Lightweight display of bridge model based on WebGL Technology

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Abstract. For the inconvenience of BIM model display, remote browsing and remote interaction of bridge engineering, this paper achieves lightweight display, information browsing and user interaction of the BIM model Web page of Shichuan River Bridge based on BIMFACE secondary development platform. The lightweight display of bridge BIM model is realized by creating three-dimensional model, model format conversion, loading display model, calling function to achieve interaction function, etc. The result shows that this method can well realize lightweight display and interactive function of three-dimensional model Web page. Model lightweight display improves BIM model utilization efficiency and facilitates project management by project participants. In addition, it can be further developed for collaborative management and virtual reality of bridge projects.

1. Introduction

With the increasing research results and applications of BIM Technology in bridge field, BIM exists in every link of bridge life cycle. At present, the application research of BIM Technology mainly focuses on construction simulation[1-4], collision check[5-8], engineering calculation, intelligent drawing[9] and calculation model conversion[10-14].

After the BIM model is established, it needs convenient display and efficient use. The lightweight display of BIM model on Web can make BIM model free from the limitation of computer software and hardware. The model can be directly displayed on mobile phones, tablets and other mobile terminals through Web pages. Each participant can obtain the model information through Web browsing. In recent years, with the development of Web3D technology, spatial models can be displayed on Web pages. Unlike VRML technology[15], unity3d[16] and other software to achieve 3D model Web display, WebGL does not need to install the corresponding rendering plug-in. It can save the development time of non-computer professional engineers. Based on the bridge space model and the secondary development platform of BIMFACE, this paper establishes an intuitive and user-friendly lightweight display of bridge engineering. This paper provides a new idea for the use of BIM model of bridge.

2. Realization and method of WebGL Technology

2.1. Introduction to WebGL technology
WebGL is a 3D drawing protocol. By adding a JavaScript binding of OpenGL es 2.0, it realizes the functions of 3D rendering and visualization of Web pages. WebGL calls computer graphics card to speed up the loading and display of 3D model on browser. WebGL directly uses HTML script to realize 3D interaction based on Web, which saves the use of Web page rendering plug-in. WebGL is very suitable for the development of Web page system based on bridge BIM model.

2.2. Implementation method

This paper uses the secondary development platform of BIMFACE of Guanglianda company. BIMFACE is based on JavaScript language and WebGL technology to realize Web lightweight display of BIM model. Its core feature is to support automatic conversion of multiple file formats in the cloud, retain the original information of the model completely and display the model lightweight. It can help engineers to carry out the secondary development of BIM application and make BIM model open directly on browser, mobile phone, tablet and other devices.

2.2.1. Model upload and conversion.

Before the lightweight display of BIM model, some preparatory work should be done. Firstly, the model source file is uploaded to the platform. BIMFACE server supports various mainstream BIM model data formats, such as RVT, DGN, IFC, RFA, NAD, 3DS, SKP, OBJ, DAC, PLY, etc. After uploading the model, the initiator file is converted to get ViewToken. ViewToken is the temporary ID of the project file invoked and displayed by the JavaScript component interface. It is used to load and browse specified models on the front end. Figure 1 shows the operation flow.

![Pre-preparation workflow](image)

Figure 1. Pre-preparation workflow

2.2.2. Loading and displaying model.

After preparing for ViewToken in advance, the model is loaded and displayed by referencing JSSDK (Software Development Kit for BIMFACE Platform) of BIMFACE. The implementation process is shown in figure 2. At first step, a new HTML file was created and opened in the browser. The project name can be written in the title tab. The relevant codes are seen in appendix.

![Loading and displaying model process](image)

Figure 2. Loading and displaying model process

After the HTML Web page is created, a new DOM element is created in the body tag to display the model or drawing. Viewer3d and app objects within the script tag are created. The relevant codes are seen in appendix.

The Viewtoken obtained in the preparation phase is used as an identifier to set the parameters of the BIMFACE SDK loader, which can call the loader to display the specified model in the Web page. The relevant codes are seen in appendix.

If the loading is successful, the successful callback function is executed; otherwise, the failed callback function is executed. The successful callback function mainly includes taking DOM element as the configuration parameter of Web application, creating Web application and adding the model to be displayed. The relevant codes are seen in appendix.
3. Bridge Model Display Based on WebGL

3.1. Establishment and import of model
The information in 3D model of bridge is complicated. The best way to handle this problem is to set up the model and detailed information in the modeling software. Then the model is exported to a model file supported by the BIMFACE platform. This platform will convert the model to a kind of file format which can be displayed and redeveloped. This paper uses the Revit software as the modeling tool and adopts the parametric modeling method. The established model format is saved as RVT format. The modeling process is shown in figure 3.

The model is divided according to the type of bridge components. Each sub model of the model is determined. Revit parametric modeling is used to develop component models which constitute component libraries. These libraries will assemble an overall model.

![Modelling process](image)

3.2. User interaction
The BIMFACE platform can be redeveloped according to the actual needs of the project, such as path roaming, loading multiple models, isolating components, component coloring, customizing model perspectives, and so on. The following describes how to develop the function through the implementation of component isolation function. The implementation process is shown in figure 4.

![Implementation process of user interaction function](image)

3.2.1. Creating button. A button is added in the page to control the isolation and de-isolation of components. The relevant codes are seen in appendix.

3.2.2. Defining Button Style. After creating a button, the button style needs to be defined, including page spacing, button length and width, button color, font color, etc. The relevant codes are seen in appendix.

3.2.3. Defining component function. After the button is created and the style is defined, calling BIMFACE JSAPI defines the component isolation function. In addition, an additional functional recovery is required to restore the component to a state that was not previously isolated. A function is constructed in the script tag. The relevant codes are seen in appendix.

3.2.4. Defining the control button content function. After the main function is created, a function is created to control the content of the button. Clicking the button makes its content from "component isolation" to "cancel isolation". The relevant codes are seen in appendix.

According to the actual needs of the project, the API provided by BIMFACE platform is called for secondary development to achieve specific functions. This saves the development time and speeds up the project progress.

4. Case study

4.1. Project Overview
Shichuan River Super Large Bridge is a continuous rigid frame bridge and located in the section from Zhichuan town to Xinjian village of S211 highway along the Yellow River. The secondary highway
project is at K15 + 820. The total length of the bridge is 256m. The superstructure of the main bridge adopts (68m + 120m + 68m) three span prestressed concrete variable cross-section continuous beam. The box girder adopts single box and single cell cross-section, longitudinal, transverse and vertical three-dimensional prestressed system. The width of the bridge is 12.15m. The height of box girder root is 7.2m. The height of mid span beam is 2.8m. The height of box girder is changed by 1.8 times parabola. The top plate width of the box girder is 12.15m. The floor width is 7.0m, and the cantilever length of flange plate is 2.575m. The top plate of the box girder is provided with a cross slope. The transverse direction of the bottom plate is horizontal.

### 4.2. Parametric modeling based on Revit+ dynamo

Bridge is composed of a variety of components, including bridge span structure, bearing system, pier, abutment and pier foundation. When building the model, it is divided into upper structure and lower structure. The corresponding family library modeling is carried out respectively. Finally, the sub model is assembled by Dynamo in the project file. Dynamo is an open source visual programming software. Users can run scripts visually, define logical fragments and write scripts in text programming language. In the same way as mind map, the logical relationship and spatial relationship between components are reflected. Dynamo transforms manual modeling into procedural modeling. Designers can make more attempts and researches in a short time by combining parameterization.

#### 4.2.1. Parametric modeling of substructure.

The substructure of Shichuan River Bridge mainly includes piles, caps, piers, abutments and bearings. After the corresponding families are established in Revit, they are placed with dynamo. The placement results are shown in figure 5. The specific process is as follows:

- The pile diameter, pile length, pier width, pier length and pier height are set as parameters;
- The established family file is loaded into the project file;
- X-coordinate, y-coordinate, component elevation and parameter data should be input into excel;
- Using dynamo to read Excel data and place family instances.

![Figure 5. Substructure model](image)

#### 4.2.2. Parametric modeling of superstructure.

The center line of bridge design is usually a three-dimensional curve with elevation in plane. When the superstructure is built, the box girder section mass family is established first. Then dynamo is used to place the section. Finally, the entity is generated. The parameterization of the superstructure is shown in figure 6. The specific process is as follows:
4.3. Model lightweight display
The established model is saved in RVT format and uploaded to BIMFACE platform for format conversion. This project does not involve the detailed display of bridge materials. Only colors are used to render, so as to make it consistent with the actual bridge. After the model format conversion is completed, create code to make the model lightweight display. Figure 8 shows the functions of model rotation, translation, zooming, sectioning and elevation measurement.
5. Epilogue
Based on WebGL technology, this paper uses the BIMFACE secondary development platform to realize the lightweight display of the model of the Shichuan River Bridge. With the obtained ViewToken, which is used to call BIMFACE's JSSDK to load the specified model. The functions of scaling, translation, rotation, component isolation, component positioning, component coloring and other functions of the model are realized by calling functions through BIMFACE's own interface. The research results of this paper can be applied to the development of the visualization platform of bridge engineering projects, and provide a technical means for displaying the 3D model of the visualization platform.

![Model lightweight display](image)

Figure 8. Model lightweight display

6. Appendices

6.1. Creating HTML file
<!DOCTYPE html>
<html>
<head>
<title>ENTRY NAME</title>
</head>
<body>
<script>
src="https://static.BIMFACE.com/api/BIMFACESDKLoader/BIMFACESDKLoader@latest-release.js" charset="utf-8"></script>
<script>
    // Enter the methods provided by the BIMFACE JavaScript SDK here
</script>
</body>
</html>

6.2. Creating DOM elements
<div id="domId" style="width:800px; height:600px"></div>

6.3. Creating viewer3d and app objects
var viewer3D;
var app;
6.4. Specifying the model to be displayed according to viewToken
```
var viewToken = '<yourViewToken>';
var loaderConfig = new BIMFACESDKLoaderConfig();
loaderConfig.viewToken = viewToken;
BIMFACESDKLoader.load(loaderConfig, successCallback, failureCallback);
```

6.5. Setting the callback function after loading the model
```
var domShow = document.getElementById('domId');
var WebAppConfig = new Glodon.BIMFACE.Application.WebApplication3DConfig();
WebAppConfig.domElement = domShow;
app = new Glodon.BIMFACE.Application.WebApplication3D(WebAppConfig);
app.addView(viewToken);
viewer3D = app.getViewer();
}
function failureCallback(error) {
  console.log(error);
};
```

6.6. Creating button
```
<button class="button" id="btnIsolation" onclick="isolateComponents()">Component Isolation</button>;
```

6.7. Defining button styles
```
.button {
  margin: 5px 5px 5px;
  width: 90px;
  height: 30px;
  border-radius: 3px;
  border: none;
  background: #11DAB7;
  color: #FFFFFF;
}
```

6.8. Defining component function
```
var isIsolationActivated = false;
function isolateComponents() {
  if (!isIsolationActivated) {
    var makeOthersTranslucent = Glodon.BIMFACE.Viewer.IsolateOption.MakeOthersTranslucent;
    viewer3D.isolateComponentsByObjectData([["levelName","F2"], makeOthersTranslucent);
    viewer3D.render();
    setButtonText("btnIsolation", " Unisolate ");
  } else {
    viewer3D.clearIsolation();
    viewer3D.render();
    setButtonText("btnIsolation", " Component Isolation ");
  }
  isIsolationActivated= !isIsolationActivated;
}
```

6.9. Defining the control button content function
```
function setButtonText(btnId, text) {
```
var dom = document.getElementById(btnId);
if (dom != null && dom.nodeName == "BUTTON") {
  dom.innerText = text;
}

Reference
[1] Chen, H. (2017) Construction Control and Simulation Analysis of the Cable-Stayed Bridge Based on BIM. Beijing Jiaotong University, Beijing.
[2] Yang, Y. (2017) Application Study of BIM Technology on Construction of Nielsen Style Arch Bridge's ribs and Suspenders. Lanzhou Jiaotong University, Lanzhou.
[3] Fan, A. Wang, Y. Zhu, R. Ning, H. (2020) Application of BIM Technology in Construction of Langtampo Super Large Bridge. Construction Technology, 49(02): 115-118.
[4] Li, Q. (2017) Research On Swing Construction Organization Of Continuous Box Girder Of Adjacent Existing Railway Line Based On BIM Technology. Southwest Jiaotong University, Chendu.
[5] Jiang, P. Yang, K. Zeng, S. Wang, M. (2018) Application of BIM Technology in Construction of Jinsha River Double Track Extra Long Bridge. Railway Standard Design, 62(08): 78-84.
[6] Zheng, J. Dang, T. Fang, X. Zhou, G. Rong, W. Chen, Z. Qi, X. (2017) Application of BIM Technology in Construction of LantianBahe Bridge. Railway Standard Design. Construction Technique, 46(12): 126-129.
[7] Qu, Q. (2019) Study on Construction Control of Prestressed Concrete Continuous Girder Bridge Based on BIM. Beijing Jiaotong University, Beijing.
[8] Jin, G. (2018) Application Study of BIM Technology in Construction of No.3 Super Large Bridge in Wolonggou. Lanzhou Jiaotong University, Lanzhou.
[9] Li, X. (2017) Design and Application for Bridge Projects Based on BIM Platform. Beijing Architecture University, Beijing.
[10] Deng, D. (2019) Research on Construction Monitoring of Long-span Continuous Rigid Frame Bridge Based on BIM Technology. Jilin University, Jilin.
[11] Wang, X. (2016) Research on Key Technology of Building Information Modeling (BIM) for Precast Segmental Concrete Bridge. Southeast University, Nanjing.
[12] Liu, D. (2018) The Study on Application of Swing Construction of Continuous Beam Bridge Based on BIM Technology. Lanzhou Jiaotong University, Lanzhou.
[13] Liu, S. (2018) Application of BIM Technology in Structural Design of a Continuous Rigid Frame Bridge. Chongqing Jiaotong University, Chongqing.
[14] Chen, K. (2019) Research on design integration solution based on BIM. Changan University, Xian.
[15] Yang, B. Luo, Z. Xiong, L. (2014) Research and Application of Virtual Reality Technology Based on 3D Modelling and VRML. Mining and Metallurgical Engineering, 34(5) : 19-22.
[16] Wang, X. Li, C. (2013) Research and Application of 3D Virtual City Based on Unity3D. Computer technology and development, 23(4) : 241-244.