RESEARCH ON INFRASTRUCTURE LIFECYCLE MANAGEMENT PLATFORM BASED ON CIM WITH INTERNATIONAL STANDARDS

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1. Introduction

- A framework for data coordination method of maintenance data can give effective solutions to innovate construction production systems.
- We aimed at of BIM concept using IFC through CIM application.
- MLIT and JACIC have been introducing and promoting CIM and BIM for infrastructure in construction and civil engineering fields.
- We don't reach the stage where it can be applied to general public construction because of case study using high price 3D CAD.
- We focus on contributing to perform maintenance using collaborative tool throughout the life cycle of infrastructure model.
- To introduce CIM, we inspected 3D terrain and structural model with precision easily appropriate quickly using "Photog-CAD®".
- We evaluated the complex model of photographing a surveying site, the CIM model based on the collaborative tool of the existing GIS.
1. Introduction

- The progress of the CIM maturity level finished a trial stage and is shifting to the implementation phase of leading.
- We studied a use case in the disaster restoration using TIN model.
- To assist preparation of application material, JACIC has been developing software named Photog-CAD®.
- This function is divided into two, composed of Photogrammetry module and Design and Cost estimation module controlled by CAD.
- The latest digital cameras equipped with GNSS adding QZSS are available, and also GIS engines.
- The latest model can be exported TIN. We take these models in 3D CAD and can perform 3D design, landscape design and simulation.
- That’s why a framework supporting the efficiency and safety of requirements for a quick recovery is regarded as demand from the viewpoint of maintenance.
2. METHOD

2.1 Photogrammetry, Mathematical Model

As an interior orientation model, we apply 5th order radial distortion model.

- Theory of estimating exterior orientation parameters is collinearity condition.
- We could write down mathematical model through geometrical consideration.
- The Derived mathematical model is as follows.

\[
dx = f \frac{a_{11}(X - X_0) + a_{12}(Y - Y_0) + a_{13}(Z - Z_0)}{a_{31}(X - X_0) + a_{32}(Y - Y_0) + a_{33}(Z - Z_0)}
\]

\[
dy = f \frac{a_{21}(X - X_0) + a_{22}(Y - Y_0) + a_{23}(Z - Z_0)}{a_{31}(X - X_0) + a_{32}(Y - Y_0) + a_{33}(Z - Z_0)}
\]

where

\[
\begin{pmatrix}
a_{11}, a_{12}, a_{13} \\
a_{21}, a_{22}, a_{23} \\
a_{31}, a_{32}, a_{33}
\end{pmatrix} = R_x(\omega)R_y(\kappa)R_z(\phi)
\]

\[
R_x(\omega) = \begin{pmatrix} 1, & 0, & 0 \\ 0, & \cos(\omega), & \sin(\omega) \\ 0, & -\sin(\omega), & \cos(\omega) \end{pmatrix}
\]

\[
R_y(\kappa) = \begin{pmatrix} \cos(\kappa), & 0, & -\sin(\kappa) \\ 0, & 1, & 0 \\ \sin(\kappa), & 0, & \cos(\kappa) \end{pmatrix}
\]

\[
R_z(\phi) = \begin{pmatrix} \cos(\phi), & \sin(\phi), & 0 \\ -\sin(\phi), & \cos(\phi), & 0 \\ 0, & 0, & 1 \end{pmatrix}
\]

\[
d = k_1 r^3 + k_2 r^5
\]
2.2 Increasing Accuracy in A Field Practice

- Photog-CAD® was named based on Digital Photogrammetry & CAD.
- Disaster recovery support system based Photogrammetric techniques.

Photog-CAD’s Characteristics:
- Safety
- Effectiveness
- Many workers

Efficient photogrammetric survey:
- Using Photog-CAD
  - Safe work
  - Labor saving
  - Time shortening

Photographs from 3 direction:
- Left
- Front
- Right
2.2 Increasing Accuracy in A Field Practice

Orientation processing
- Magnification display Method
- Acquisition the reference point and the corresponding point

3D model

Design QTO Work

Cross section

Cost estimation documentation

Photog-CAD®
2.3 Calculation Module For Designing

- We design restoration work when data of cross sections are exported.
- The CAD module can refer built in database of standard work items and unit price of them for each prefecture.
- When we apply standard work items, we can simply select one from the pull down menu, unit price and CAD parts are set automatically.
- Once new items are registered, they can be used repeatedly on the PC.

Design of the slope restoration work, Development of the retaining wall
2.3 Calculation Module For Designing

- We researched the Annotated model in consideration of the difference with 3D CAD drawings and 2D CAD drawings in representation such as dimension line about public works structure.

Explicit statement to order products properties such as dimensions, clearance or the geometry clearance.
3. RESULTS (Case Studies)
3.1 Case 1. Steep and vertically long slope

The idea of DSM acquired by Photog-CAD®, each case study contains DSM and typical cross section.

- This site is a steep slope where soil slid down after heavy rain.
  Height of the slope is about 17 meters above the road.
- This is the case using Photog-CAD® helps surveyors avoiding accidents.
3. RESULTS (Case Studies)

3.2 Case 2. Taken Picture from oblique direction

- This site is terraced paddy field. We took pictures looking up from the left direction toward damaged paddy.
- The vertical rod at the left end and target define X-axis are located so that we take pictures from the front direction to X-axis. With this, we can estimate proper cross section.

Terraced paddy from left side direction
3. RESULTS (Case Studies)
3.2 Case 3. Taken Picture in downward direction

- This site is a revetment of a steep river.
- We were forced to take photos downward from the other side of the river.
- We used not only targets but also remaining structure corners as natural target.

Other side of river from downward direction
3. RESULTS (Case Studies)

3.2 Case 4. Cultural Property

- This is the retaining wall of river revetment were piled flatly or in the form of a valley, and is not a damaged site.
- We can acquire shape of the structure of a cultural property. Modeling is with a mouse.
- We used not only targets but also corners of remaining structure, root of trees, and so on as natural target.
3. Results

The plan of the JACIC managed Cloud Service Model included various services on the construction sector. These models were structured using standards such as IFC to exchange classifying objects model.
4. Discussion

We acquired 3D terrain model data from 3 pieces of photographs by such as UAV. This is because it divides the area with the number of the wide setting that obeyed LOD and LOP automatically.
4. Discussion

- CIM model should be formulated throughout the whole infrastructure life cycle, enabling IPD, simulation, design optimization and improved efficiency based on CPPM in advanced projects.
4. Discussion

- We can acquire TIN of the structure using a digicame with Photog-CAD®.
- Project domains are pushed forward in buildingSMART International as BIM for Infrastructure, and it is necessary to suggest the property set of the model at the time of the disaster in reference to the CIM structure.

CIM, CIIM for photogrammetric surveying Image
5. Conclusion

- We explored VE structure based on CIM infrastructure model. It is effective to classify as the small model with the topography model. We become able to extract a template related CIM model from leveraging CIM based Database.
- Overall Architecture of the life cycle model including the disaster restoration on small-scale area and short-term lifecycle is as follows.
6. FUTURE STUDY THEME

- Experiment environment can be established in VE evaluation place.
- Surveying and monitoring on LIM can be to survey for Big Data.
- We would create CIM DB to promote innovation in VE on ILM.
Thank You very much for your kind Attention.

Tokyo Gate Bridge, Tokyo's newest landmark, the 'Dinosaur' Bridge
This Photograph was taken by Nobuyuki SUZUKI, Professor at Toyo University