The use of the BIM-model and scanning in quality assurance of bridge constructions

C. N. Rolfsen, H. Hosamo, A. K. Lassen, D. Han

Department of Civil Engineering and Energy Technology, OsloMet – Oslo Metropolitan University, Norway

C. Ying

Chongqing Smart City and Sustainable Development Academy, Chongqing, China

ABSTRACT: For bridges with complex structures and difficult construction, quality is a real issue. The use of the BIM-model is important to seek good quality in the design of the bridge. Furthermore, the model is important for construction and supervision, but it is undeniable that quality assurance after completion could be a problem. The use of a scanner could ease this problem. The bridge completion state mode is collected by 3D laser scanning technology. The theoretical model is compared with the actual state, so that the concrete bridge member is subjected to three-dimensional digital detection such as dimensional deviation and flatness of the surface of the member.

1 INTRODUCTION

In recent years, with the rapid development of China's economy, traffic flow has increased significantly. Some bridges have greatly exceeded the design flow requirements, and in addition some bridges have construction quality problems. Overload transportation, large traffic flow and other direct reasons result in a serious decline in the technical state of bridges at all levels, some sections of the bridge frequently appear early disease, some bridges even occurred structural damage, this situation not only poses a threat to lives of broad masses of people, but also causes high material losses. Therefore, bridge safety has become a major concern, and the quality of the bridge under construction should be increased. (Ran, 2018).

In the field of engineering, the laser scanner is considered to be the most suitable tool for construction engineering monitoring and construction process control. The BIM model integrates a large amount of data for construction projects, including the location and dimensions of components. Close range photogrammetry is a measurement method to obtain a large amount of physical and geometric information from photos of the measured object in an instant. In this paper, two main routes are combined at the end. The first one is to compare the theoretical BIM model with the measured point cloud model to detect the deviation and determine the location of the deviation. The second route is to collect high-definition photos of components, automatically identify photos with damage, and locate the actual location of photos with damage in the real world, so as to achieve rapid detection of component damage.

Through the defect detection and safety evaluation of concrete bridges, it is of great significance to repair and reinforce the bridges according to the inspection results. In the early stage of the cracks maintenance, reducing the investment in bridge reconstruction and increasing the service life of the bridge is in line with the concept of sustainable development. Facing the need for bridge damage and defect detection in China, it is urgent to develop non-intrusive defect detection technology and devices to improve the level of bridge maintenance and safety guarantees in China.

2 PRINCIPLES AND METHOD

A BIM model is a three-dimensional digital representation which integrates all kinds of relevant information of a construction project (Carvalho; et al., 2019). It is the digital expression of all the geometric, physical and performance information of the building. The BIM model could be combined with a laser scanner to do the quality assurance. The three-dimensional laser scanning technique can also be called " the real-life scenery duplication technique " (Xiujun, 2007). It uses a laser scanner to scan the surface of the object intensively to obtain point cloud data similar to the point cloud modeled by finite element method. The close range photogrammetry technology collects high-definition images of the structure surface through a high-definition camera, and identifies and quantifies structure surface damage through image gray information (Hoang, 2018).

In this study, BIM technology, 3D laser scanning technology and photogrammetry technology are ap-

plied to the quality inspection of construction of completed bridges. Close-range photogrammetry technology is used to detect the appearance defects of components, which are not easy to find, and to accurately identify and locate them, while the BIM model is compared with the actual field model obtained by 3D scanning, so as to detect and evaluate the construction quality of the completed model. The technical route is shown in figure 1.

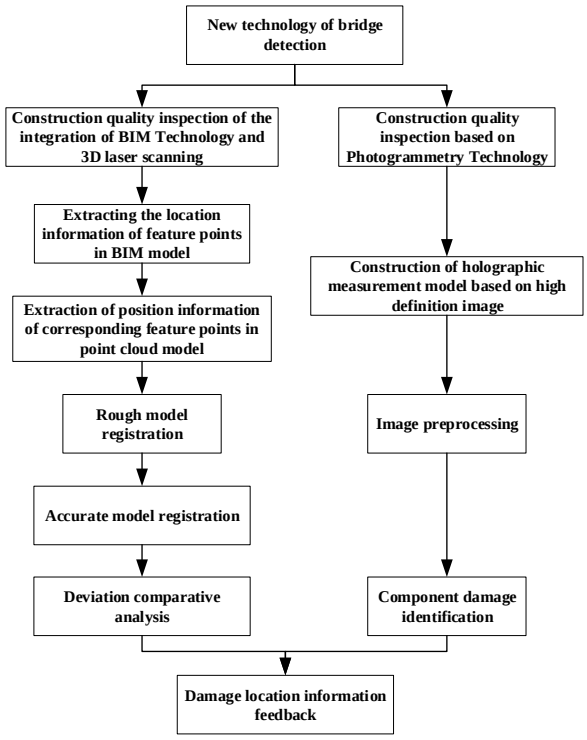

Figure 1. Technical route

3 FUSION OF BIM TECHNOLOGY AND 3D LASER SCANNING FOR QUALITY TESTING

Based on a new bridge project, the technical route is explored and applied, and the construction error of box girder is detected.

Based on BIM technology and 3D scanning technology, the component quality inspection flow is as follows:

3.1 *Extracting feature point position information from BIM model*

By fitting the feature surface, the points intersected by three feature surfaces are taken as the feature points, and the feature points are not less than 3 and the feature points are not coplanar, and the coordinate information of the feature points is extracted for model registration (Shibasaki， et al., 2010)

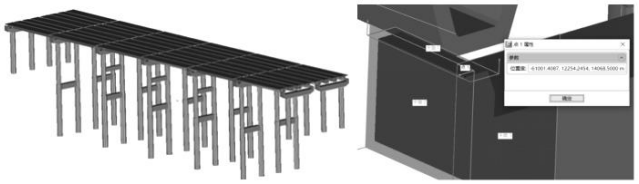

Figure 2. Feature point information extraction

3.2 *Extraction of corresponding feature point position information in point cloud model*

The same method is used to extract the feature point information corresponding to the BIM model in the point cloud model for coordinate transformation (Zhiwei， et al., 2016).

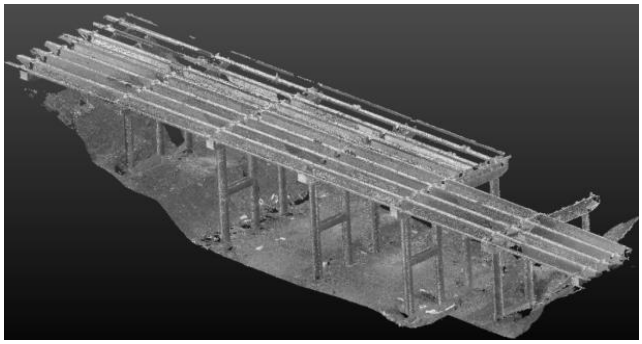

Figure 3. Point Cloud Model

3.3 *Rough registration*

Through the manual registration function, the BIM model is preliminarily aligned with the point cloud model. The common part of the two models is selected and the n-point alignment is adopted to make the two models roughly aligned.

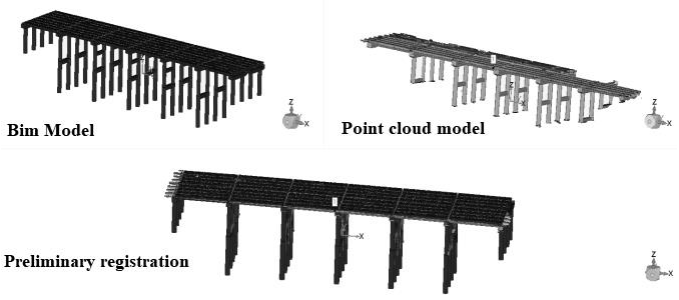

Figure 4. Alignment of BIM Model and Point Cloud Model l

3.4 *Accurate registration*

The feature point information input coordinate matrix, which is optimized iteratively by the algorithm, makes the objective function obtain the optimal value, that is, the deviation is minimized.

3.5 *Deviation comparison*

Taking the fine BIM model as the reference object and the point cloud model as the test object, the deviation chromatogram is generated, the deviation chromatogram is qualitatively analyzed by the deviation chromatogram, the large deviation area is preliminarily determined, and the deviation value is obtained by annotation in the larger deviation area for quantitative analysis, so as to judge the construction quality (Wang, 2015).

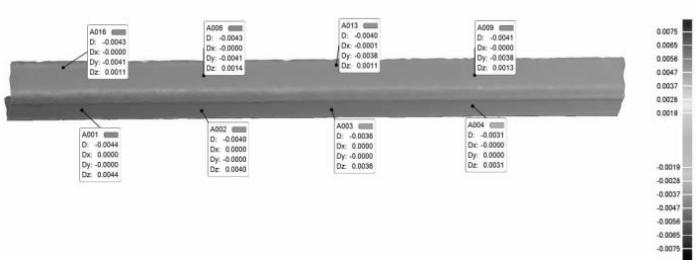

Figure 5. Deviation chromatogram

4 CONSTRUCTION ENGINEERING QUALITY TESTING BASED ON PHOTOGRAMMETRY

The UAV collects the high-definition image as the data source to identify and locate the component damage. The steps are as follows:

4.1 *A holographic photogrammetry model based on HD image photos*

The high-definition image data obtained by UAV tilt photography (unmanned aerial vehicles) are calculated in spatial triangle to obtain the location information of each photo, so as to match the image and obtain the structure real scene model (Zhuo et al., 2017).

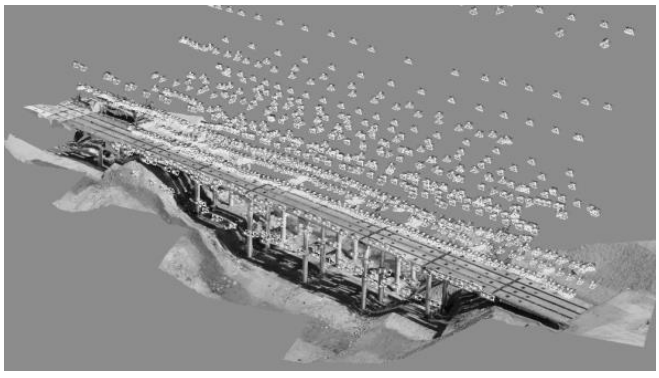

Figure 6. Full-bridge photogrammetry model

4.2 *Image preprocessing*

The concrete surface image collected by the camera is a color image. Although the amount of information in the color image is large, the information in the gray image is enough. In order to improve the operation speed and save the storage space, the collected color image should be converted into the gray image.

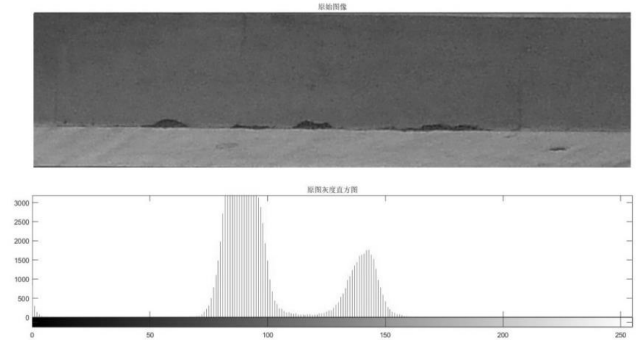

Figure 7. Gray Histogram

4.3 *Component damage identification*

The lattice matrix is used to collect the structural information of the object, update the information and store it as a digital image. The coordinate system of the digital image is established on the image, the image information is recognized according to the time sequence, the damaged area of the image is extracted, the damaged area of the image is denoised by the Gauss function, and the damaged area of the image is denoised by the wavelet decomposition method for the second time. At the same time, the damage orientation of the object structure is calculated (Jiya and Qian, 2017).

4.4 *Damage location information feedback*

Recording the name of the damaged photo and reading the GPS information (including longitude, latitude, and altitude information), so that it is fed back to the holographic measurement model to accurately locate the damage location.

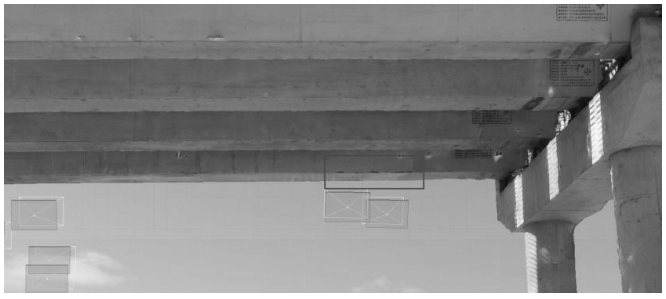

Figure 8. Precise location of damage

5 ANALYSIS AND DISCUSSION

As an information carrier, photos or images contain the greatest amount of information of the measured object. Combined with damage identification by imaging technology, the collected massive photos are identified by images to obtain the surface damage of the structure and conduct qualitative and quantitative

analysis. Close-range photogrammetry technology requires higher lens pixels of the equipment, and the photographing must follow a certain order, which has poor effect on smooth surface and transparent objects.

In the construction stage, the BIM model used in the field management needs to integrate effective technical means as auxiliary. 3D laser scanning technology can record the complex situation of a construction site efficiently and completely, and compare it with the BIM model, which will bring great help to project quality inspection and project acceptance. The combination of 3D laser scanning and BIM model refers to the comparison, transformation and coordination of BIM model and corresponding 3D scanning model, so as to achieve the purpose of assisting engineering quality inspection, rapid modeling and reduced rework. However, the adoption of new technology also increases the cost to a certain extent, but the long-term economic benefits outweigh this.

6 CONCLUSION

This paper shows how the use of realistic capture technology to collect the appearance, geometry, and deformations of the bridge in the completion stage and performance of big data analysis can map the quality state of the bridge in the physical world in real time and ensure the bridge structure safety. Furthermore, this paper shows that the technology has the following advantages:

(1) The holographic BIM model corresponding to the quality state of the bridge in the physical world is established to realize the timely detection and timely adjustment of the construction quality problems of the bridge under the harsh environmental conditions, so as to significantly reduce the construction risk and the construction period and improve the construction quality of the bridge.

(2) Based on background subtraction, an adaptive threshold segmentation method based on gray-scale estimation is proposed to realize the complete extraction of cracks.

(3) The combination of the technologies innovatively integrates 3D scanning, photogrammetry and BIM technology to realize the perception of bridge state depth.

With the further development of 3D laser scanning technology and BIM Technology, their application in project management will be further expanded and deepened.

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