

Indexing Sectioned BIM Models for Mapping Crack with BIM 3D Model

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Abstract

In Current artificial structures, we must periodically make their safety inspections. In this process, we should consider the safety of workers and the accuracy of safety checks and also consider time and cost savings for safety inspections. Additionally, in the fields of architecture and civil engineering, we are unavoidable the use of foreign commercialized BIM model tools. To address these challenges, we propose mapping crack areas and BIM 3D design drawings based on augmented reality (AR) for the safety inspection of Huge Bridges. For this purpose, we define indexing of 2D/3D drawing models, create the tabulation of all 2D/3D drawings into a database, analyze QR codes, and finally integrate with augmented reality devices. we may expect our method to improve the efficiency of safety inspections on bridge sites. Moreover, we will enable the domestics of our pure technology.

Keywords: Augmented Reality (AR), Safety Inspection, Building Information Modeling (BIM), QR code, Mapping Technique.

1. Introduction

Currently, safety inspections of artificial facilities are essential. The current safety inspection method involves workers visually inspecting hazardous areas and manually recording inspection data [1]. This method cannot guarantee the safety of workers and the accuracy of data. Furthermore, managers cannot quickly identify and respond to issues occurring on-site. To address these limitations, we propose the development of a safety inspection application using augmented reality (AR) technology and the indexing of 2D drawings [2]. In this paper, we suggest the case of indexing 3D models for mapping Building Information Model (BIM) 3D design drawings. This enables more accurate issue identification and data input [3].

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2. Related Works

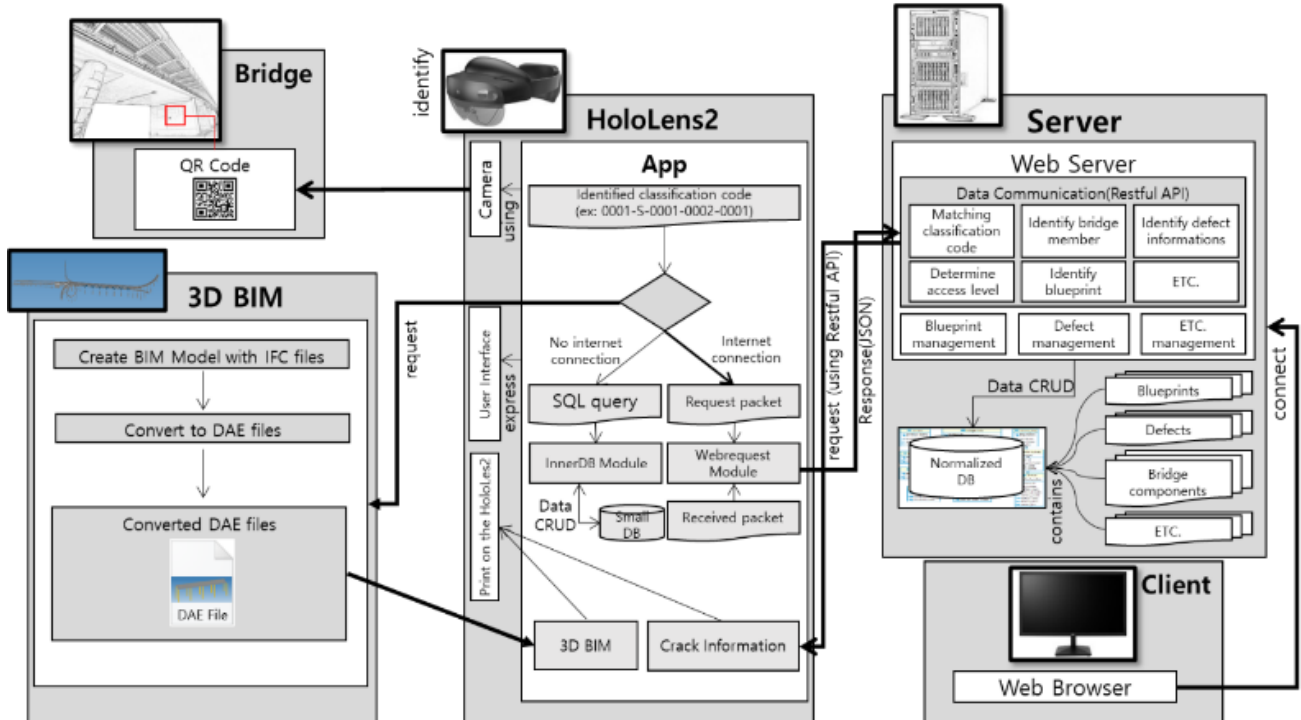


Figure 1. Whole Process

Figure 1 illustrates the overall process of the research. We developed an augmented reality application by indexing 2D design drawings and applied the indexing of 3D models to the augmented reality application [4]

2.1. Classification Code’s Definition and DB Table Normalization

| Classification Code Format | | | |
|---|---------|----------------------------|---|
| [Section Number]-[Spot code]-[Spot classification Number]-[Building components type unique Number]-[Building components type classification Number] | | | |
| Classification code | Section | Design name | File path |
| 0001-S-0001-0002-0001 | B | Bottom plate (Upper) bar 1 | 01. B spot\1. B spot Bottom plate upper \Bspot Bottom plate upper bar 1.dwg |
| 0001-S-0002-0002-0001 | B | Bottom plate (Upper) bar 2 | 01. B spot\1. B spot Bottom plate upper \Bspot Bottom plate upper bar 2.dwg |
| 0001-S-0003-0002-0001 | B | Bottom plate (Upper) bar 3 | 01. B spot\1. B spot Bottom plate upper \Bspot Bottom plate upper bar 3.dwg |
| ... | .. | ... | ... |

Figure 2. Classification Code Format

Figure 2 depicts the format and sequence defining the classification code for bridges. Figure 3 represents the classification codes generated according to this format. The classification codes are defined for bridge sections, spots, and components, dividing them into sections, spots, and components, respectively.

Within a section or spot, there can be multiple spots or components. To classify the same spot or component, unique identification numbers are defined for spots and components [5].

To manage bridge drawings and crack conditions, we redesign the E-R Schema of a database (DB). Figure 3 illustrates the designed DB tables. We indexed the 2D design drawings of the bridge, and stored them in the DB [6]. Using an AR device, we identify the indexing information from QR code information, then retrieve crack information from the DB tables based on this index information. On the AR device, we can add, modify, and delete crack information. We perform CRUD operations on crack information in the DB through a web API[7]. This method enables both indexing of 2D and 3D drawings and effective management of crack information [8].

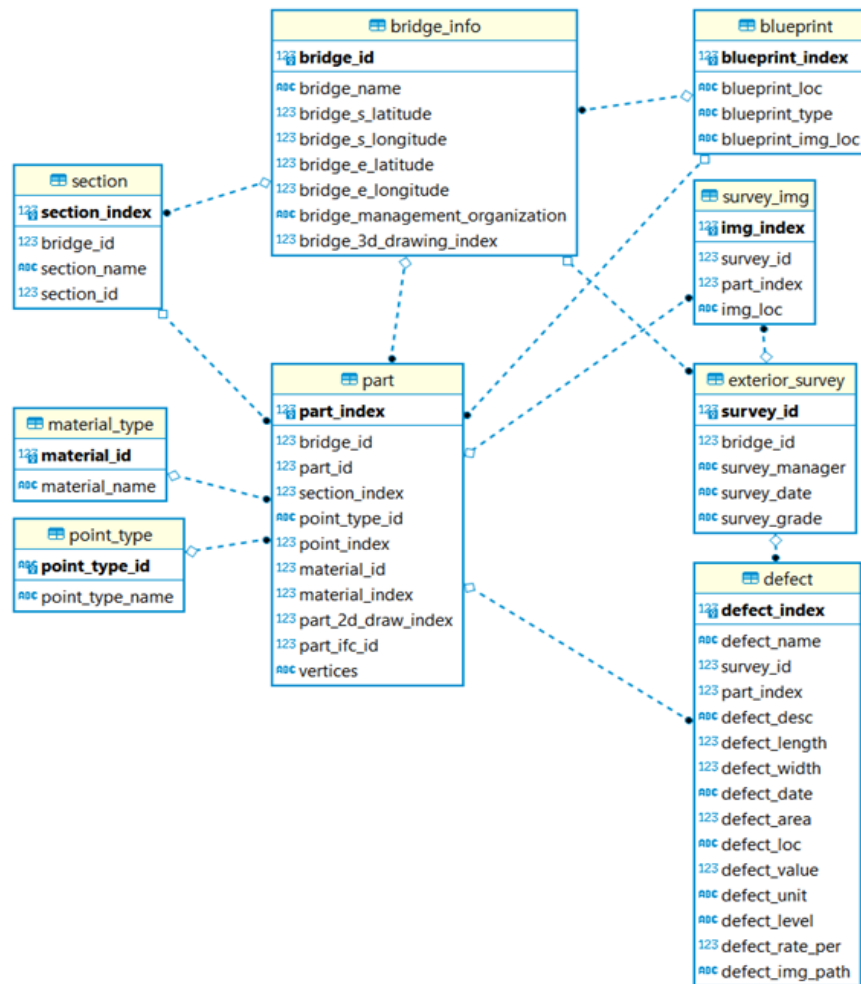


Figure 3. Normalized Database Table

2.2. QR Code Tracking Application

The QR code contains the classification code information defined in 2.1. Through QR code recognition, it is possible to map the classification code with the DB designed in 2.2 and then retrieve crack information stored in the database.



Figure 4. QR Code Tracking Application

Figure 4 is a QR code recognition application operating on an AR device developed with Unity. Through the mapping of the classification code designed in 2.1 with the database (DB), it is possible to index 2D drawings in Drawing Database File(DWG) format, and map them to augmented reality.

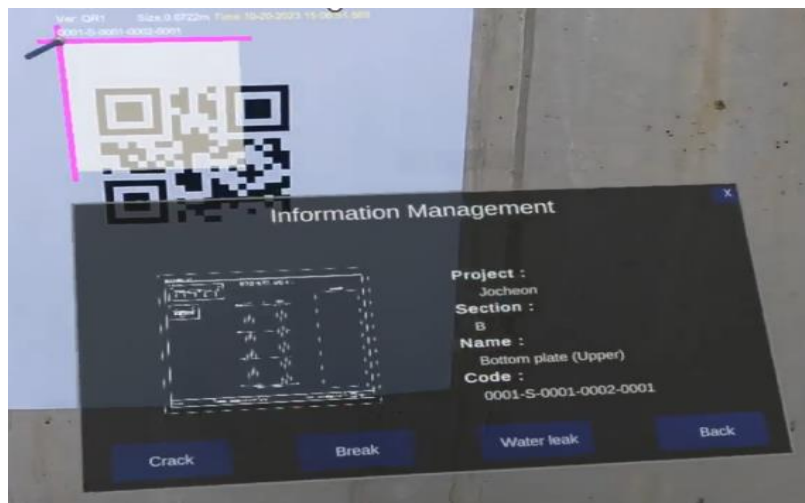


Figure 5. 2D drawing and bridge crack information printed on AR device through QR Code Tracking

Figure 5 depicts the output on the AR device of the indexed 2D drawing and crack information through QR code recognition [9].

3. Indexing BIM 3D Model

BIM 3D models are saved in the IFC file format. To index BIM 3D models for augmented reality, integration with augmented reality development tools such as Unity is necessary. However, IFC files are not directly compatible with Unity, posing a challenge. To address this issue, the following research was conducted.

3.1. Mapping Using Trimble Connect

Figure 6 depicts the output of a BIM 3D model on an AR device using the Trimble Connect tool, which can be integrated with the AR device independent of Unity. When you upload an IFC file to Trimble Connect, it

is stored on the Trimble server. By running the Trimble Connect tool on the AR device, you can load and display BIM 3D models.

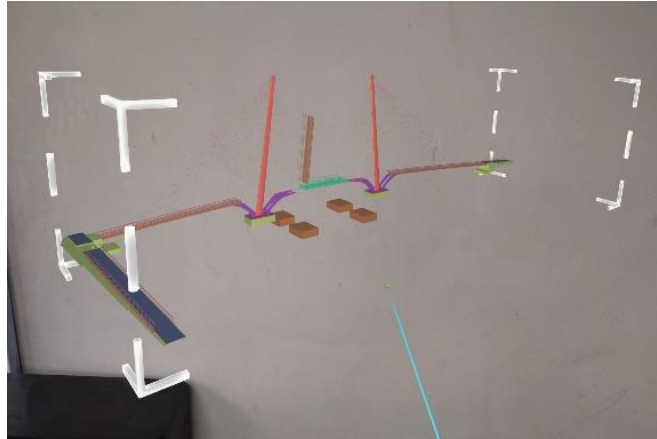


Figure 6. Bim 3D Model printed on AR Device through Trimble Connect

3.2. Mapping Using IFC Converter

Using the IFC Converter, we convert the 3D model into a format compatible with Unity and map it accordingly. The model is converted to the OBJ (Object) file format, which is compatible with Unity, and then uploaded to Unity. The uploaded BIM 3D model in OBJ format allows for indexing and can be used without the need for additional tools. However, when converting to the OBJ format, detailed component information of the bridge present in the IFC file is consolidated into a single object. In other words, many component details are merged, making the designed IFC file a single object, and modifications or additions to information become impossible. To address this limitation, we convert the file format to DAE (Digital Asset Exchange) instead of OBJ.

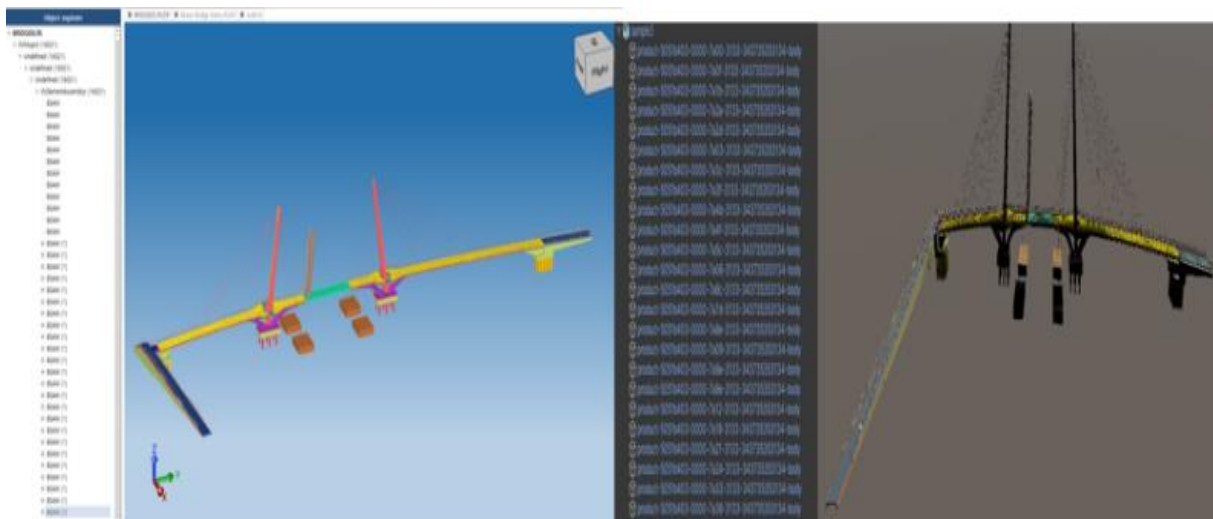


Figure 7. IFC File and Converted DAE File

Figure 7 shows the IFC file viewed through the IFC Viewer and the converted DAE file viewed in Unity.

While the component names in the listed component information have been changed, the detailed content remains intact, and integration is possible.

3.3. Indexing the Sectioned BIM 3D Models

Since the IFC file format is primarily an export format, it is inherently created to be unmodifiable. Although modifications are possible by duplicating and recreating component information using an IFC Editor, the use of IFC Editor tools often incurs significant costs. However, when you convert the file to DAE format and upload it to Unity, multiple component details are automatically transformed into Prefab an editable object format in Unity. By modifying the automatically converted Prefabs, indexing of the 3D model becomes possible. One can create multiple component Prefabs into a single Prefab, allowing the generation of 3D models for multiple spots and sections.

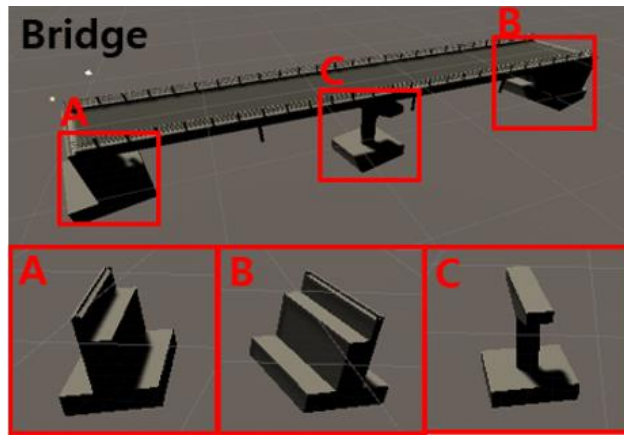


Figure 8. BIM 3D Model indexed

Figure 8 shows the BIM 3D model created in Unity by selecting and creating a new Prefab from multiple Prefab component details that you wish to modify in Unity.

| Classification Code Format | |
|--|-------------------------|
| [3D]-[Section Number]-[Spot Code]-[Spot classification Number]-[Building components type unique Number]-[Building components type classification Number] | ➔ |
| A | 3-0001-S-0001-0002-0001 |
| B | 3-0001-S-0002-0002-0001 |
| C | 3-0001-S-0003-0002-0001 |

| Classification Code | Section | Design name | File path |
|-------------------------|---------|----------------------------|---|
| 3-0001-S-0001-0002-0001 | B | Bottom plate (Upper) bar 1 | 01 . B spot\1. B spot Bottom plate upper\Bspot Bottom plate upper bar 1.dae |
| 3-0001-S-0002-0002-0001 | B | Bottom plate (Upper) bar 2 | 01 . B spot\1. B spot Bottom plate upper\Bspot Bottom plate upper bar 2.dae |
| 3-0001-S-0003-0002-0001 | B | Bottom plate (Upper) bar 3 | 01 . B spot\1. B spot Bottom plate upper\Bspot Bottom plate upper bar 3.dae |
| | | | |

Figure 9. Classification Code format for BIM 3D Model

Figure 9 illustrates an example depicting the classification code format for BIM 3D models. The classification codes for existing 2D drawings are defined without considering their conversion to 3D. To

represent the flag that denotes a 3D model, a '3' is prefixed to the existing classification code, and the table is redefined with this new classification code. The newly defined classification codes are then mapped to the 3D files.

4. Case Study

Markers are generated on top of the QR code to distinguish between multiple QR codes. The output panel displays indexed 2D drawings, crack photos, and crack information. Additionally, an indexed BIM 3D model is displayed in the output panel. All information is editable and allows for modifications and additions.

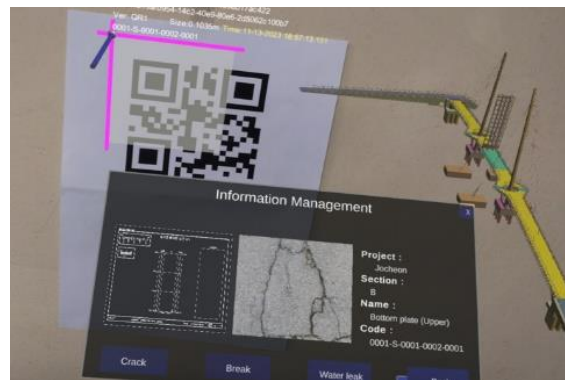


Figure 10. Crack Information and BIM 3D Model printed on AR Device

Figure 10 depicts an image retrieved from the database through QR code recognition. The displayed BIM 3D model can utilize Unity's motion recognition features for functionalities such as movement, zooming, scaling, rotation, etc., using object manipulation capabilities.



Figure 11. Left and Right Rotation/Extension of a BIM 3D Model on AD Display

Figure 11 illustrates the use of a hand tap within an application equipped with motion recognition features to zoom in on the BIM 3D model. Through such functionality, detailed information about the bridge represented by the BIM 3D model can be visualized, providing accurate data.

4. Conclusion

We suggest indexing 3D models for mapping augmented reality-based bridge crack areas and BIM 3D

design drawings. Similar to the indexing of 2D design drawings, indexing of 3D models is achievable by converting BIM 3D models in the IFC file format to DAE files. Mapping BIM 3D design drawings allows for more accurate information retrieval and modification. Moreover, acquiring pure technology without relying on foreign commercialization tools enables the possibility of localization. Using augmented reality technology on-site, it is possible to safely and accurately verify bridge information, allowing the immediate maintenance decision for operations managers through a comparison of BIM 3D design drawings and crack analysis[9].

We anticipate the ability to conduct safety inspections and maintenance on-site using AR devices tailored to the site conditions in the safety inspection field.

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