Managing Scheme for 3-dimensional Geo-features using XML

Kyong-Ho Kim, Seung-Keol Choe, Jong-Hun Lee, Young-Kyu Yang
GIS Team, Image Processing Dept., ETRI-CSTL
161 Kajong-dong, Yusong-gu, Taejon, 305-350, KOREA
Email: kkh{skchoe, jong,yang}@etri.re.kr

Abstract

Geo-features play a key role in object-oriented or feature-based geo-processing system. So the strategy for how-to-model and how-to-manage the geo-features builds the main architecture of the entire system and also supports the efficiency and functionality of the system. Unlike the conventional 2D geo-processing system, geo-features in 3D GIS have lots to be considered to model regarding the efficient manipulation and analysis and visualization. When the system is running on the Web, it should also be considered that how to leverage the level of detail and the level of automation of modeling in addition to the support for client side data interoperability.

We built a set of 3D geo-features, and each geo-feature contains a set of aspatial data and 3D geo-primitives. The 3D geo-primitives contain the fundamental modeling data such as the height of building and the burial depth of gas pipeline. We separated the additional modeling data on the geometry and appearance of the model from the fundamental modeling data to make the table in database more concise and to allow the users more freedom to represent the geo-object.

To get the users to build and exchange their own data, we devised a file format called VGFF 2.0 which stands for Virtual GIS File Format. It is to describe the three dimensional geo-information in XML(eXtensible Markup Language). The DTD(Document Type Definition) of VGFF 2.0 is parsed using the DOM(Document Object Model). We also developed the authoring tools for users can make their own 3D geo-features and model and save the data to VGFF 2.0 format. We are now expecting the VGFF 2.0 evolve to the 3D version of SVG(Scalable Vector Graphics) especially for 3D GIS on the Web.

1 INTRODUCTION

Nowadays, Virtual GIS or 3D GIS is an emerging field of research and development due to the advanced technologies in computer graphics, virtual reality, and web-based technology. There are papers and commercial products on Virtual GIS or 3D GIS, but most of them have strength on surface handling, and are lack in managing and analyzing geo-objects[1][2][3].

We focused our development on the feature-based 3D GIS in Web environment, and here, the geo-feature plays core roles determining the efficiency and functionality of the system. We explain about the managing scheme for 3-dimensional geo-features especially in Web-based environments. As shown in Fig. 1, the overall architecture for geo-feature management is

composed of authoring, parsing, and modeling module with the core structure for geo-features. Each module will be explained in more detail in later chapters.

2 GEO-FEATURES

Geo-features play a key role in object-oriented or feature-based geo-processing system. So the strategy for how-to-model and how-to-manage the geo-features builds the main architecture of the entire system and also supports the efficiency and functionality of the system. Unlike the conventional 2D geo-processing system, geo-features in 3D GIS have lots to be considered to design

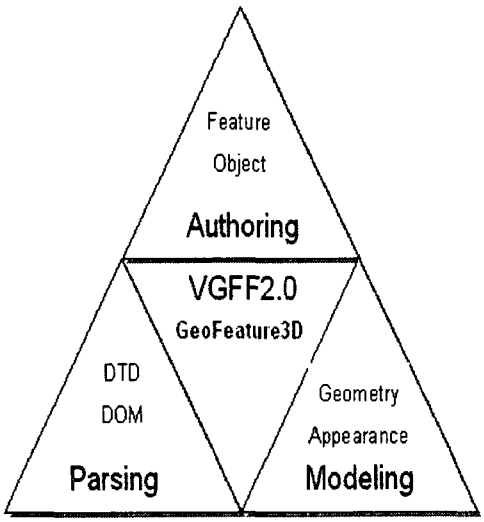

Fig. 1. The overall architecture for managing 3D geo-features

regarding the efficient manipulation, analysis, modeling and visualization.

We grouped geographic objects in the world into a set of geo-features. Each geo-feature is linked with one or more geo-primitives to be able to represent complex 3D geo-objects in 3D geo-space. We defined a set of geo-primitives to make it efficient to manipulate, analyze, model and visualize 3D geographic information(Fig. 2).

To make it easy to manipulate the 3D spatial information and keep the information as compact as possible, each geo-primitive has 2D positional data with additional 3D data. For example, the geo-primitive for building feature contains 2D polygon data with single height value, and for pipeline feature, it contains 2D path data with burial depth value(s). Unlike the CAD system representing 3D volume with the 3D vertices composing it, this method is easier to manipulate relatively simple-shaped geo-objects, and it works especially for Web-based 3D GIS. Another merit of this method is that the 2D functionalities can also be performed without any change of data structure. So we can do 2D and 3D manipulation, spatial analysis and synchronized visualization on the same data at the same time.

Another aspect considered for geo-primitives is modeling and visualization. The level of detail of an arbitrary 3D shape is usually proportional to the amount of data used to represent it. In the Web-based environment, the level of detail of 3D geo-object can not

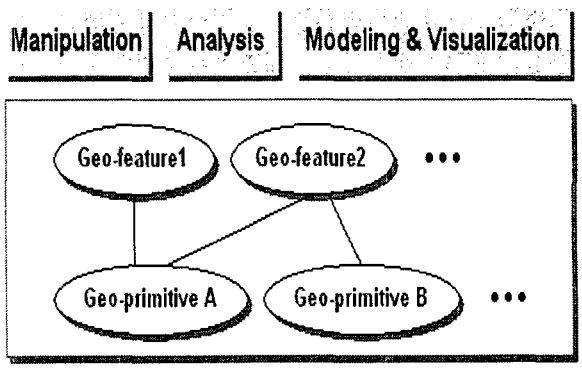

Fig. 2. Geo-features and geo-primitives designed for the efficiency of manipulation, analysis, modeling and visualization of 3D geographic information.

help being restricted due to the network bandwidth and transmission time. So we designed geo-

primitives to model and visualize the geo-objects as simple(box, cone, cylinder etc.) and medium(extrusion, face set, the combination of simple shape, etc.) level of detail. To support more enhanced modeling and visualizing functions we implemented the Modeling module and it will be explained more in later chapters.

3 VGFF 2.0

There are many file formats to store and exchange geographic information. There are standard formats such as SDTS, but most other formats were made by different commercial vendors and they are not widely used to exchange spatial information because the formats are usually not opened in public. In case of 3D GIS, There is little format to store, exchange, and manipulate efficiently the 3D geographic information.

So we devised a format for 3D GIS named Virtual GIS File Format(VGFF, in short) version 2.0. It is a revised version of VGFF 1.0[4] and is based on XML(eXtensible Markup Language) 1.0 format[5].

XML is, by definition, "the universal format for structured documents and data on the Web". There are so many features and advantages of XML, but the most important one is that XML can represent all kinds of document in the world and provides method for putting structured data in a simple text file. Due to this feature, several formats were devised based on XML, such as SMIL(Synchronized Multimedia Integration Language), MathML(Mathematical Markup Language), and SVG(Scalable Vector Graphics)[6][7][8]. Especially, SVG is a language for describing 2D graphics for Web environment. The final goal of VGFF is to be a 3D version of SVG.

We defined VGFF using the Document Type Definition(DTD) of XML. The DTD for VGFF contains geo-features, geo-primitives, multimedia data and appearance information. These informations are hierarchically structured and parsed using Document Object Model(DOM)[9] of XML. An example of VGFF is shown in Fig. 3.

```
<?xml version="1.0" ?>
<!DOCTYPE VGFF SYSTEM "vgff.dtd">
<VGFF date = "1999.6.18"
      editor = "Kyong-Ho Kim" >

   <MBR minX = "208879.387"
        minY = "445753.869783"
        maxX = "210445.475122"
        maxY = "447291.054553" />

   <APTFeature
      id = "700"
      name = "APT" >
     <Appearance />
     <APTObject
       id = "7001"
       name = "진주아파트" >
       <APTAttribute>
          <Exs>20</Exs>
          <Name>진주아파트</Name>
          <Dong>10</Dong>
          <Story>10</Story>
          <Pyung>-1</Pyung>
          <CompY>-1</CompY>
       </APTAttribute>
       <APTGeometry>
         <SBuildExt
           height = "40.0"
           convex = "false" >
          <Poly2d>
            209733.89 446224.03
            209825.5 446240.86
            209827.62 446227.88
            209736.02 446211.88
            209733.89 446224.03
          </Poly2d>
         </SBuildExt>
       </APTGeometry>
       <Multimedia>
       </Multimedia>
     </APTObject>
   </APTFeature>
</VGFF>
```

Fig. 3. An example of VGFF. Notice that this file is created conforming to the "vgff.dtd" which defines the structure of VGFF.

4 AUTHORING

XML is, by nature, a text-based syntax that can be understood by both machine and humans[10]. So VGFF can also be edited easily using simple text editor. User can create new geo-features composed of user-defined attributes and determine how to model it by modifying or creating the DTD for VGFF. And users can also build their own data by editing or creating VGFF file. To make it easy for user to create VGFF, we devised two authoring tools, Feature Authoring Tool(FAT) and Object Authoring Tool(OAT). The FAT is for creating new features, defining new attributes, and determining the modeling and visualization method. The result of feature authoring can be saved as a modified or newly created DTD.

User can build their own 3D GIS data according to the structure defined by DTD, using OAT. OAT makes it easy to insert attribute values and spatial data, which are modeled and visualized interactively

with user. The result data is saved as VGFF file, which can be parsed by any XML parser[11]. Fig. 4 shows the authoring workflow.

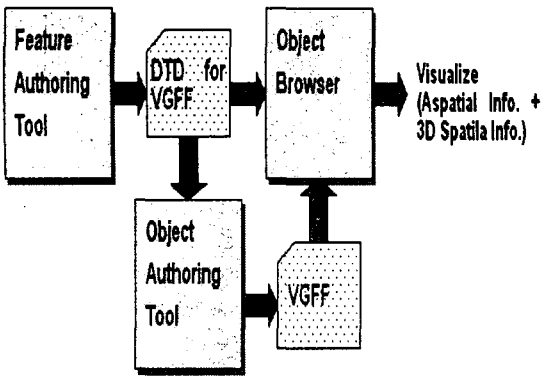

Fig. 4. The authoring workflow.

5 MODELING

How to model the geo-objects in real world into 3D geo-space in computer is one of the most important problems in 3D GIS. It may good to model geo-objects as detail as possible to provide high virtual reality. But there must be a trade-off between the reality proportional to the amount of data and the network bandwidth and transmission and processing time in Web-based application. We used the three levels of detail modeling strategy considering this trade-off as shown in Table 1.

Table 1. Three-level modeling strategy

Modeling level	Geometry	Appearance
Level-1 (Low level)	Simple geometry (Box, Cone, Cylinder, etc.)	Single color
Level-2 (Medium level)	Medium geometry (Extrusion, Face-set, Combination of simple geometry)	Single color and Simple texture(texture tile)
Level-3 (High level)	Complex geometry (wire-frame)	Photo-realistic texture

We use the level-1 and level-2 strategies usually when manipulating 3D scene as a whole. And use level-3 strategy on the per-object basis.

We can control the geometry and appearance of geo-objects using the GeoModeler module. The user-customized modeling and visualization parameters are saved as a Modeling Meta File(MMF) which is also based on XML syntax, and reloaded by GeoModeler. By separating the geographic information(in VGFF) and modeling and visualization parameters(in MMF), we can get the multiple view on the same scene, and thus, can simulate the city planning functionality.

Fig. 5 shows how to visualize the geo-objects.

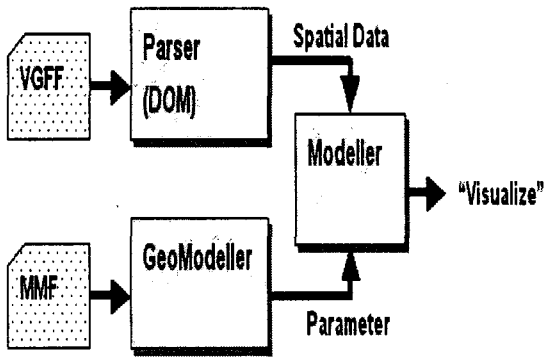

Fig. 5. Module diagram for modeler. Modeler combines the spatial data from VGFF parser and modeling parameters from GeoModeler, and visualize the geo-objects 3-dimensionally.

6 CONCLUSIONS

In this paper, we've explained about the managing scheme for 3-dimensional geo-features in Web-based environments by mainly utilizing XML. We designed structures for geo-features and geo-primitives to enhance the efficiency of manipulation, analysis, modeling and visualization of 3D geographic information. To store and exchange the 3D geographic data, we devised a file format called VGFF, and by conforming to the XML syntax, several useful features which XML have as a wide-spread and noteworthy standard format was also utilized. Several tools for authoring and modeling, such as Feature Authoring Tool, Object Authoring Tool, and GeoModeler were devised for user to create geo-features, build data, and control

modeling level. On the basis of this geo-feature handling strategy, several functionalities like spatial analysis, surface handling, and query processor are being implemented now.

References

[1] Koller, D., Lindstorm, P., Ribarsky, W., Hodges, L. F., Faust, N., and Turner, G. Virtual GIS: A Real-Time 3D Geographic Information System. In *Proceedings of Visualization'95*, October 1995, pp. 94-100

[2] IMAGINE Virtual GIS,http://www.virtualgis.com/

[3] ArcView 3D Analyst,

[4] http://www.esri.com/software/arcview/extensions/3dext.html

[5] Kim, K. H. , Lee, K., "Development of Web-based 3D GIS", Third Annual Symposium on Geographic Information System, 23-26, Vancouver, 1999

[6] Extensible Markup Language(XML),

[7] (http://www.w3.org/XML/)

[8] Synchronized Multimedia,

[9] (http://www.w3.org/AudioVideo/)

[10] W3C's Math Homepage,

[11] (http://www.w3.org/Math/)

[12] W3C Scalable Vector Graphics(SVG),

[13] (http://www.w3.org/Graphics/SVG/)

[14] Document Object Model,

[15] http://www.w3.org/DOM/

[16] Java Project X FAQ, (http://java.sun.com/xml/javaprojectx/faq.htm)l

[17] XML Parser for Java, (http://www.alphaworks.ibm.com/tech/xml4j/)