

Experimental Development of Web-based Building Information Model using 3D VML Library

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Abstract

3D visualization is known to improve the cognitive process of understanding the spatial relationship between objects. As the World Wide Web turned out an effective tool for yielding collaboration among those who locate in the physically separated places, the computer industry introduced technologies for sharing 3D vector graphics among professionals over the Internet. Vector Markup Language (VML) is an application of Extensible Markup Language (XML), which defines a format for encoding 2D vector information on the Web browser. Recently, a 3D VML library was introduced to extend the utilization of VML for Web-based 3D graphics. This research attempted to create a 3D campus model using the 3D VML library in order to investigate the merits and demerits of the 3D VML library for a large 3D Building Information Model (BIM).

Keywords

3D VML, 3D BIM, XML, 3D Web

1. Introduction

Tufte (1990) inferred from the Galileo's confusion in observing the sunspot's movement that the spatial relationship among 3D objects could be more intuitively explained using 3D expression. He claimed that Galileo's confusion was mainly caused by his observation of 3D movement using a flat media. The Architecture, Engineering, and Construction (AEC) industry has long depended on 2D drawings for sharing design information. Architects or engineers disassemble the building they design and express them using several floor plans and sections, while construction professionals review all 2D drawings and assemble them back into one entire building in their mind in order to understand the intention of the designers. This process usually requires a significant amount of education and sometimes site experiences. The AEC industry has shown unchanged interest on utilizing 3D visualization for explaining the building design and construction. A perspective 3D representation or a miniature model of the

constructed building is a good example that explains the AEC industry's long desire of expressing the building design using 3D language.

As 3D CAD gained popularity in the AEC industry, professionals sought to manage the building information using 3D CAD. The CAD vendors satisfied the professional's desire by releasing CAD packages that manipulate the 3D Building Information Model (BIM) in a stand alone computer. The emergence of the Internet technologies such as Virtual Reality Modeling Language (VRML) motivated the AEC industry to attempt a Web-based 3D BIM for those who are in remote locations. VRML is one of the most popular tools for delivering 3D vector graphics over the Internet. In spite of slow Internet transmission speed, VRML successfully illustrates an interactive 3D vector model on the Web browser. However, VRML lacks in extensibility for communicating with database, which is critical for manipulating the Web-based 3D BIM. Recently, the World Wide Web Consortium (W3C) released two applications of Extensible Markup Language (XML) for illustrating 2D vector graphics on the Web browser: Vector Markup Language (VML) and Scalable Vector Graphics (SVG). Developers then introduced supplementary libraries such as the 3D VML library for manipulating 3D vector graphics. Examples show that the 3D VML library illustrates the 3D model very effectively along with other information mostly described by HTML tags, which motivates an attempt to test the 3D VML library for manipulating the large 3D BIM.

2. Web-based 3D Visualization Tools

2.1 VRML

Virtual Reality Modeling Language (VRML) is a file format for describing interactive 3D objects on the Internet. VRML defines most of the commonly used semantics found in today's 3D applications such as geometry, viewpoints, light sources, and material properties. A VRML world created in a text file is embedded within an HTML document by using the <EMBED> tag, which is similar to using the tag to place a 2D image in an HTML document. The embedded VRML world is only displayed on a plug-in VRML viewer such as Cortona or Cosmo Player. Users' capability of manipulating the VRML world is usually limited by the functions of these VRML viewers. Therefore, interaction between the VRML world and other information described by the HTML tags or retrieved from the database sometimes gets complicated.

2.2 XML

The computer industry made some advancement recently in delivering vector graphics on the Web browser. In late 1998, a technical specification of Vector Markup Language (VML) was submitted to World Wide Web Consortium (W3C). VML is an application of eXtensible Markup Language (XML) and it defines a format for delivering a text-based vector graphics on the Web browser. The VML code therefore can be incorporated with the HTML code, and it runs on the Microsoft Internet Explorer without any plug-in software installed (W3C, 1998). In 2001, the W3C announced Scalable Vector Graphics (SVG), which is another specification for describing 2D graphics in XML (W3C, 2001). SVG is known a better, cleaner, and more complete standard than VML, however the users need to install a plug-in viewer to see the vector graphics on the Web browser.

2.3 3D VML Library

Although VML and SVG seem to be more extensible tools for delivering vector graphics and additional information over the Internet, they are designed only for manipulating 2D vector information on the Web browser. It was Gareth Richards at gersolution.com who introduced a 3D VML library that would enable the developers to display 3D vector graphics using VML (Richards, 2000). The 3D VML library is

essentially a collection of JavaScript codes that creates a perspective view of the 3D model using VML. The speed of displaying the 3D VML model is heavily rely on the computing power of the client computer. Lutz Tautenhahn (2002) introduced a SVG-VML-3D, which is essentially similar to the 3D VML library, for illustrating 3D vector graphics on the Web browser using SVG or VML.

2.4. XML Data Island

The 3D VML library defines 3D polygons in an XML data island. The XML data island is an “island” of data that is embedded inside HTML file (Microsoft, 2003). The syntax of the XML data island used in the 3D VML library is introduced in Figure 1.

```

<XML>
  <SCALE> numeric value of scale </SCALE>
  <POINTS>
    <P>
      <X> x coordinates of the point 1 </X>
      <Y> y coordinates of the point 1 </Y>
      <Z> z coordinates of the point 1 </Z>
    </P>
    repeat for all points used in the 3D model
  </POINTS>
  <FACES>
    <F id= identification name of the face>
      <V> the first point used for fabricating the face </V>
      <V> the second point used for fabricating the face </V>
      <V> the third point used for fabricating the face </V>
      repeat for all points used for fabricating the face
    </F>
    repeat for all faces used for building the 3D model
  </FACES>
</XML>

```

Figure 1: Syntax of the XML data island

The XML data island contains three root level sections: 1) SCALE, which defines the scale of the polygon set; 2) POINTS, which defines the points that make up the polygon set; and 3) FACES, which defines a face of the polygon. A group of faces would identify one 3D object.

3. Development

3.1. Relational Database for 3D Building Information Model

Although the XML data island seemed to be simple to use, creating the XML data island for a large model would be a confusing process. In order to improve the process of creating the XML data island for the 3D campus model, a relational database was designed using the Microsoft Access as shown in Figure 2. The database consists of three tables: 1) tblPoint, which defines the points that make up the polygon set; 2) tblPolygon, which defines the polygons that make up the buildings; and 3) tblBuilding, which defines the building information. These tables are related with each other and the Microsoft Access provides a convenient environment for defining relationships between points, polygons, and buildings as shown in Figure 3. If the users click the “+” icon of a certain row in the table, that row expands and brings up the related sub-information. It is a convenient feature that helps to enter the geometry data with minimum consideration of the relationship between points and polygons.

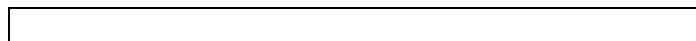


Figure 2: Database structure for the 3D campus map

Figure 3: Data entry for the 3D campus map

In order to convert the geometry in the database into the XML data island automatically, an interactive Web application was developed using Active Server Pages (ASP). This application retrieves the 3D geometry of the building from the database and creates an XML file in the Web server using the XML data island format introduced in Figure 1.

3.2. Modification of 3D VML Library

The 3D VML library rotates the model on the global axis by default. Rotating the 3D model on the global axis may not always work for browsing the building. Sometimes the 3D model tilts unusually if the leaned model is rotating on the global z axis as shown in Figure 4 (a). In order to keep the 3D model vertically, the 3D VML library was modified so that the 3D model is always rotating on the local z axis as shown in Figure 4(b).

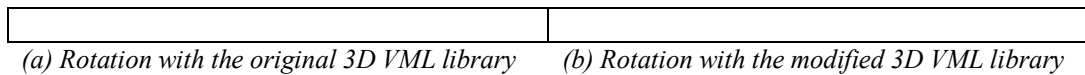


Figure 4: Modification of the 3D VML library for rotation

4. Application

A 3D campus model of Texas A&M University was created to test the modified 3D VML library. The AutoCAD was first used for creating a 3D model of the campus. The coordinates of each and every vertex that builds up the campus buildings were collected manually. The geometry data collected in the database was then converted into the XML data island as shown in Figure 5 using the Web application developed in this research.

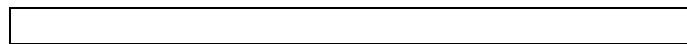


Figure 5: XML data island for the 3D campus map

The Web page for the 3D campus model 1) delivers the XML data island to the client computer; 2) creates the 3D polygons using the VML library; 3) and display them on the Web browser. Figure 6 illustrates the Web site that displays the 3D campus model of Texas A&M University. As shown in the figure, the Web page provides functions for navigating around the buildings.

Figure 6: 3D campus model of Texas A&M University

Constructing the 3D campus model revealed that the speed of the 3D VML library may not satisfy those who are familiar with the VRML world. It took about 1 minute 30 seconds to download and display the

3D campus model shown in Figure 6 on the Microsoft Internet Explorer 6.0 that was running on the Personal Computer with the 652 MHz Crusoe Process TM5800 and 240MB of RAM. Once the 3D campus model is loaded on the client computer, it took about 5 seconds for every movement of navigating around the model. The delay in displaying the campus model may result from the slow speed of interpreting the JavaScript codes in the 3D VML library. The process of converting the 3D geometry into a 2D perspective view requires a significant amount of computing for manipulating the matrix. The JavaScript interpreter embedded in the Microsoft Internet Explorer may not be fast enough to produce a smooth movement for the navigation in the 3D model. In order to make this 3D campus model more practical, the process of converting the 3D geometry into the 2D perspective view should be implemented faster.

5. Conclusion

The 3D campus model demonstrated a possibility of using VML for realizing Web-based 3D BIM. VML was cooperatively used with JavaScript and plain HTML for displaying 3D vector graphics, which implied a possibility of combining VML with Active Server Pages (ASP) and then providing more dynamic environment for 3D BIM. However, the 3D campus model also demonstrated that the 3D VML library should be running faster to attract the users. Although there has been no movement in W3C for 3D VML or 3D SVG yet, it should not be unreasonable to expect a faster XML-based 3D vector graphics tool in the near future.

In this research, no additional information was added to the 3D campus model but the geometry of the campus buildings. Further research is expected to suggest a new XML data island format for manipulating additional building information in 3D BIM.

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