QUALITY SPECIFICATIONS FOR ROADWAY BRIDGES,
STANDARDIZATION AT A EUROPEAN LEVEL

Scientific Report on Short Term Scientific Mission

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1. AIMS AND OBJECTIVES

The ultimate aim of this work is to make 3D digital model of bridges for the purpose of the Bridge Management Systems.

Currently, inspection process involves periodical visual inspection conducted by the experienced engineers–inspectors to estimate physical and functional states of a bridge. The inspectors follow the predefined standards and manuals to estimate the defects on the structure producing descriptive reports. So, current approach requires long time and needless costs, besides it relies on a subjective human assessment what is variable factor. In the other hand, there is occurring new Machine Vision Techniques which provide information from imagines using computational methods. Machine Vision Techniques provide reduction of time and costs, as well as better quality of the results because of absence of changeable human judgment.

The purpose of 3D digital bridge model is to be provided by a model of damages to predict future behavior and in a more efficient way to assess necessity for repairs of bridges in Bridge Management Systems. But, only semantically rich BIM model of a bridge can be provided by damages. In this purpose, the work conducted during this Short Term Scientific Mission (STSM) carries out review of current research at the Technion and defines guidelines for some extentions. According to this, it is more efficient to assess necessity for repairs of bridges in Bridge Management Systems.

2. WORK CARRIED OUT

The work conducted with colleagues in the Technion dealt with my introduction to results from their research project and the establishing frameworks for future extension of the research in making the semantic rich BIM model of a bridge.

The research work which is conducted at the Technion, involved in the Infravation – research project, comprises semantic enrichment of bridge information models (named Seebridge – semantic enrichment engine). The Seebridge team has developed a system which parses the IFC file of a BIM model to infer additional facts and add them to the model, system uses sets of rules compiled in advance.

Here, initial IFC file is achieved by another part of the Infravation at Georgia Tech, where they perform a capturing of the state of a bridge by remote sensing technologies. Afterwards, it is performed the recognition of the bridge components from the point cloud data which provide a 3D geometry model. Therefore, the content of IFC file is set of general IFC elements.

Previously, at the Technion is composed Information Delivery Manual (IDM). In this document, it is defined the process of bridge inspection and the information needed to describe a bridge, its parts, the relationships between them, the defects and their association to the bridge parts, and the metadata concerning the inspections themselves.

Aforementioned rules are defined by experts in the domain of interest and implemented into programming codes which composes a rigorous and robust method. The rule sets provide:

- Classification of the objects in the input model according to the bridge component types defined in the Information Delivery Manual (IDM).
- Instantiation of abstract bridge objects such as axes, spans and systems.
- Numbering of bridge objects according to the IDM specification for the purpose of unique identification of components for inspection and maintenance.
- Aggregation of bridge objects to systems and spans.
- Instantiation of missing objects and correction of objects' geometry. The need for these functions arises from the fact that some objects are wholly or partially absent from the input information, due either to occlusions in the laser scan or errors in the 3D reconstruction.

In the course, in the SeeBridge project several aspects are emphasized for the conversion process Scan to BIM. They are:

- Classification
- Instantiation of abstract objects
- Numbering/identification
- Aggregation
- Geometry corrections
- Instantiation of missing objects

The output of this process is a semantically rich BIM model.

It should be noted that in this research the bridge components are recognized by rule based method and the intention is to conduct the recognition process using techniques of machine learning. It is expected that this approach can provide the optimization of the recognition process for specific bridge elements and it will help in elimination issues with occlusions in the laser scan.

3. MAIN RESULTS

In the aim of conduction of recognition process using techniques of machine learning, it is defined:

- list of targeted components of a bridge and
    - it is collected tables of cross sections which are specific for Israelian, US and Serbian construction practice
- techniques of machine learning which are planned for this approach

For purpose of this task, it is defined to use 3D geometry model which is composed of the planes. This model arises from the point cloud data of a bridge using appropriate software tools.

The recognition of components is based on mutual connections of the planes, the orientation of a plane in the model space and dimensions of a plane. Using appropriate technique (neural networks are defined for the first phase) it is possible to identify a group of planes which belongs to the specific component of a bridge. The identified groups could be classified according to pre-defined lists of components and their cross-sections.

4. FUTURE COLLABORATION

Future collaboration is based on extension of the semantic enrichment using new techniques in the aim of the achievement of a precise BIM model for a bridge. Further, the target of future collaboration is a conduction of successful methods of the semantic enrichment on another bridge types to create BIM model of different bridge types.

All collaboration is planed through together research papers.

5. FORESEEN PUBLICATIONS/ARTICLES

In according to aforementioned defined extension of the research by the implementation new methods in recognition process. It is planned two publications.

- The first publication of together interest is comparison of the results of the implemented methods in the recognition process for bridge components and in the recognition process of rooms in a building. This work is in accordance with the research of colleagues from the Technion whose research field is focused on the BIM models for the buildings too. A part of a implementation of machine learning in a room classification of the BIM model for buildings is already conducted at the Technion.
- The second planed publication is in the aim to indentify the method of machine learning which together with rule-based principle provide the best results in classification of the specific bridge.

6. REFERENCES

[1] SeeBridge Information Delivery Manual (IDM) for Next Generation Bridge Inspection; R. Sacksa, A. Kedarb, A. Borrmannc, L. Mad, D. Singere and U. Kattelf; *33rd International Symposium on Automation and Robotics in Construction (ISARC 2016)*

[2] Automated Compilation of Semantically Rich BIM Models of Bridges– Information Delivery Manual; http://www.infravation.net/projects/SEEBRIDGE

[3] Rule-sets for semantic enrichment of bridge information models; http://www.infravation.net/projects/SEEBRIDGE

[4] Semantic Enrichment for Building Information Modeling; M.l Belsky, R. Sacks and I. Brilakis; *Computer-Aided Civil and Infrastructure Engineering 31 (2016) 261–274*

[5] Detection of walls, floors and ceilings in point cloud data; I. ANAGNOSTOPOULOS, V.PATRAUCEAN, I. BRILAKIS, P. VELA

[6] Integrated Imaging and Vision Techniques for Industrial Inspection; Z. Liu, H. U. P. Ramuhalli, K. Niel (2015)

[7] Machine Vision Techniques for Condition Assessment of Civil Infrastructure; C. Koch, Z. Zhu, S. G. Paal and I. Brilakis (2015)

[8] SeeBridge Information Delivery Manual (IDM) for Next Generation Bridge Inspection; R. Sacksa, A. Kedarb, A. Borrmannc, L. Mad, D. Singere and U. Kattelf; *33rd International Symposium on Automation and Robotics in Construction (ISARC 2016)*

7. ANNEXES

7.1. CONFIRMATION BY THE HOST INSTITUTION ON THE SUCESSFUL EXECUTION OF THE STSM

STSM Applicant (first name and last name): Marija Petronijevic

Home Institution: Faculty of Civil Engineering, University of Belgrade, Serbia

Host Institution: Technion – Faculty of Civil and Environmental Engineering, Israel

I hereby confirm that Ms Marija Petronijevic successfully performed above described work in our lab at Technion in February 2017, with total duration of 20 days, within the framework of the TU1406 Short-Term Scientific Mission (STSM) programme.

It was mutual benefit for the applicant and our group, in consideration of both performed activities and the expected strengthening of cooperation between the Home and Host institutions.

06.04.2017, Haifa

Yours sincerely,

Assoc. Prof. Rafael Sacks

Signature:

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