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RESEARCH FOR GENERATING 2D-DRAWINGS OF SUPERSTRUCTURE IN HIGHWAY BRIDGE

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Abstract: Maintenance of highway bridges built during the high economic growth period is performed based on their design drawings and as-built drawings. For these elevated highway bridges, however, drawings were produced on paper media at the times of design and completion; therefore, in many cases they have already been disposed, making it difficult to perform maintenance. In such a case, regenerating the detail design of the current status is required, but it takes huge cost. For this problem, a large number of researches have been made on automatic generation of three-dimensional models for maintenance of highway bridges from point cloud data obtained through MMS (Mobile Mapping System). However, it is hard to use the models generated in these researches because engineers do not consider the original geometric information of highways. Thus in this research, we aim to regenerate the CAD drawings of the superstructure of an elevated highway bridge, and propose a method for extracting alignment information of the elevated highway bridge from point cloud data of MMS. We verify the usability of our method and system by comparing the experimental data with surveyed drawings in our experiments.

1 INTRODUCTION

In Japan, many elevated highway bridges built in the high economic growth period have been worn out. Particularly for elevated highway bridges, it is urgently required to propose effective and feasible maintenance plans to extend their lifetime. Further, to ensure the appropriateness of inspection, repair plans and construction methods, the construction drawings (e.g. design drawings and as-built drawings) need to be provided to correctly understand the current status. However, drawings of many elevated highway bridges constructed during the high economic growth period around the 1970s were produced on paper media. After the lapse of 30 years document retention period(MLT 2010, MLT 2001), many of them have been disposed. In such a case, it is necessary to regenerate the detail drawings of current status. However, the field surveying will be necessary involving road closure, which will result in huge costs. To avoid this, many researches were done to obtain the data of current status without disturbing the traffic flow by using Mobile Mapping System (MMS). These researches, however, were made on automatic generation of 3D models from point cloud data, which were only tailored for visual data processing of the superstructure of an elevated highway bridge, without considering the original alignment information of the elevated highway bridge. Therefore, it is too hard to rely on as the drawing of current status to use for maintenance. Thus in this research, we aim to regenerate two-dimensional (2D) CAD drawings in SXF format(CAD Data Exchange Standards Subcommittee 2005) of the superstructure of an elevated highway bridge, and propose a method for extracting alignment information of the elevated highway bridge from the 3D data, in order to solve the problem of current status.

2 SYSTEM OVERVIEW

This research aims to regenerate the CAD drawings of the superstructure of an elevated highway bridge by performing a proposed method to extract alignment vector information of the superstructure from point cloud data of MMS measuring the elevated highway bridge. System flow is shown in Figure1.

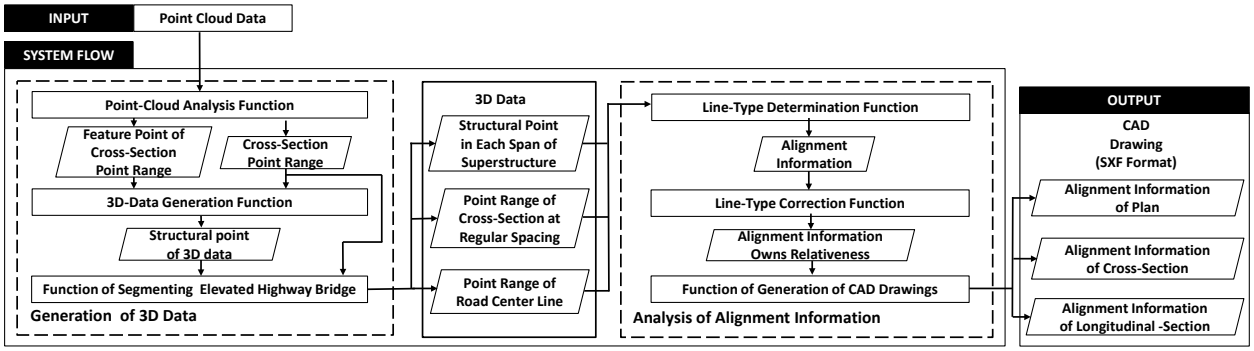

Figure 1: System flow

This system consists of two parts of functions: Generation of 3D data and analysis of alignment information. Firstly, in the generation of 3D data, we analyzed the point cloud data obtained through MMS to get the point range of plan, cross-section and longitudinal-section of elevated highway bridges, which generated the 3D data. Secondly, we extracted the joint of elevated highway bridge to segment superstructure and generate the 3D data which can keep the information in each span of them. Then in the analysis of alignment information, we used the 3D data obtained through the generation part of 3D data to calculate the alignment information through analyzing the point range of plan, cross-section and longitudinal-section, thereby obtaining the required alignment information. On this basis, we considered the association of geometric information of the front and back of the superstructure to correct the alignment information, thereby improving the precision of geometric information. Finally, we calculated the formula parameters of the alignment information in each span of superstructure, with CAD drawings generated.

2.1 Point-Cloud Analysis Function

The high-precision laser scanner carried in MMS can ensure the accuracy of data amount. However, the collected data amount through the laser scanner is too large, making it difficult to analyze via common software. Thus, in this function, we analyzed the feature of point cloud data as shown in Figure 2, to recognize the features of elevated highway bridges, thereby extracting only the useful data for generation of 3D data.

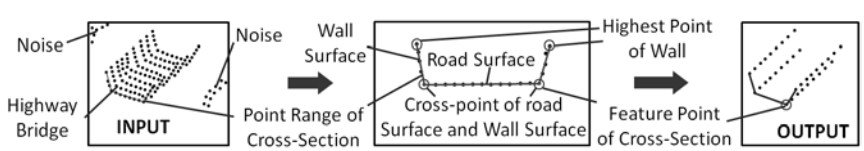

Figure 2: Point-cloud analysis function

2.2 3D-Data Generation Function

As such, we extracted the useful point cloud data through the point-cloud analysis function, and automatically generated 3D data which can be processed by common software. We also extracted the center line to use for maintenance based on 3D current status drawings. In this function, we used the point range and feature points of each cross-section obtained through the point-cloud analysis function as

input data, and output the point range representing the road alignment of the elevated highway bridge and the feature points of the cross-section point range at regular spacing, as shown in Figure 3.

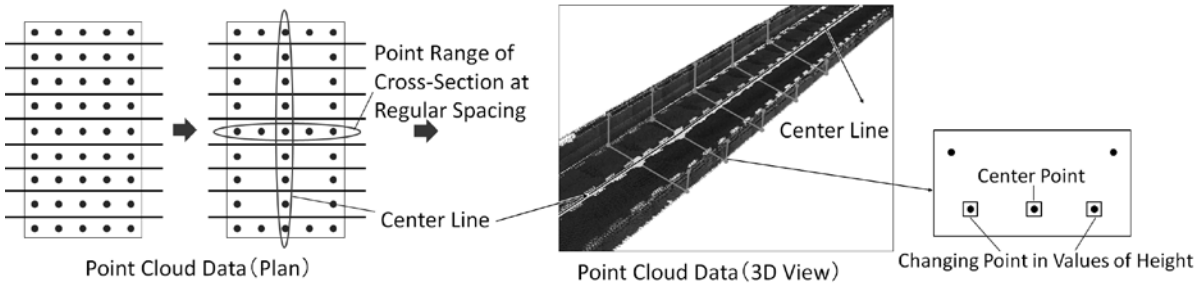

Figure 3: 3D-data generation function

2.3 Function of Segmenting Elevated Highway Bridge

In drafting the construction plan, a design proposal is supposed to be made for each span of the superstructure. In this regard, we segment the 3D data from span to span of the elevated highway bridge, in order to fulfil the design requirement of the construction plan. In this function, we extracted out the joint parts between the spans of superstructure by using colour information. Then we segmented the structural points of 3D data based on the joints, as shown in Figure 4.

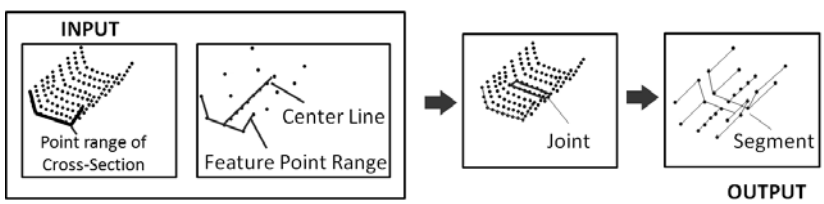

Figure 4: Function of segmenting elevated highway bridge

2.4 Line-Type Determination Function

To extract out the alignment information, it is essential to figure out the line type. In the alignment of road plan, we applied straight lines, arcs and clothoid curves. In addition, we used straight lines and quadratic curves in the vertical alignment. In this function, we chose the joints which were output through the 3D data generation part as the candidate locations of the start and end points of the alignments, and determined the line types of all alignments by performing the method of least squares as shown in Figure 5.

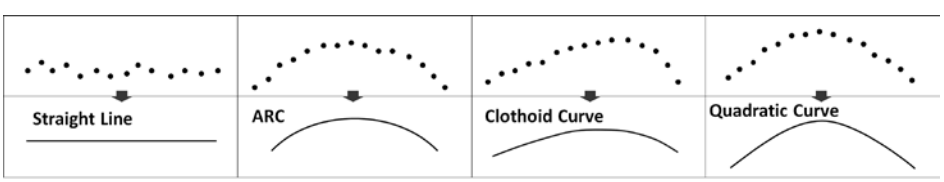

Figure 5: Line-type determination function

2.5 Line-Type Correction Function

When the curvature radius of an arc or a clothoid curve is too long or there are too many abnormal feature points, the line type may be misjudged. In this function, we harnessed the feature of a clothoid curve to link a straight line with an arc for improving the extraction precision of alignment information by correcting the possibly misjudged line type, as shown in Figure 6.

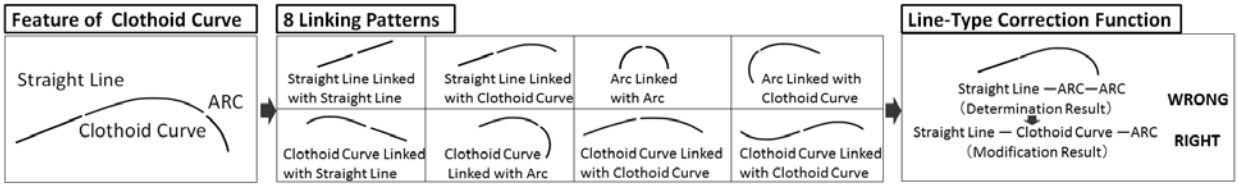

Figure 6: Line-type correction function

2.6 Function of Generation of CAD Drawings

In this function, we calculated the CAD alignment parameters based on the formula of various CAD alignments as shown in Figure 7, and generated CAD drawings. However, we used a cubic Bezier curve to represent a quadratic curve.

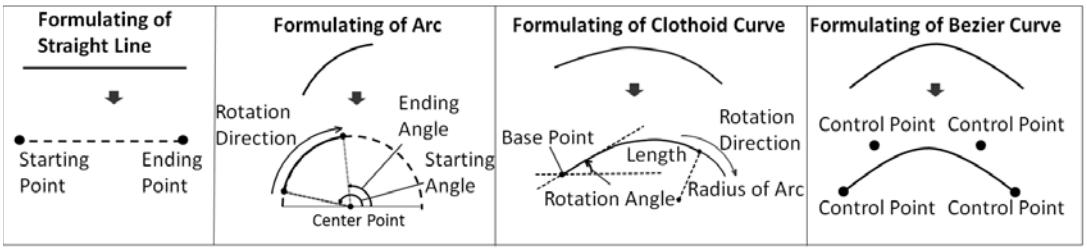

Figure 7: Function of generation of CAD drawings

3 CONCLUSION

In this research, we tried to generate CAD drawings by using the features of 3D data obtained through MMS measurement of elevated highway bridges, as shown in Figure 8. In the future, we will verify the applicability of our method to practical business and aim to improve the precision of alignments so that municipalities in Japan can use CAD drawings generated by applying this method.

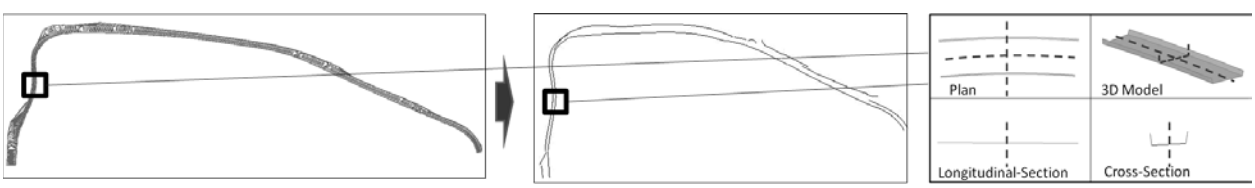

Figure 8: Output image

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