt by high-throughput UAV platform, the dynamic monitoring of structural characteristic parameters of highway green belt will be realized quantitatively. Then the quantitative evaluation system of highway green belt is put forward, which provides theoretical and technical support for the design of Highway green belt, tree species selection, structure optimization and pruning management.

Acknowledgments
We would like to acknowledge Pengcheng HU (CSIRO) for his generous help with the photography and software used for 3D reconstruction, Yan GUO (China Agricultural University) for his help in image interpretation algorithm. This study is supported by the National Key Research and Development Program of China (2017YFC0804904) and National Natural Science Foundation of China (31771678).

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