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Lidar Integration in 3D Documentation of Complex Civil Buildings.

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Extended Abstract

The integration of Lidar (Light Detection and Ranging) technology in the 3D documentation of civil complex buildings has revolutionized the field of architectural documentation, providing unparalleled precision and efficiency in capturing and modeling intricate structures. This paper delves into the methodologies, advantages, and challenges associated with employing Lidar for the comprehensive 3D documentation of civil structures, such as bridges, tunnels, and multi-story buildings, highlighting its transformative impact on civil engineering, construction management, and historical preservation.

Lidar technology employs laser pulses to generate detailed 3D point clouds, accurately representing the geometry of complex structures. This non-contact method of data acquisition is especially beneficial for documenting large-scale civil buildings, where traditional surveying techniques may be labor-intensive, time-consuming, and prone to human error. Lidar's rapid data collection capabilities enable the efficient capture of millions of data points, facilitating detailed documentation even in areas that are difficult to access or unsafe for manual surveying [1], [2].

The integration process begins with data acquisition, where Lidar sensors mounted on tripods, vehicles, or drones emit laser pulses that reflect off surfaces and return to the sensor, measuring distances to create a point cloud. This raw data undergoes processing using advanced software, which filters out noise, registers multiple scans, and aligns them into a unified, accurate 3D model. These models can then be utilized for various purposes, including structural analysis, renovation planning, and maintenance [3], [4].

A critical advantage of Lidar technology is its ability to produce high-resolution, accurate 3D models that serve as a foundation for Building Information Modeling (BIM). This integration enhances collaborative efforts among architects, engineers, and construction managers by providing a shared, precise digital representation of the building. The rich detail captured by Lidar enables thorough inspections and precise measurements, aiding in identifying structural issues, planning interventions, and ensuring compliance with safety standards [5].

Moreover, Lidar's utility extends to the preservation of historical civil buildings. Its non-invasive nature is particularly advantageous for documenting and preserving delicate or deteriorating structures. The digital archives created through Lidar scanning provide invaluable records for future restoration and conservation efforts, ensuring that the historical integrity of these buildings is maintained [6], [7].

Despite its numerous benefits, the adoption of Lidar in 3D documentation presents challenges. The vast amounts of data generated necessitate advanced data management and storage solutions. The interoperability of Lidar data with existing architectural and engineering software requires significant technical expertise and can be complex. Additionally, the initial costs associated with acquiring Lidar equipment and training personnel can be substantial, posing a barrier for smaller firms or projects [8].

Nevertheless, the future of Lidar in civil building documentation looks promising. As technology advances, it is expected that the cost of Lidar systems will decrease, and software will become more user-friendly, broadening its accessibility. Continued research and development are anticipated to enhance the capabilities of Lidar, such as improving data processing algorithms and integrating real-time data acquisition and analysis [9], [10].

In conclusion, Lidar integration in the 3D documentation of civil complex buildings marks a significant advancement in the field. Its ability to capture precise, high-resolution data rapidly and efficiently makes it an invaluable tool for modern civil engineering, construction management, and heritage conservation.

References

[1] B. Albertz J., "*A Look Back: 140 Years of Photogrammetry: In Photogrammetric Engineering & Remote Sensing*, ‘‘ vol. 73, no. 5, pp. 504-506, 2007.

[2] Akgul M., Yurtseven M., Gulci S., Akay A.E., "Evaluation of UAV and GNSS-Based DEMs for Earthwork Volume,’’ *Arabian Journal for Science and Engineering*, vol. 43, no. 4, pp. 1893-1909, 2018. DOI: 10.1007/S13369-017-2811-9

[3] Balázsik V., Tóth Z., Abdurahmanov I., "Analysis of Data Acquisition Accuracy with UAV," *International Journal of Geoinformatics*, vol. 17, no. 1, pp. 1-10, 2021. DOI: 10.52939/ijg.v17i1.1697

[4] Erdelyi J., Kopacik A., Kyrinovic P., "Construction control and documentation of facade elements using terrestrial laser scanning" *Applied Geomatics*, vol. 10, no. 2, pp. 113-121, 2018. DOI: 10.1007/s12518-018-0208-4

[5] Guo M., Sun M., Pan D., Wang G., Zhou Y., Yan B., Fu Z., "High-precision deformation analysis of yingxian wooden pagoda based on UAV image and terrestrial LiDAR point cloud" in *Heritage Science*, vol. 11, no. 1, pp. 1-18, 2023. DOI: 10.1186/s40494-022-00833-z

[6] Haala N., Alshawabkeh Y., "Combining Laser Scanning and Photogrammetry—A Hybrid Approach for Heritage Documentation. In M. Ioannides, D. Arnold, F. Niccolucci, & K. Mania (Eds.) ", *The 7th International Conference on Virtual Reality, Archaeology and Intelligent Cultural Heritage*, 2006, pp. 163-170. DOI: 10.2312/VAST/VAST06/163-170

[7] Hassan A.T., Fritsch D., "Integration of Laser Scanning and Photogrammetry in 3D/4D Cultural Heritage Preservation—A Review.‘‘ *International Journal of Applied Science and Technology*", vol.9, no.4, pp. 9-16, 2019. DOI: 10.30845/ijast.v9n4p9

[8] Jaafar H.A., Meng X., Sowter A., Bryan P., "New approach for monitoring historic and heritage buildings: Using terrestrial laser scanning and generalised Procrustes analysis. Structural Control and Health Monitoring", Vol. 24, no. 11, DOI: 10.1002/stc.1987

[9] Pavelka K., Šedina J., Pacina J., Plánka L.,Karas J., Šafář V. "RPAS Remotely Piloted Aircraft System", in *České vysoké učení technické v Praze*, ISBN 978-80-01-05648-6, 2016.

[10] Kwoczynska B., Piech I., Polewany P., Gora K., "Modeling of sacral objects made on the basis of aerial and terrestrial laser scanning", in *Baltic Geodetic Congress*, 2018, pp. 275-282. DOI: 10.1109/BGC-Geomatics.2018.00059