

CASE STUDY ON UTILIZING DIGITAL TECHNOLOGY FOR THE PRESERVATION OF HISTORIC WOODEN STRUCTURES

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The purpose of this study is to introduce case studies utilizing digital technology for the preservation of Japan's historic wooden structures (temples and shrines). Historical structures face the risk of disappearance due to natural disasters such as major earthquakes, fires, typhoons and floods. Should damage occur, documentations are essential for reconstruction. Utilizing the latest digital technology facilitates the creation of drawings. The method involves the practical application of digital technology for surveying wooden temples and shrines designated as National Treasures or Important Cultural Properties. The content introduces multiple case studies where data obtained through surveying was processed, analyzed, and converted into drawings such as floor plans, elevations, sections, details and perspective drawing. Having traditional master carpenters who have worked on these structures perform the surveying yields more precise data, enabling the creation of floor plans, elevations, cross-sections and 3D drawings. This technology is applicable in many countries for preservation and reconstruction, saving time and saving costs.

Keywords: 3D scanning, Point cloud technology, Master carpenter, Orthographic images.

1 PURPOSE OF THE STUDY

The purpose of this study is to present practical examples of digital surveying applied to the preservation and reconstruction of historic wooden buildings and to show the possibilities to apply the technique for preservation. Numerous culturally valuable historic structures have been threatened by natural disasters. Detailed records are indispensable for accurate reconstruction. Recent advances in digital technologies have made it easier to measure and document wooden historical buildings.

2 RESEARCH METHODS

From 2023 to 2025, surveys of wooden cultural heritage buildings were conducted. A total of forty-six survey cases were collected, organized, and analyzed. Based on these data, the advantages and challenges of applying digital technologies to the documentation of historic wooden architecture were examined.

3 PRACTICAL APPLICATIONS IN JAPAN

During this three-year period, the authors conducted surveys of temples and shrines including sixteen designated National Treasures or Important Cultural Properties. Traditionally, architectural surveys were conducted manually and produced drawings by hand. This approach required considerable time, and the accuracy of drawings depended heavily on the skill of individual surveyors. Master carpenters can bring surveying equipment into interior spaces such as attics and underfloor areas.

4 DIGITAL SURVEY METHODS

4.1 Overview of Point Cloud Data and 3D Measurement

The case study presented in this paper focuses on the survey of the three-story pagoda of Myōtsū-ji Temple, a National Treasure located in Fukui Prefecture (Fig. 1). A three-dimensional laser scanner was used to measure the structure. The scanner emits millions of laser pulses per second, and position data are calculated based on the return time and angle of the reflected laser. Measurements were taken from multiple positions to minimize blind spots.

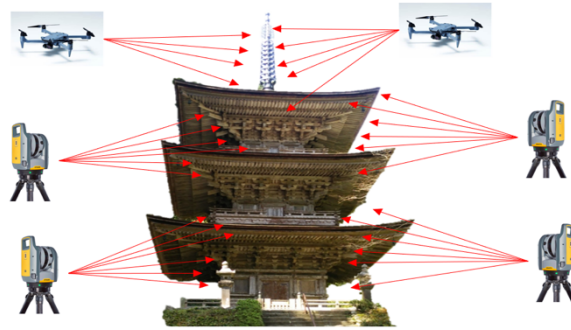


Fig. 1. Overview of point cloud data measurement methods, Source: T&I Co. Ltd. Report.

4.2 Acquisition and Utilization of 3D Data

Based on the collected point cloud data, various architectural drawings such as floor plans were created. The data were also converted into two-dimensional CAD drawings, perspective views, and three-dimensional CAD models, from which sectional drawings could be generated (Fig. 2).



Fig. 2. Data process, Source: T&I Co. Ltd. Report.

4.3 Overall Workflow for Point Cloud Data Utilization

Point cloud data were acquired using Trimble 3D laser scanners and processed with Real Works software (Fig. 3). The processed data were then developed into two-dimensional CAD drawings and into three-dimensional models using Rhinoceros and SketchUp. Final outputs included orthographic point cloud drawings, vector-based CAD drawings, three-dimensional mesh models, and layered component drawings. There are two main approaches to handling point cloud data in two-dimensional CAD software. Scanner emits 2 million laser pulses per second. Measurement range is 0.6 m to 150 m. Range error $\pm 1.5\text{mm}$ per 20 m. Color information is 10 MP to 20 MP (Mega Pixel). Time/Cost example: Survey of 10m x 10m x 10m(height) temple: Labor: 2 persons, 2 days. Conventional survey and scaffolding set up cost (typically): Labor 2perons/day and 1 month. Temporary setup cost is US\$5,000, depends on conditions in Japan.

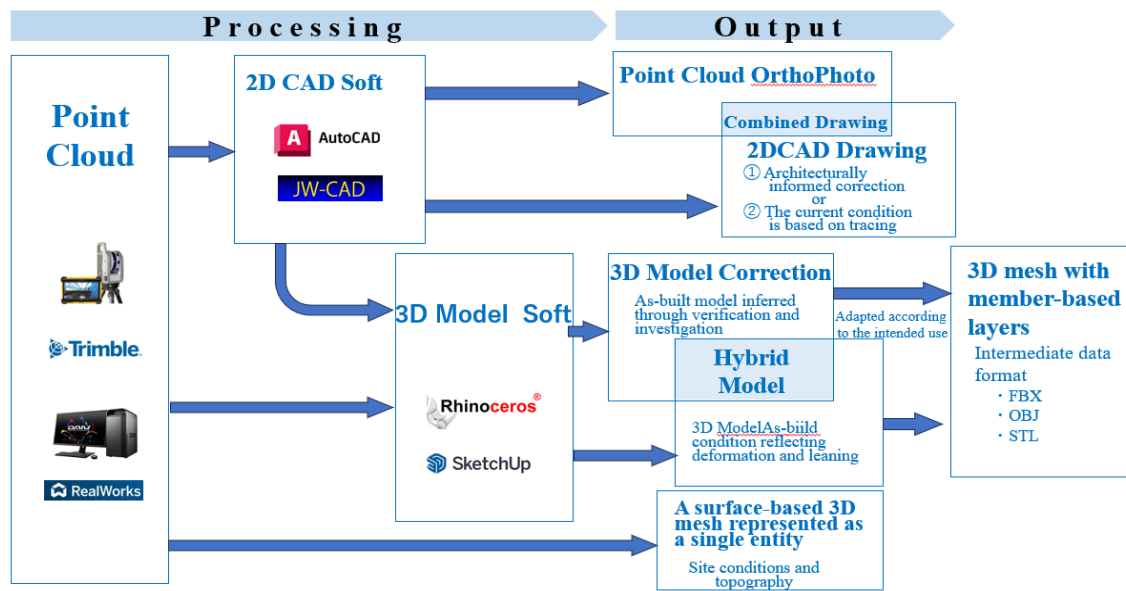


Fig. 3. Point cloud data processing work flow, Source: T&I Co. Ltd. Report.

4.4 Workflow Using Orthographic Images, Vectorization Workflow Using CAD Software

Point cloud data were processed in two-dimensional CAD software to produce orthographic drawings, including plans, elevations, sections, reflected ceiling plans, and roof plans (Fig. 4).

And using two-dimensional CAD software, vector-based drawings were created by tracing point cloud data imported from Trimble and Real Works. Floor plans, elevations, sections, ceiling plans and roof plans were produced.

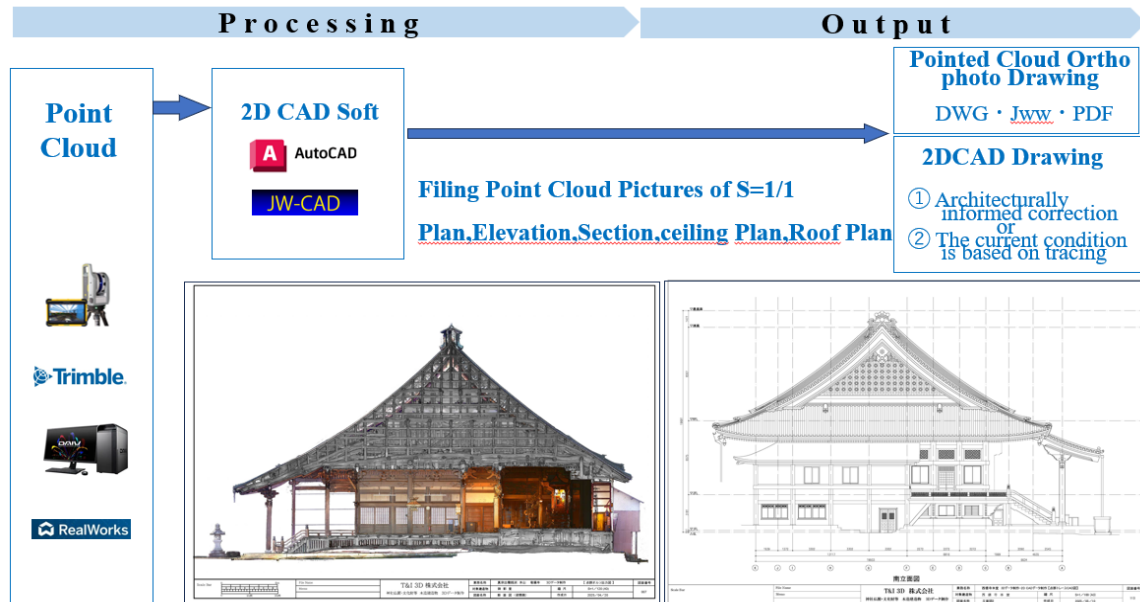


Fig. 4. Point cloud utilization in 2D CAD, 2D CAD drawing, Source: T&I Co. Ltd. Report.

4.5 Combined Drawings Using Orthographic Images and Vector Data

Orthographic point cloud images and vector-based CAD drawings were combined to produce scaled drawings with grid lines, heights, and dimensions. This method allows standard CAD drafting techniques to be applied (Fig. 5).

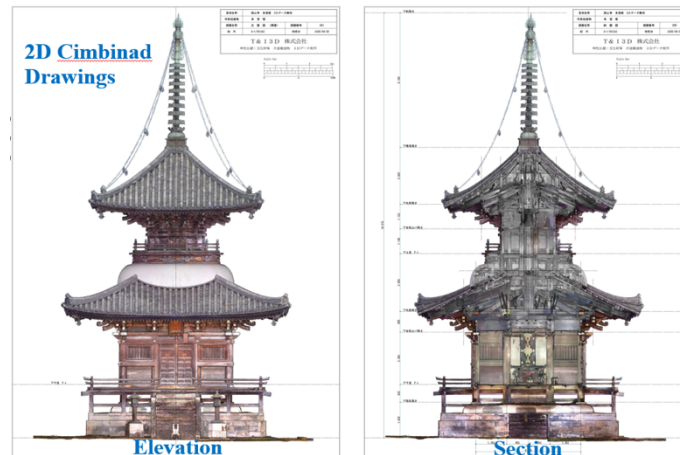


Fig. 5. Composite drawing example, Source: T&I Co. Ltd. Report.

4.6 Handling Point Cloud Data Directly in CAD Software

Point cloud data were imported into AutoCAD using proprietary formats (RCP/RCS). These datasets allow rotation, tracing, and dimensioning directly within the CAD environment (Fig. 6).

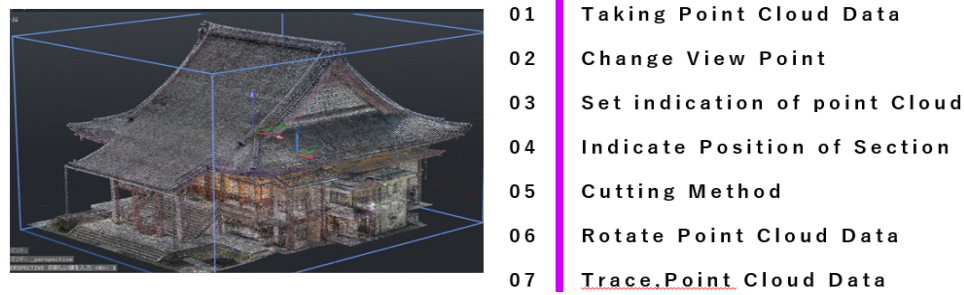


Fig. 6. Handling point cloud data, Source: T&I Co. Ltd. Report.

4.7 Three-Dimensional Modeling Based on Point Cloud Data

Three-dimensional models were created from point cloud data for use in construction drawings. By correcting distortions and irregularities, accurate component dimensions could be derived. Complex architectural spaces were modeled in three dimensions before generating two-dimensional drawings (Fig. 7). By recording the current conditions of wooden structures long-term deterioration and deformation can be monitored.

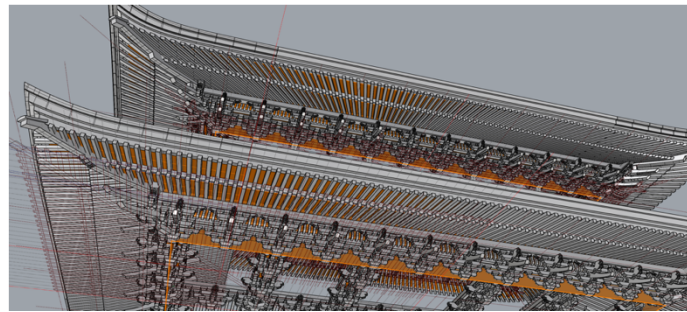


Fig. 7. Created based on 3D point cloud data, Source: T&I Co. Ltd. Report.

4.8 Differences Between Point Cloud Data and 3D Models

Point cloud data consist of dense collections of measured points that accurately represent building surfaces. In contrast, three-dimensional models allow components to be separated into layers, enabling visibility control and the calculation of volumes and surface areas (Fig. 8).

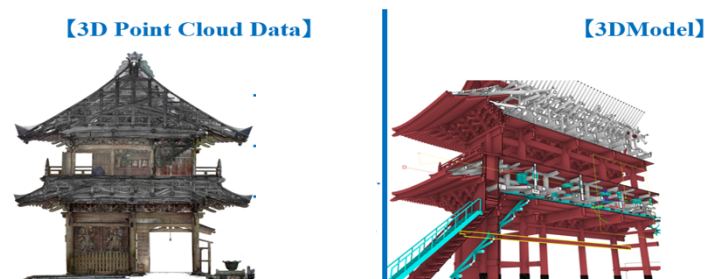


Fig. 8. Difference between point cloud data and 3D models, Source: T&I Co. Ltd. Report.

5 DISCUSSIONS

Using digital technology, historical structures can be meticulously visualized, revealing interiors, exteriors, attics and subfloor frameworks, enabling the creation of diagrams that dissect the buildings. In Japan, where many structures are wooden, point cloud data serves as a preservation record safeguarding against loss or damage from fires and earthquakes. While numerous historical buildings lack fully documented drawings, digital technology enables their preparation at reasonable cost and within a reasonable timeframe (The Fukui Newspaper).

Additionally, in 2019, the wooden roof of Notre-Dame Cathedral in France was destroyed by a fire. Importantly, point cloud data consisting of billions of points had been previously acquired using digital technologies. These data enabled the generation of accurate architectural drawings, which contributed to the efficient restoration project (Kimmelman 2024, Souza 2025).

6 CONCLUSIONS

Digital surveying offers several advantages for the documentation of historic wooden buildings: improved efficiency in reconstruction, detailed understanding of concealed spaces such as attics and underfloor areas, reduced risk of damaging cultural properties due to non-contact measurement, rapid conversion of survey data into drawings, and easier measurement of high-elevation areas using drones. When surveys and analyses are conducted by master carpenters experienced in traditional construction, highly accurate data can be obtained for even the smallest components, enabling the creation of detailed plans, elevations, sections, and three-dimensional drawings. This approach is applicable in many regions worldwide; however, understanding local construction methods and historical backgrounds is essential before implementation.

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