Engineering Virtual Environments with X3D

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Session Outline

- Polys: Overview, Case study: Bioinformatics
- Hetherington: Case study: Architecture
  - *Break -*
- Brutzman: Tactical Simulation, X3D content examples
- Gračanin: Traffic Visualization

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Traffic Visualization

- Introduction
- Framework and technologies.
- Example: traffic visualization for the Twin Cities (Minnesota) area
- Conclusion

Why Transportation Traffic?

- Transportation and the highway system are the backbone or critical elements in the public infrastructure system.
- Road transportation is one of the common components of emergency response plans and activities.
- Demand for road travel continues to grow as population increases, particularly in metropolitan areas but new constructions have not kept pace.

Traffic Congestion

- Congestion is largely thought of as a big city problem, but delays are becoming increasingly common in small cities and some rural areas as well.
- Traffic demands vary significantly by time of day, day of the week, and season of the year, and are also subject to significant fluctuations due to recreational travel, special events, and emergencies (e.g. evacuations).

Why Visualization?

- High-performance visualization systems are becoming crucial for traffic planners, because the wealth of traffic data collected by an ever-expanding sensor network is growing much faster than it can possibly be analyzed manually.
- Traffic planners and traffic users need an intuitive graphical user interface (GUI) to monitor the traffic in real-time and interact with data for further analysis.
- The supporting system must integrate information from a variety of sources, such as sensors, cameras and databases, and display it in a well organized, highly ergonomic graphical environment.

Visualization Challenges

- The system state description is derived from many data sources so to fuse this data and concisely define the state of the system is a daunting task.
- Simplistic graphic maps fail to effectively capture temporal information or all levels of spatial resolution.
- The information is, in general, complex, multi-dimensional, physical or abstract information that is intrinsically difficult to represent and manipulate.

Flavors of Visualization

- Visualization for an expert user.
- Visualization for a non-expert user.
- GIS based visualization.
- Higher dimensional (three and above) visualization.

Real and Virtual

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Technologies Used

- Geography Markup Language (GML) has been defined as an XML encoding for geographic information.
- Scalable Vector Graphics (SVG) is an open standard specifically designed for the web for describing two dimensional vector graphics in XML.
- XML Style Sheet Transformations (XSLT).
- eXtensible 3D (X3D).

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SVG

- SVG is an open standard specifically designed for the web for describing two dimensional vector graphics in XML.
- The principal objective is to manage 2D vector data with quality and accuracy.
- Compared to bitmap formats (e.g. JPEG, GIF and PNG), SVG has the benefit of faster download speeds, and with high resolution printing, high-performance zooming and panning inside of graphics without reloading, gradients, animation, filter, kerning, masking, scripting and linking.

GML

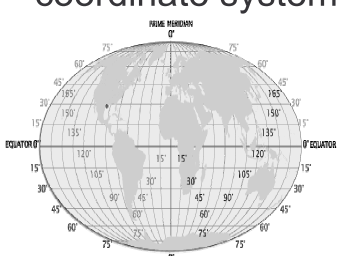
- An XML encoding for storing geographic information containing both spatial and non-spatial attributes of data.
- A medium of uniform geographic data storage and exchange among diverse applications, especially in a wide-area Internet context.
- A data descriptive language, the data is stored in a self-descriptive manner (and human readable).
- Stores the data but does not indicate how the data is to be displayed.
- A mechanism for information discovery, retrieval and exchange.

Putting it Together

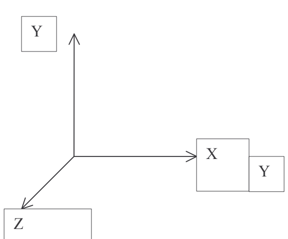
- Since GML, SVG and X3D are all XML-based, it is easy to apply stylesheet (XSLT) to the geographical content (GML) and generate 2D (SVG) and 3D (X3D) geographical presentation.
- Use XSLT to map the road traffic data to the corresponding region in the virtual environment.
- Mapping data to 3D world requires converting two-dimensional sensor coordinates into a three-dimensional coordinates in the virtual environment.

Coordinate Systems

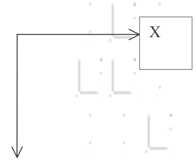
- X3D and SVG have different coordinate systems compared to the geographic coordinate system; conversion is needed.



Geographic Coordinate System [1]



X3D/VRML Coordinate System

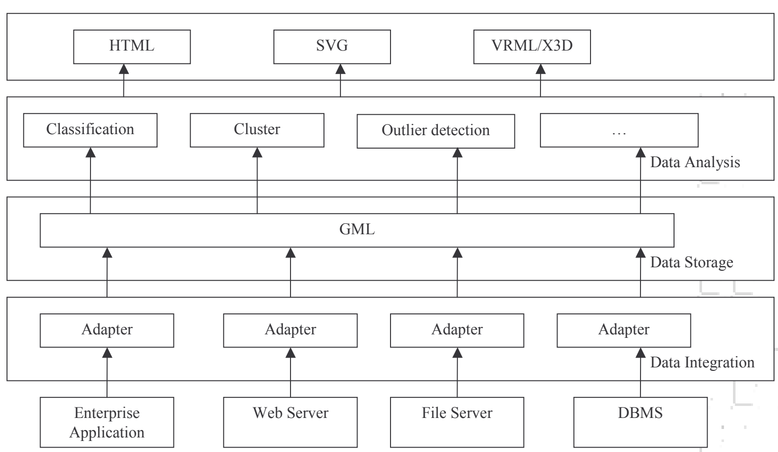


SVG Coordinate System

Framework Description

- Data source layer: enterprise information systems, file system servers, relational or object-oriented database system, etc.
- Data Integration: adapters are applied to them to convert them into a global and consistent format.
- Data storage layer: data converted into GML format for exchange, whenever required.
- Data analysis layer: geo-spatial data is retrieved from the data storage layer and be further analyzed based on requirement using data mining techniques.
- Visualization layer: GML data can be extracted and styled to suitable graphical representation (SVG and VRML/X3D).

Framework Architecture



Approach

- Create SVG or X3D graphics based on the characteristics of queried data.
- The 2D map (SVG) gives user a big picture and overview of the whole world, while the virtual world (X3D) present geographical objects in more details.
- Both 2D and 3D environment can be presented at different levels of details or at different scales, giving user a choice of the granularity of presented data.
- In most of the cases, the value of the selected data type (e.g. traffic volume) is used to create a visual cue in the 3D virtual environment.

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Visual Cues

- The visual cues include both geometry and appearance. The preferred choice in this case is the vertical extrusion of the polygon specifying the region of the sensor.
- The amount of the extrusion is proportional to the value of the sensor data. In addition, a color coding is used to indicate different levels of data.
- The time dimension of the data is presented by animating the visual cues with appropriate scaling factor.

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User Interactions

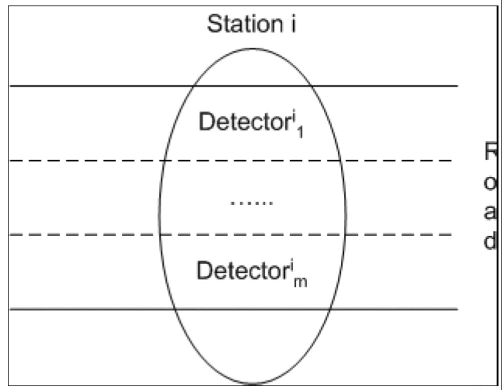
- Due to the spatial and temporal characteristics of the data, several selection mechanisms are available.
- User can use ”traditional” dialogs provided “in HTML” to select data type for a given road or a set of roads, as well as the time interval of interest.
- The user can also “pick” in the 2D and 3D virtual environment a region of interest to select sensor data mapped to that region.
- The user can freely navigate and select a location.

Example: Minnessotta Metropolitan Area

- Data from the Traffic management Center of Minnesota Department of Transportation.
- A database archive of sensor network measurements from the freeway system in the Twin Cities metropolitan area.
- The sensor network monitors the occupancy and volume of traffic on the road.
- Data was converted into GML format, and then XSLT is applied to the GML files to generate SVG and X3D files.

Input Data

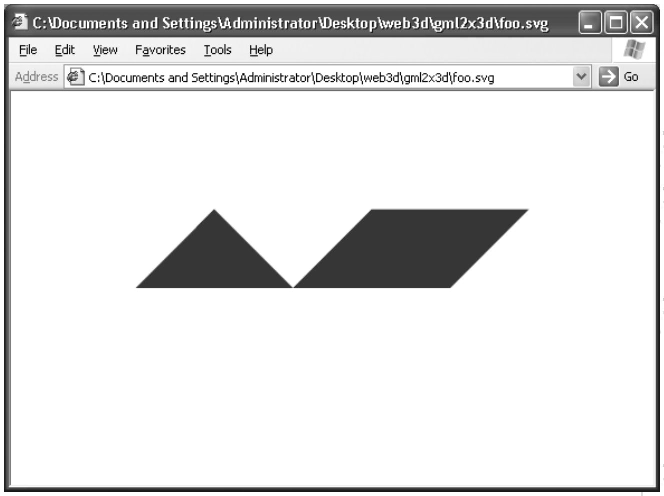
- Each of the highways in the map is composed of a series of stations.
- Each station is a polygon with a collection of points.
- Each point is given the geographical position (latitude and longitude).



GML Data

```xml
<?xml version="1.0" encoding="UTF-8"?>
<highwaymap
  xmlns:gml="http://www.opengis.net/gml">
<station id="1">
<size>3</size>
<gml:LineString
  srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
<gml:coord><gml:X>0.0</gml:X><gml:Y>0.0</gml:Y></gml:coord>
<gml:coord><gml:X>20.0</gml:X><gml:Y>20.0</gml:Y></gml:coord>
<gml:coord><gml:X>40.0</gml:X><gml:Y>0.0</gml:Y></gml:coord>
</gml:LineString>
</station>
<station id="2">
<size>4</size>
<gml:LineString
  srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
<gml:coord><gml:X>40.0</gml:X><gml:Y>0</gml:Y></gml:coord>
<gml:coord><gml:X>60.0</gml:X><gml:Y>20.0</gml:Y></gml:coord>
<gml:coord><gml:X>100.0</gml:X><gml:Y>20.0</gml:Y></gml:coord>
<gml:coord><gml:X>80.0</gml:X><gml:Y>0.0</gml:Y></gml:coord>
</gml:LineString>
</station>
</highwaymap>
```

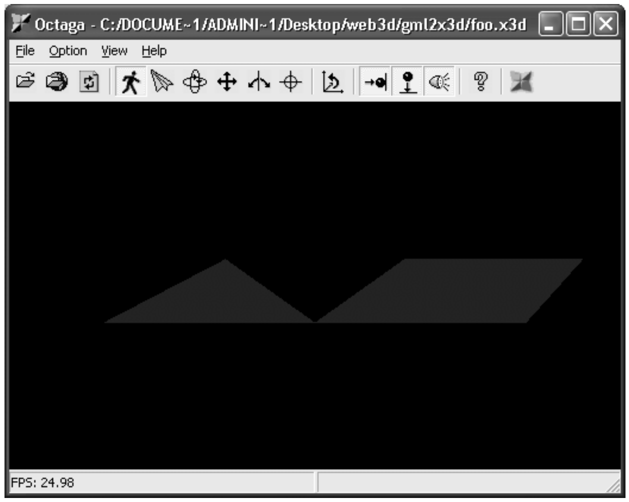
SVG View



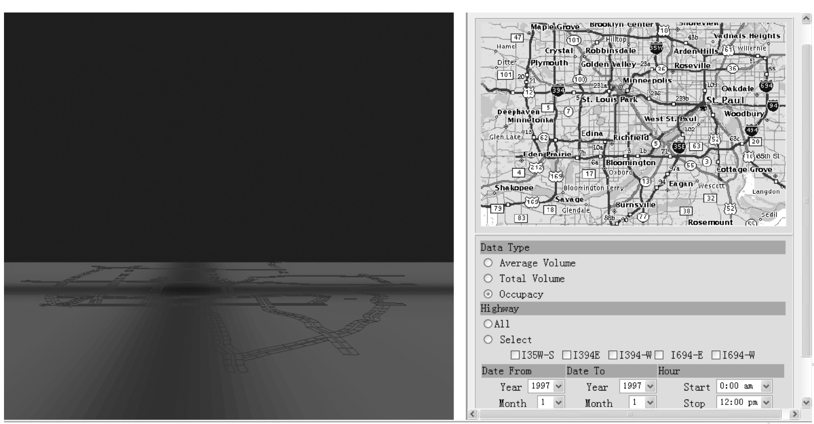
SVG File

```
<?xml version="1.0" encoding="UTF-8"
  standalone="yes"?>
<svg viewBox="0 -50 100 100"
  enableZoomAndPanControls="false"
  preserveAspectRatio="xMidYMid meet"
  id="main">
<g id="map">
<path d="M 0.0 0 L 20.0 -20  L 40.0 0 z"
  fill="&#10;&#9; red&#10;&#9;    "/>
<path d="M 40.0 0 L 60.0 -20 L 100.0 -20
  L 80.0 0 z" fill="&#10;&#9;
  red&#10;&#9; "/>
</g> </svg>
```

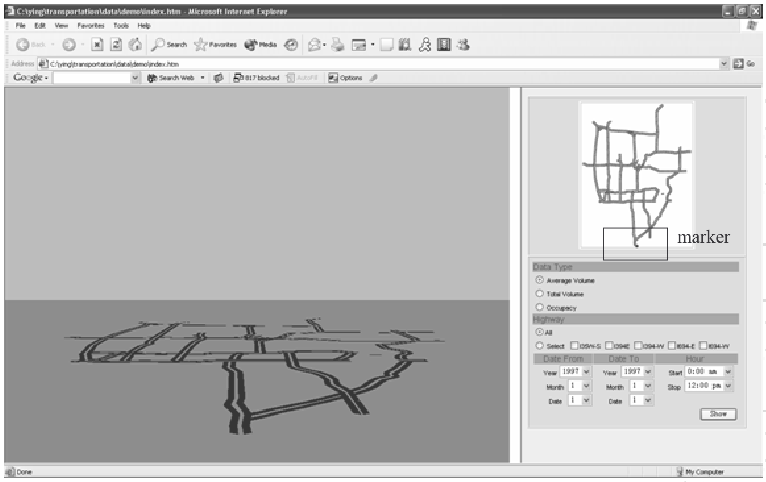
X3D View



Sample Screen



Web Based Interface



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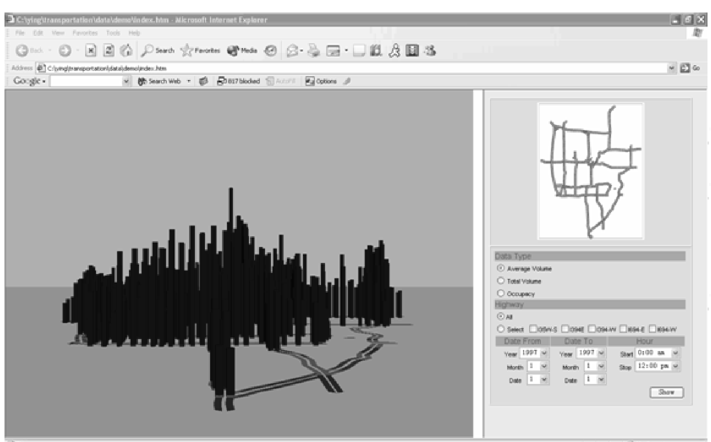
Dynamic Data Display



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Conclusion

- X3D, in combination with other standards like SVG and GML can be used for Web visualization of geo-spatial related problems.
- Data sources integration within a common framework.
- Extensive use of XSLT.
- “Synchronization” between X3D and SVG.

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References

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3. S. Cox, P. Daisey, R. Lake, C. Portele, and A. Whiteside, "OpenGIS Geography Markup Language (GML 3.0) Implementation Specification," http://www.opengeospatial.org/specs/?page=specsD.
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