Standard 2D and 3D geo-spatial data formats for a 
Volcano Geographic Information System

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Abstract. This paper describes a work in process to model 2D and 3D geo-spatial data. There are several options to manage this type of data but we are looking to work with formats which allow the data exchange in a network context. In addition, the format should support analysis and visualization of data in a risk management environment. The model described in this paper will be tested with the Popocatépetl volcano data. In this context, decision making is a very important activity, about 200,000 people distributed in 50 towns are in danger when the volcano starts its activity. Plan Operativo Popocatépetl office at Puebla is responsible to coordinate the actions to help and to keep the integrity of these people. Visualization of geographic data allows an expert to analyze the different risk situations. The actual work will support the decision making process and will describe a geo-spatial data model in the context of disaster management. Several tests have been made in the context of the volcano, we already have a geographic database and an Internet interface.

1. Introduction

For the last seven years, the Popocatépetl volcano in Mexico has shown important activity. This volcano covers three different states: Estado de México, Morelos and Puebla with several urban cities in risk. Actually the government make decisions based on printed information consisting of tables and maps, which is an inefficient and inaccurate procedure. In this project we are looking to provide digital and automated tools to support the decision making process. This paper describes our work to model and represent spatial and non spatial data.

Printed maps indicate the danger around the volcano. These maps have been provided by the National Disaster Prevention Center of México (CENAPRED) the organism which is responsible of monitoring the volcano. An emergency map indicates that 10 km around the crater is a very dangerous zone. There is no people living in this area. From 10 km to 20 km we have a dangerous zone where several towns are located. The closest town, Santiago Xalitzintla, is about 12 km from the crater so it is necessary to have a plan to evacuate people in case of danger. This plan must include the actions needed to keep order when evacuating each town. Puebla’s government works based on the Plan Operativo Popocatépetl office to coordinate the
actions of evacuation in case of danger. Figure 1 shows the zones of danger around the Popocatépetl volcano.

Several scenes of danger have been described by CENAPRED and the Plan Operativo Popocatépetl office. Four stages of danger are actually described for these scenes:

- Green flag: the volcano is active but it is not dangerous
- Yellow flag: the volcano is active and a evacuation plan could be necessary
- Orange flag: very high probability of events around the volcano. People must be evacuated
- Red flag: The volcano is in activity (earthquakes, ash, mud and pyroclastics flows)

The Office has made an estimation of the resources needed to execute a plan. The parameters estimated by the office are the following:

- total of habitants by town
- the number of habitants which can exit by their own means
- total of people to evacuate
- the number of buses needed to transport the people
- the kilometers between a town and its refuge

![Fig. 1. Risk Areas Around Popocatépetl Volcano](image)

This problem is represented by an application developed by our research group. Our goal is to include in the context of the project a tool to visualize 2D and 3D spatial data. We will develop a model to work with the applications already developed to support the decision making process in the case of a Popocatépetl eruption. The new component will allow to exchange 2D and 3D spatial data in a network environment with the introduction of standard data models. These standards will allow data access
2. Volcano GIS

Our group of research started to work with this problem on January 2000. Several components have been developed in order to have an application that responds the needs presented in the last section. García [1] developed a translator from Shapefile format to OpenGIS [2] a standard representation of geographical data. Loyo [3] built a first prototype of the volcano zone by using a 1:250 000 cartography. Vera [4] created a first tool to visualize geometric data in an Internet environment. Loranca [5] modeled the 9-intersection topology, which supports spatial queries in our project. Ramirez [6] generated a module to edit and to correct cartography before storing it on the database. Morales [7] modeled spatial data and built the database. Montero [8] developed tools to access and query this database. In this context, our paper describe the work developed by Antonio Razo. This work integrate a 3D visualization component in the project described. Figure 2 shows a general scheme of the project with the different components. The process and presentation 2D and 3D data is managed in the services component.

![Fig. 2. Popocatépetl Volcano Project](image)

3. Related Work

The GIS volcano project has adopted the OpenGIS [2] specification as the format to maintain and store the spatial data. The OpenGIS consortium, composed by several companies and universities, has developed a specification for 2D and 3D spatial data. The principal objective of the specification is to propose a standard way to manage and to store spatial data. In the context of this specification it is possible to relate
spatial to non spatial data. A very important advantage of the OpenGIS specification is that it allows the data exchange in a network context. Several GIS applications can manage this format and share data between them. The consortium has proposed a map service in the internet by using their Web Map Server and the Geographic Markup Language (GML). GML is a language developed in XML (eXtended Markup Language) and it can represent and exchange 2D and 3D data.

On the other hand the World Wide Web Consortium (W3C) [9] has developed different initiatives to support the interoperability in an internet context. The most important and better known of these technologies is the Hyper Text Markup Language (HTML). This consortium is the creator and the principal promoter of XML [9] and all the technologies related to this universal format. The W3C define two specifications in XML to represent and to model spatial data as a standard format. The first of these specifications is the Scalable Vector Graphics (SVG) which principal objective is to manage 2D vector data with quality and accuracy.

The second specification is X3D which is an XML equivalent of the Virtual Reality Modeling Language (VRML). Both specifications VRML and X3D allow the management of geo-referenced 3D data.

A data format can be useful for some specific application. However, it seems that a good compromise is to manage several formats and to translate from one format to another. Some formats are good to visualize results and other are good to process a query from a database. In particular, our proposal is to work with GML to retrieve the data, and then present the results of a query using SVG or X3D. XSL (eXtended Stylesheet Language) [9] is a technology which allows the translation between different XML formats. The figure 3 shows how we plan to use it.

Fig. 3. Translation scheme between several formats
4. Work in process

Our project actually integrates the spatial database of the volcano Popocatépetl region. This database is supported by the OpenGIS specification [2]. A component to access this database has been developed in the context of our project [8]. This module has been implemented by using Java as a programming language. The database connection is realized using JDBC (Java Data Base Connection) and the results are presented using Servlets and JSP (Java Server Pages). The module presents the results of a query in HTML format. The queries can consult spatial or descriptive data. We are looking to generate the results on a GML document and then translate this document into a 2D or 3D representation using SVG or X3D in addition to descriptive data.

![Popocatépetl volcano in 3D using OpenGL](image)

**Fig. 4.** View of the Popocatépetl in 3D using OpenGL.

We started to work with our cartography translating it into SVG and X3D. At this moment, we have tested the visualization of the cartography by using OpenGL [10]. Figure 4 shows an example of the volcano in 3D.

The geometric components of the Popocatépetl volcano zone with the risk map can be represented by using XML format. As an example we can model a shelter:

```xml
<Shelter>
    <Number> 12 </Number>
    <Name> Secundaria No.2 </Name>
    <Capacity> 300 </Capacity>
    <gml:localization>
        <gml:Point>
```


In the example we can see that the grammar of this language is similar to HTML but in this case we are just modeling. In particular the example shows the geometric coordinates and some parameters related to a refuge. If we use XSL to translate this information into SVG the result will look like this:

```xml
<svg width="450" height="500">
  <g id="shelter12" style="fill:blue; stroke:black">
    <circle cx="58.64" cy="211.24" r="10" />
    <text id="SL" x="48.0" y="212.0">Secundaria No.2</text>
    <text id="SL" x="48.0" y="200.0">Capacidad 300</text>
  </g>
</svg>
```

This code generate a visual 2D representation of the shelter with information associated to it. If we need a 3D representation we use X3D:

```xml
<X3D>
  <GeoLocation geoCoords="586453.3 2112458.7 2080.4" geoSystem="UTM", "Z14">
    <Shape>
      <Sphere radius='3'/>
    </Shape>
    <Shape>
      <Text string='"Secundaria No.2"'/>
    </Shape>
  </GeoLocation>
</X3D>
```

The main advantage of using X3D is the GeoVrml 1.0 Specification [11] that extend VRML to support geographic applications. With this specification we can geo-
reference all the 3D data. The figure 5 present how this examples look like on a browser. This is a just a simple example but we will work with more complex entities.

Fig. 5. Visual representation in SVG and VRML

5. Conclusions and future work

The visualization in a Geographic Information System is a very important module. This task can be done by using several formats. We think that the use of a standard format will allow us to exchange data, for example we can be process data in one site and visualized it in another. In a distributed environment the use of standard formats allow also to exchange and to share data. In particular our project works in this context, because the risk management need several experts to have an opinion about the same phenomenon. The data can be also managed in a server and the users can access the data from different geographic sites. The management of this type of data in a distributed environment is a wide subject of research.

The data can be translated into different formats. We are working with XSL to translate a GML document into HTML, SVG and X3D. Java language will be used to build an application to do this work. We will define an architecture to manage the translation with the mechanisms to query and to analyze the data through internet. We have already developed the interfaces to work with these formats.

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