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

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Background (1/3)

Status of highway bridges in Japan

High economic growth period

Number of bridges built over 50 years

(【Source】MLIT.: The current status of bridges in Japan)
Background (2/3)

- Concerning those highway bridges
  - Various damage
  - Effective and feasible maintenance plans

- Corrosion of concrete
  (Source: Metropolitan Expressway Company Limited: Shuto Expressway)

- Gap of bridge joint
  (Source: East Nippon Expressway Company Limited: Sendai Expressway)
Background (3/3)

- To ensure maintenance plans
  - Current status drawings

Maintenance works of Hanshin Expressway

(Source) Hanshin Expressway Company Limited: Construction of fresh-up on Ikeda route
Problems (1/2)

- Document retention period of construction drawings
  - 30 years (About new guidelines of delivery by MLIT.)

- Media of drawings of highway bridges
  - Paper media before 1970’s
  - Electronic delivery began in 2001

- Status of drawings
  - Disposed

The demands of maintenance plan: Regeneration detail drawings
Problems (2/2)

- Concerning regenerating detail drawings
  - Range of maintenance: Over several thousand meter
  - Status of highway bridge: Many vehicles are running on it
- Result of field surveying: Road closure

Problem: Huge Costs

Image of road closure
Previous Research

- To reduce the cost of field surveying
  - Mobile Mapping System (MMS)
  - Generate drawings in a low cost

- Issues of these research
  - Only visual data processing

Problem for maintenance:
No alignment information
Research Object

- Regenerate CAD drawings
  - Extract alignment vector information
  - Use point cloud data of MMS

Actual Structure

Auto-regeneration of 2D-Drawings

Final Object:
Maintain highway bridges
**System Flow (1/7)**

**INPUT**
- Point Cloud Data

**SYSTEM FLOW**

- **Point-Cloud Analysis Function**
  - Feature Point of Cross-Section Point Range
  - Cross-Section Point Range
  - 3D-Data Generation Function
  - Structural point of 3D data
  - Function of Segmenting Elevated Highway Bridge

- **3D Data**
  - Structural Point in Each Span of Superstructure
  - Point Range of Cross-Section at Regular Spacing
  - Point Range of Road Center Line

- **Line-Type Determination Function**
  - Alignment Information
  - Line-Type Correction Function
  - Alignment Information Owns Relativeness

- **Function of Generation of CAD Drawings**
  - Analysis of Alignment Information

**OUTPUT**
- CAD Drawing (SXF Format)
- Alignment Information of Plan
- Alignment Information of Cross-Section
- Alignment Information of Longitudinal Section
System Flow (2/7)

- **Point-Cloud Analysis Function**
  - Noise Reduction
  - Feature Points Extraction

**INPUT**
- Noise
- Highway Bridge
- Point Range of Cross-Section

**Point cloud data (Plan)**
- Feature Points of Cross-Section
- Cross-point of road Surface and Wall Surface
- Highest Point of Wall

**OUTPUT**
- Road Surface
- Wall Surface
- Surface and Wall Surface

**Function of Segmenting Elevated Highway Bridge Generation of 3D Data**

- Point-Cloud Analysis Function
- 3D-Data Generation Function
System Flow (3/7)

3D-Data Generation Function

- Point-Cloud Analysis Function
- 3D-Data Generation Function

Function of Segmenting Elevated Highway Bridge

Generation of 3D Data

- Point Range of cross-section at a regular Spacing
- Center Line
- Center Point

Point Cloud Data (Plan)

Point Cloud Data (3D View)

Changing Point in Values of Height

- Center Line

- Point Cloud Data (Plan)
System Flow(4/7)

Function of Segmenting Elevated Highway Bridge

Segmentation

INPUT

Point range of Cross-Section

Feature Point Range

Center Line

Joint

Segment

OUTPUT
# System Flow (5/7)

- **Line-Type Determination Function**

<table>
<thead>
<tr>
<th>Line-Type Determination Function</th>
<th>Line-Type Correction Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function of Generation of CAD Drawings</strong></td>
<td>Analysis of Alignment Information</td>
</tr>
</tbody>
</table>

- **Not straight line**
- **Not straight line and clothoid curve**
- **Radius of approximate circle is extremely long**
- **Radius of approximate arc of two parts of curve are different**

- **Straight Line**
  - Part 1
  - Part 2

- **ARC**

- **Clothoid Curve**

- **Quadratic Curve**

- **Not straight line**
System Flow (6/7)

- Line-Type Correction Function

8 Linking Patterns

<table>
<thead>
<tr>
<th>Straight Line Linked with Straight Line</th>
<th>Straight Line Linked with Clothoid Curve</th>
<th>Arc Linked with Arc</th>
<th>Arc Linked with Clothoid Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothoid Curve Linked with Straight Line</td>
<td>Clothoid Curve Linked with Arc</td>
<td>Clothoid Curve Linked with Clothoid Curve</td>
<td>Clothoid Curve Linked with Clothoid Curve</td>
</tr>
</tbody>
</table>

Feature of Road Alignment

- Straight Line
- Clothoid Curve
- ARC

Line-Type Correction Function

- Straight Line — ARC — ARC (Determination Result)
- Straight Line — Clothoid Curve — ARC (Modification Result)

Feature of Road Alignment

- Straight Line
- Clothoid Curve
- ARC

Linking Patterns

- Clothoid Curve Linked with Straight Line
- Clothoid Curve Linked with Clothoid Curve
- Clothoid Curve Linked with Clothoid Curve
- Clothoid Curve Linked with Clothoid Curve

Correct Linking Patterns

- Straight Line — Clothoid Curve — ARC
- Clothoid Curve — Clothoid Curve

Wrong Linking Patterns

- Straight Line — ARC — ARC
- Clothoid Curve — Straight Line

Analysis of Alignment Information

- Line-Type Determination Function
- Line-Type Correction Function
- Function of Generation of CAD Drawings
Function of Generation of CAD Drawings

- Formulating of Straight Line
  - Starting Point
  - Ending Point

- Formulating of Arc
  - Rotation Direction
  - Starting Angle
  - Ending Angle
  - Center Point

- Formulating of Clothoid Curve
  - Base Point
  - Starting Angle
  - Length
  - Rotation Angle
  - Radius of Arc

- Formulating of Bezier Curve
  - Control Point
  - Control Point
  - Control Point

For plan and long-wise
For plan
For plan
For long-wise
Experiment and Result (1/3)

Part of Route 1 Loop Route (Osaka)
Experiment and Result (2/3)

Experiment Result

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of evaluation points</td>
<td>168 Points</td>
</tr>
<tr>
<td>Error range less than 10cm</td>
<td>113 Points</td>
</tr>
<tr>
<td>Degree of approximation</td>
<td>67.26%</td>
</tr>
</tbody>
</table>

3D Data

2D CAD Drawing

Plan

Cross-Section

3D Model

Longitudinal-Section
Experiment and Result(3/3)

Area both output drawing and actual surveying drawing exists

Area actual surveying drawing exists

Area output drawing exists
Recent Result

Accuracy: Over 90%
Conclusions

- Generate 2D CAD-Drawing by a method of extracting alignment information
- In the future
  - Improve the precision of alignments
  - Verify the applicability to practical business
- Final purpose
  - Municipalities in Japan can use output drawings of our system to maintain their highway bridges
Thank you for your attention
Evaluation Points and Error Range
Point Cloud Data
Recent Result