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# Development and Challenges of UAV Technology in Civil Engineering Surveying and Mapping

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***Abstract:*** In recent years, as the cost of Unmanned Aerial Vehicle (UAV) technology has steadily decreased and advancements in data processing speed and image recognition have accelerated, UAVs have become increasingly favored in civil engineering surveying and mapping. The purpose of this paper is to study the development of UAV technology in the field of civil engineering surveying and mapping and its current application methods. By analysing the above contents, the problems still existing in the current practical use of UAV technology are studied. Through a review of relevant literature, newly developed technologies will be integrated with current UAV capabilities to propose recommendations for future improvements. This article employs literature analysis and case study methodologies to investigate the utilization of UAV technology. It delineates the current state of development and the challenges that UAV technology faces in the surveying field by examining extant academic research materials and legal regulations. It also provides a concise overview of the distinctive benefits of UAV technology. Simultaneously, the deficiencies of UAV technology in field environments are investigated, particularly focusing on data collection and accuracy in engineering surveying projects. UAV technology has obvious advantages compared with traditional methods in the field of civil engineering surveying and mapping. It can complete surveying and mapping tasks efficiently and quickly in many application scenarios. The high flexibility of UAVs and the high-precision scanning of their sensors are enough to meet the needs of current engineering surveying and mapping. The wide application of UAV technology still faces problems such as imperfect laws and regulations, insufficient surveying and mapping scope, and large surveying and mapping data. Addressing these issues requires the development of new laws and the creation of algorithms to enhance data processing capabilities.

***Keywords:*** Civil Engineering, Project Management, Unmanned aerial vehicle (UAV), Engineering Mapping.

## 1. Introduction

With the continuous development of modern civil engineering technology, buildings have become taller, and project scales have grown larger. Therefore, traditional project management methods that rely on manual investigation are struggling to keep pace with increasing demands. Larger projects mean that the construction party needs to spend more funds to hire security personnel for management,

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and the larger the scale of the project, the more hidden security risks. Traditional manual investigation methods will inevitably have omissive situations, and may even put themselves in danger. To sum up, civil engineering project management urgently needs a new and more efficient monitoring method.

In recent years, UAV technology has risen, and its characteristics of lightweight and high mobility have made it widely concerned in the field of civil engineering, and gradually used in all aspects of civil engineering. For example, in terrain mapping during the early stage of construction, drones equipped with laser scanning equipment can quickly scan the terrain at a high altitude through flight advantages, overcoming the limitations of traditional mapping, which requires extensive equipment, navigation through complex terrains, and multiple personnel.

This paper will briefly introduce the application and current status of UAV technology in the field of civil engineering project management, and discuss the application scenarios of UAV technology in the actual construction process, so as to highlight the unique advantages of UAV technology compared with traditional manual methods. In addition, this paper will combine the practical cases of UAV technology used in engineering management, identifying the challenges encountered in real-world applications and evaluating its technical limitations. This is combined with successful use cases to provide specific optimization recommendations.

The main research method used in this paper is case analysis. Through the analysis of actual cases, the paper deeply understands the technical bottlenecks and shortcomings of today's UAV technology, discusses future development directions in civil engineering management, and puts forward corresponding optimization suggestions. These insights will support the ongoing growth and advancement of the civil engineering industry.

## 2. Application Status of UAV Technology

At present, the use of UAV technology in civil engineering primarily relies on UAV platforms and their mounted sensors, such as cameras and LiDAR, to achieve objectives. For example, Lidar scanning technology is widely used in surveying and mapping [1], and in 3D mapping modelling of scanning earthworks [2]. UAV technology has been widely used to replace costly mapping tools such as manned spacecraft.

Although UAV technology offers many advantages over traditional methods, certain challenges remain. For example, Finn and Wright pointed out in their investigation report that the use of UAVs in moral and privacy aspects may pose a threat to civil liberties. The report pointed out that the content captured during the drone flight cannot be monitored by a third party, and it is very easy to violate the privacy of the public. At the same time, the current laws and regulations on commercial drones are not clear, and an effective punishment scheme cannot be given in the event of infringement. In summary, while UAV technology has demonstrated clear advantages in civil engineering monitoring, improvements in legal and regulatory frameworks are necessary for broader adoption.

In terms of the accuracy of engineering surveying and mapping, the laser radar scanning technology carried by the current UAV has been able to replace the way of using manned aircraft, and has become a new and more cost-effective method of scanning and mapping in a small range. This is due to the popularity and development of LiDAR technology in remote sensing. This technology can scan 3D point data with high accuracy in conventional open terrain, but there are still some errors in forest terrain, making the final 3D modeling accuracy less. For example, with directional video observation included, the LiDAR scanning system can generate a point cloud with a horizontal RMS error of 0.34 m and a vertical error of 0.14 m at a nominal flight altitude of 50 m [3]. One possible explanation for this may be that in heavily forested areas, LiDAR scanning technology is still limited to high-precision mapping.

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# 3. Problems of UAV Technology in Practical Use Scenarios

## 3.1. Imperfect Laws and Regulations

Although the use of drones in the construction industry is mainly for monitoring safety and mapping terrain, it also needs to comply with relevant legal requirements. However, the legal framework surrounding drone usage remains underdeveloped, and there is still no clear and consistent regulation governing their use. This means that when drones are used for surveying and monitoring during construction, the monitoring data collected will only be reviewed by surveyors, and there is no perfect system process. In this process, only surveyors themselves are involved, and the shooting content is also reviewed and managed by surveyors, which is likely to violate the privacy of others and bring legal problems.

For example, in the Land Surveyors Act of California, the use of drones is regulated as follows, "Any data collected by an autonomous drone used for civil engineering or other surveying activities must be supervised or approved by a licensed land surveyor (i.e. an individual)." However, this regulation imposes minimal restrictions on measurement drones, only requiring users to self-review the captured content. There is no third-party organization overseeing or managing the process, resulting in a lack of sufficient regulatory supervision.

## 3.2. Limited Surveying Range

Although the UAV can be competent for small-scale surveying and mapping tasks, in the face of large-scale surveying and mapping tasks, its limited endurance makes it difficult to complete these tasks at one time. After a period of flight, it is necessary to frequently change the battery and then take off again for multiple surveying and mapping. At the same time, in the face of harsh environments such as heavy rain and wind, the UAV needs to spend more power on power in order to maintain smooth operation, and the mapping range will be more limited. At the same time, in bad weather, the UAV will also cause unstable and inaccurate mapping data due to the jitter problem.

In addition, the flying range of drones has also been strictly regulated. The Federal Aviation Administration (FAA) has specified the flying range of drones in its part 107 that drones generally cannot be flown more than 400 feet above the ground unless the drone remains within 400 feet of a building. Government controls on drones also limit the maximum area they can survey in a single flight.

## 3.3. Large Data Volume

In large-scale mapping work, it is often necessary to use multiple drones to work together in order to ensure efficiency. The huge amount of data generated by these drones during the mapping process has strict requirements for software algorithms. The amount of three-dimensional point cloud data generated by LiDAR sensors is huge, and the software not only needs to process the data obtained by each drone separately, but also needs to integrate the data processed by multiple drones to ensure the smooth connection between the data obtained by multiple mapping. In order to ensure that the scanning data of different UAVs do not conflict, the algorithm of 3D image processing software has high requirements. For example, after multiple scans at intervals, the point cloud data may contain "noise," which refers to unwanted points that do not represent stationary objects, such as moving cars or pedestrians, or artifacts from reflective surfaces like window panes or smooth marble. Dealing with this "noise" is a complex task that requires continuous optimization of algorithms and time spent removing "noise" from 3d point data.[5]

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## 4. Suggestions for Future Optimization

First of all, relevant laws and regulations must be improved, and unified standards should be established. Relevant management departments should clearly stipulate the requirements for the current use of UAVs in civil engineering surveying and mapping. This requires authorities to expand and update existing regulations, while establishing regulatory bodies to adopt real-time monitoring systems within the range of drones to ensure effective enforcement of laws and regulations. For example, the Civil Aviation Authority (CAA) has introduced regulations on the use of drones, which specify that the pilot or operator of any drone flying between 250 grams (0.55 lb) and 20 kg (88 lb) is required to register as a drone operator. This regulation clarifies the division of responsibilities in the use of drones, so that drone users can pay more attention to the operation of their operations.

Second, improvements in the controller system and design of UAVs are essential to increasing endurance. Optimizing the design and enhancing the controller system are two feasible approaches. By optimizing the controller system and adopting a more power-saving algorithm, the energy consumption of the UAV in bad weather environment can be reduced, thus extending the flight time of the UAV. For example, Proportional Control, Integral Control, and Derivative Control (PID) algorithm can optimize the stability of UAVs, enabling them to maintain steady flight under external environmental disturbances, such as strong winds, while reducing power consumption and prolonging flight duration [6].

In addition, in terms of design, the use of lightweight materials and aerodynamic optimization can also reduce the drag of the UAV during flight. At the same time, by evaluating and simulating the power and energy consumption of the aircraft in various flight conditions, A fixed-wing (FW) vertical take-off and landing (VTOL) UAV is designed to retain the flexibility of a four-rotor UAV. It also greatly reduces the energy loss during flight.[7]

Finally, in order to deal with the processing needs of huge data volume, the calculation and storage methods of 3D point cloud data generated by LiDAR sensors can be optimized to reduce or share the data processing amount of 3D point data. For instance, Levent Candan et al. developed a method utilizing UAV-mounted LiDAR for real-time 3D point cloud mapping. They employed an optimized LiDAR sensor system that allows real-time calculation of 3D point data during drone flight, alleviating the burden on post-flight software for data processing.

## 5. Conclusion

At present, UAV technology has been widely used in all aspects of the field of civil engineering surveying and mapping. Its high flexibility allows it to replace manual labour for a wide range of tasks, and due to its simple and easy-to-control features, UAVs can effectively map complex and hazardous terrains. Therefore, UAV technology has become an important tool in the field of civil engineering mapping.

However, despite its advantages over traditional methods in terms of versatility and scanning speed, certain limitations of UAV technology are evident in case studies. The current laws and regulations have not fully stipulated the scope of use of UAVs, and the image acquisition function of UAVs may also infringe others' privacy. In addition, the instability of the UAV in strong winds or heavy rainfall will also lead to the deviation of scanning data and reduce the endurance of the UAV.

For the future development of UAV technology, the paper proposes feasible solutions to the above problems. First, systematic regulations and industry norms can be formulated to determine the scope and requirements of UAV technology in the field of engineering surveying and mapping, and the user of UAV can be registered. In addition, the introduction of new designs, lightweight materials, and the optimization of point data generation algorithms will improve scanning accuracy and enhance UAV endurance.

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However, the research in this paper also has some shortcomings. While it analyzes the current shortcomings of UAV technology in civil engineering surveying and mapping, it falls short in exploring future technological applications for UAVs. With the development of artificial intelligence and the improvement of computer computing power, future UAV surveying and mapping methods can be combined with artificial intelligence. For example, the image algorithm combined with artificial intelligence can simulate 3D point cloud data, and compare it with the data obtained from actual mapping to improve the accuracy of the data.

## References


[1] *Kovanič, Ľ., Topitzer, B., Peťovský, P., Blišťan, P., Gergeľová, M. B., & Blišťanová, M. (2023). Review of photogrammetric and lidar applications of UAV. Applied Sciences, 13(11), 6732.*

[2] *Siebert, S., & Teizer, J. (2013). Mobile 3D mapping for surveying earthwork using an unmanned aerial vehicle (UAV). In ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction (Vol. 30, p. 1). IAARC Publications.*

[3] *R. L., & Wright, D. (2016). Privacy, data protection and ethics for civil drone practice: A survey of industry, regulators and civil society organisations. Computer Law & Security Review, 32(4), 577-586.*

[4] *Wallace L., Lucieer A., Watson C., and Turner D. (2012). Development of a UAV-LiDAR system with application to forest inventory. Remote Sens. 4(12): 1519–1543.*

[5] *Ullrich, Andreas, and Martin Pfennigbauer. "Advances in lidar point cloud processing." Laser Radar Technology and Applications XXIV. Vol. 11005. SPIE, 2019.*

[6] *Susanto, T., Setiawan, M. B., Jayadi, A., Rossi, F., Hamdhi, A., & Sembiring, J. P. (2021, October). Application of Unmanned Aircraft PID Control System for Roll, Pitch and Yaw Stability on Fixed Wings. In 2021 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE) (pp. 186-190). IEEE.*

[7] *Dündar, Ö., Bilici, M., & Ünler, T. (2020). Design and performance analyses of a fixed wing battery VTOL UAV. Engineering Science and Technology, an International Journal, 23(5), 1182-1193.*