MAINTENANCE SYSTEM ASSEMBLAGE BY UTILIZING 3D LASER MEASUREMENT DEVICE

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ABSTRACT

In order to perform a sustainable structural maintenance management, it is required an integral system which enables to manage all structural information from beginning of construction during life cycle of a structure quantitatively and continuously such as initial design drawing, diagnostic record drawing and repair/retrofit design drawing. However, it is troublesome to obtain field in-site information in connection with functional change and repetition of repair/retrofit in many cases, and large-scale scaffold temporary construction may be required in the investigation. Therefore, it will be efficient to provide an investigation system which enable capture huge numerical information together with various picture information remotely and manage the information data systematically. Moreover, by combining with 3-D GIS system, the structural 3-dimensional spatial information can be retrieved in real time and can be functioned as presentation tool to show the reliability of structure performance.

In this paper, the measurement principle of 3D Laser measurement device is reviewed and structural maintenance system assemblage by utilizing 3D Laser measurement device is introduced. As the examples of the applications, the world culture heritage the A-bomb memorial dome at Hiroshima city is discussed. It is considered that this system is suitable to be applied for urban structural maintenance management.

1. INTRODUCTION

It is important to perform an economical and reliable maintenance management system for urban structures to grasp degradation condition and plan strategy for repair and retrofit (Tominaga, et.al., 2001). Maintenance evaluation and structural diagnosis should be carried out prior to repair/retrofit construction to grasp structural actual performance (Sumitro, et.al., 2002). Moreover, in performing a retrofit design, it will be effective in structure analysis if 3-dimensional digital model is provided (Nishimura, 2001 and Hanamura, et.al., 2001).

Photogrammetry was carried in order to grasp the current state information in 3-dimensional coordinates of the Atomic bomb memorial dome in which has been protected as one of the world historical heritage.

The fundamental information for delivering to next generations was created by the Hiroshima-city since 1996 (Hiroshima City, 1998 & 1999).

Unlike the usual building, the most part of dome's wall are curved surfaces in high intricacy. The total surface area of the dome is approximately to 4000 square meters. To extract the coordinates of outer and inner walls surface, marking fixed points and making photography plans were carried out carefully. Especially, photography of the central stairs room of this dome was performed by remote control equipment that can be photographed from the ground. In drawing measurement, the projection sides were set up so that they might become parallel to each wall's surface. The extracted coordinates of about 2 million points were built as a solid model in the computer, and then elevation and sectional views were created. The coordinates of each point can simply be searched by newly developed coordinates management system (Nishimura and Sumitro, 2002).

In this paper, how to apply photogrammetry and information processing technology in order to produce the effective system for recording and restoration of buildings is described. Furthermore, the 3-dimensional visualization system by utilizing newly developed sensory technology, such as 3D laser is introduced as well.

2. FIELD MEASUREMENT AND ORTHO-GRAPH PROCESSING

2.1 Measurement principle

3D laser scanner device measures distance between measured subject and sensors by pulse laser and it enables to measure the laser beam direction simultaneously, therefore, 3-dimensional coordinates can be captured in real time approach as shown in Figure 1. Post processing like photograph analyses can be avoided. 3D visualization with arbitrary sectional views can be generated capturing 3-dimensional data from several points with one reference global coordinate. Examples of 3D urban scanning results are shown in Figure 2.

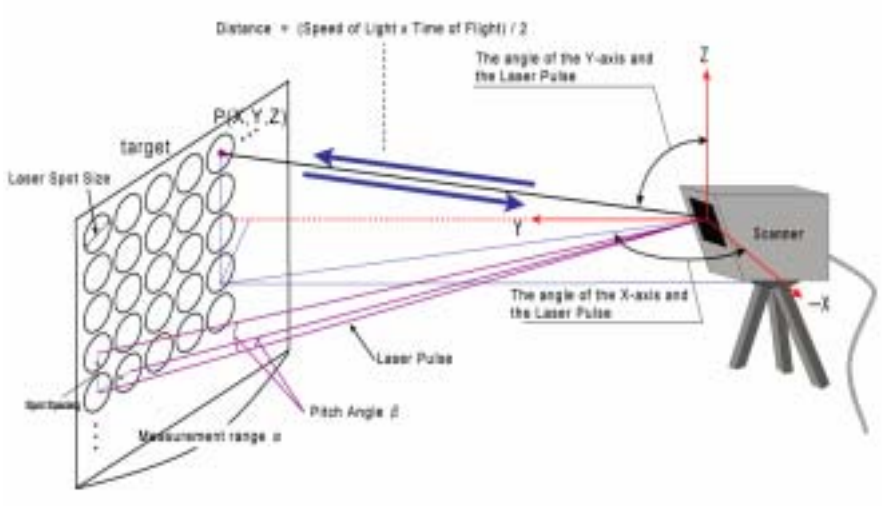

Figure 1: Measurement principle

2.2 Measurement device

In this verification field test Optech's ILRIS-3D was used. It is a complete, fully portable, laser-based imaging and digitizing system for capturing structural deformation. ILRIS-3D is a compact and highly integrated package with digital image capture and sophisticated software tools that address the needs of users. A field-ready system, ILRIS-3D is carried by a single operator and requires no specialized training for deployment.

About the size of a motorized total station, with on-board digital camera and large-format LCD viewfinder, ILRIS-3D has a visual interface similar to that of a digital camera. Typical working range is 3-800 m. Field deployment is made extremely efficient by ILRIS-3D's high data rate — point cloud data are captured at 2,000 points/sec. A typical scene with adjacent point spacing can be fully scanned in 10-15 minutes, capturing a remarkable 1.2 to 1.8 million points. ILRIS-3D is completely eye-safe in all modes of operation, even when its beam is viewed directly through binoculars. ILRIS-3D's setup is rapid and simple — no leveling required — and the system is controlled via a handheld remote.

The target area and scan status are displayed locally on screen, and data is written directly to an on-board removable flash card. An imbedded Pentium processor controls all functions. The scan data is processed by software bundled with ILRIS-3D. The data set consists of XYZ and intensity point cloud data, a digital camera image of the captured scene, and field notes entered during the scan by the operator. Files can be output quickly and efficiently in a variety of formats. ILRIS-3D is ruggedly designed for field use. Applicable operation temperature is rated from 0o C to +40o C, and is weatherproof for use outdoors.

Table 1: Specifications

Topic	**Comment**
Performance Range	350 m (4% target) 800 m (20% target)
Data sample rate	2,000 points/second
Modeling accuracy	3 mm
Laser Spot Size	D = 0.17R+12, where
Minimum Spot Spacing	S = 0.026R, where
Control interface	Palm (or compatible) PDA
Power input	24 VDC battery or AC converter
Scanner Size	L312 W312 H205mm
Scanner weight	12kg
Eye Safety	Class I laser product IEC 60825
Accuracy	Target registration accuracy 4 mm Modeling accuracy 3 mm Depth resolution 3 mm
Spot size	29 mm @ 100 m
Spot spacing	< 2.6 mm @ 100 m

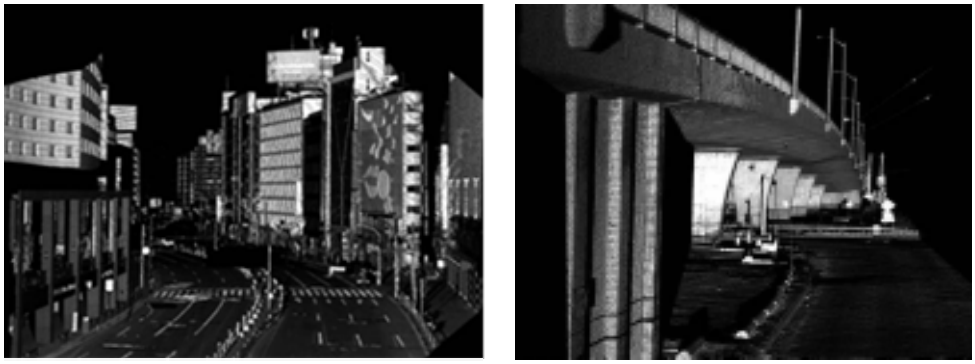

Figure 2: 3D urban scanning results

2.3 Field measurement

In order to digitize the whole structure of the A-bomb memorial dome at Hiroshima city, the data was captured from several measurement points. After guiding to an exact position, the scanning was started just after the 3D laser scanner device was carried in a work stand.

Moreover, in order to carry out data composition from every section with sufficient accuracy, a reference point which shown in a photograph, a datum point for composition, and a conversion index point to global coordinates, were conducted. Figure 3 shows the reference point and Figure 4 shows the measurement result, respectively.

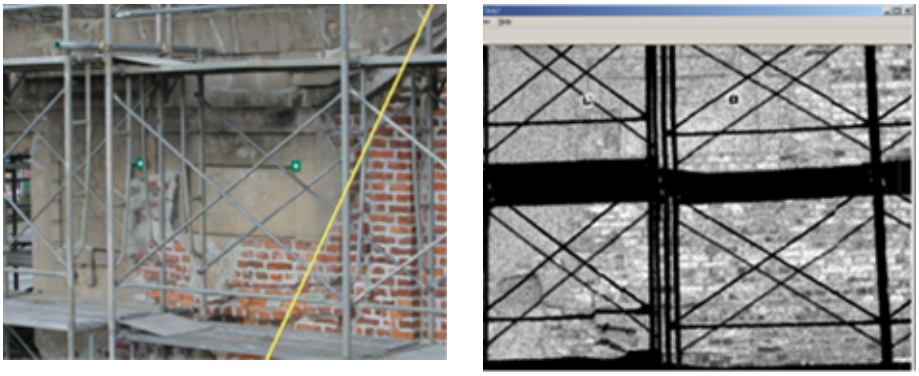

Figure 3: Reference point

Figure 4: Measurement result

2.4 ORTHO-PHOTOGRAPH

Conventionally ortho-photograph is generated by photogrammetry technology. The principle of digital photogrammetry is based on technology to acquire the geometric relationship on profile information of a photographic subject which were projected on CCD plan. Digital photogrammetry analyses are troublesome due to huge spatial marked points.

In case of 3D Laser analyses, since the data acquired by 3D laser is already constituted from the measurement stage by 3-dimensional cloud data, so it can be said that creation of ortho-photograph become easily.

However, with cloud data, the photograph taken with the external high resolution digital camera is only being applied to a point-wise problem, and output quality will be restricted to the cloud data density of laser measurement.

In order to utilize the digital picture information on high resolution effectively, a surface model is built from cloud data and the high resolution mapping technology on digital picture of a model is needed. (see Figure 5)

Figure 5: Photograph mapping

3. REAPPEARANCE VERIFICATION

In structural maintenance management, it is important to capture the precious structure profile. It will contribute to decision making on structural maintenance strategy if the structure deformation data can be collected in time-domain to assess the structure behavior. Although accuracy level needed in structural monitoring is different from geographical measurement, labor and time saving may be another consideration item.

To verify the reappearance characteristic on actual concavo-convex of an object model, a video recorder was installed in the distance of 50m to record the related phenomenon (see Figure 6). From generated model of the recorded data, it is confirmed that height of 5mm concealment by bottom up capturing procedure.

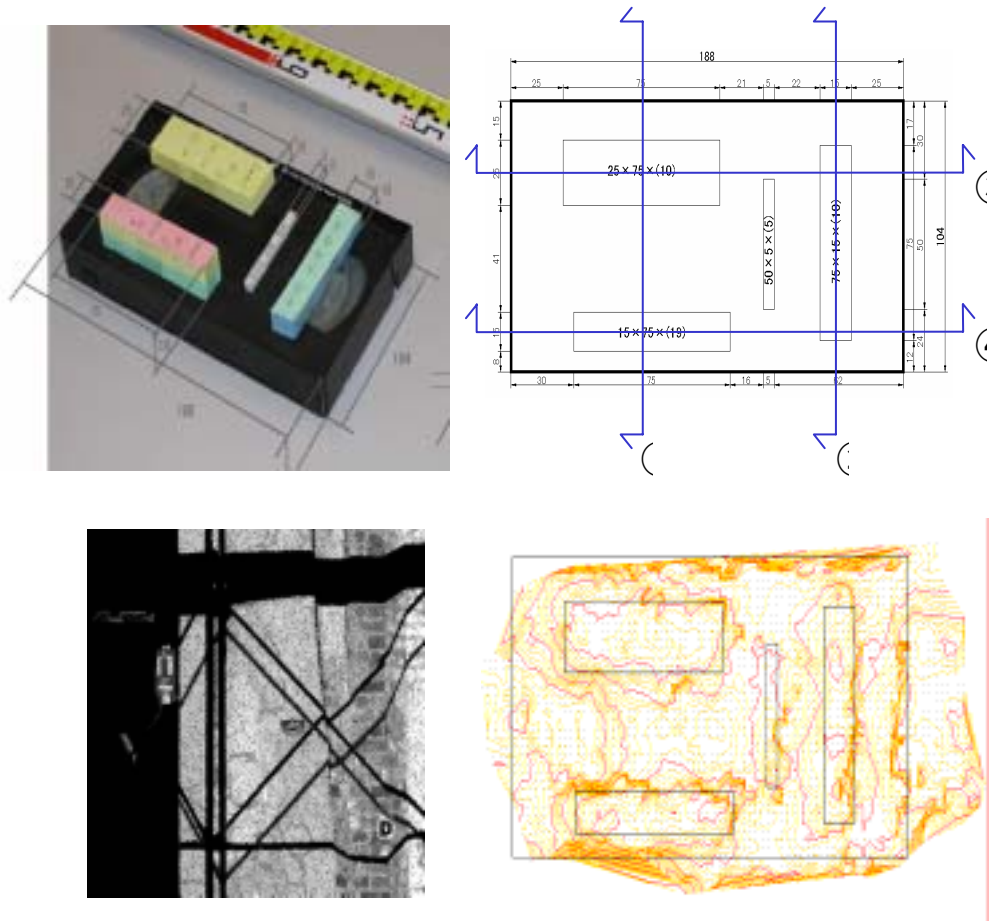

Figure 6: Reappearance of a model

4. PRESERVATION MAINTENANCE MANAGEMENT

As Information management to grasp structural deformation due to deterioration, it is important to carry out an integrated management system of field investigation results and structure repair history. Up to now, twice preservation constructions were performed in the Atomic bomb memorial dome. It is important to arrange the records of past two preservation activities and construct a system that can deliver those information (when, when and how the preservation construction were done) to future generations.

By up grading integrated 3-dimensional management system to the former two-dimensional handwriting-revised repair and investigation records, the planning and consideration of future preservation management becomes easily.

Figure 7 shows the example of integrated management of repair and investigation records based on photogrammetry CAD drawing. More detailed record can be displayed by choosing each investigation item and repair portion.

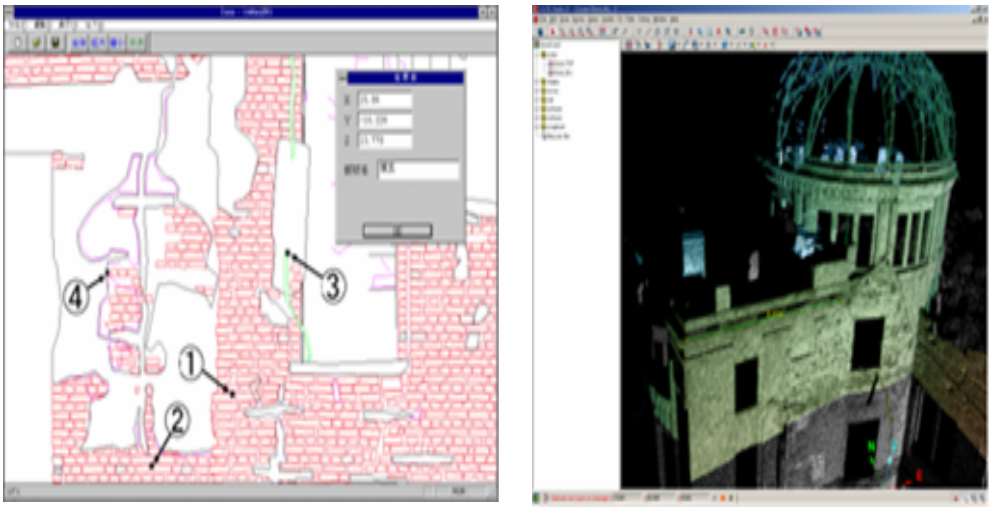

Figure 7: Reappearance of a model

The 3D structural model can be integrated with structural diagnostic and repair history, it enables to evaluate the detailed form from arbitrary viewpoint on a desk without necessary to have a field investigation.

The structural visual information can be grasped 3-D remotely, thus the structural behavior can be detected and the health of the structure can be monitored. Remote real time 3-D visualization-based measurement will contribute to a reliable maintenance management system to raise safety and reliability of a structure.

5. CONCLUDING REMARKS

By combining huge shape information with various drawing information for maintenance purpose, a integrated management system by utilizing 3-dimensional management system has been developed. By using the personal computer, additional information can be inputted easily and three-dimensional visualization can be displayed quickly. Moreover, the system has been applied to the Atomic bomb memorial dome, and the possibility of three-dimensional preservation management was introduced. As the results, conventional two-dimensions maintenance management and repaired condition records can be visualized into three-dimensions, therefore, planning and, technical and economical consideration related to preservation strategy become easier.

The 3-dimensional GIS information management system used in this research can be utilized in many fields as an effective tool for preservation and maintenance management as well as cultural property. By making damage condition and repair history information feed back to a repair plan, a real time 3-D visualization can be performed and a more rational repair plan and construction can be achieved. Especially, this system can be greatly utilizable as a tool of observational construction method and real time structural visualization in the maintenance management society to grasp structural behavior in near future.

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