

# DEVELOPMENT PROCESS OF INTERACTIVE “GEOHISTORY” STORMING AND VIRTUAL DISCOVERING

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## ABSTRACT:

This paper demonstrates how to explore a design of a multimedia supported four dimensional (4D) information system to aid geographically-oriented the documentation of the two Ottoman fortresses of “*Seddülbahir*” and “*Kumkale*” through internet. This paper also presents a methodology for the integration of historical architectonic and Spatial Information (SI) technology, and new perspectives for historical documentation projects. Additionally, this paper examines a variety of ways in which Spatial Information System (SIS) application for a historical documentation project can be integrated with technological developments within the fields of database, visualization and internet. Building three-dimensional (3D) models, storing them and providing a user interface to visualize and manipulate them require new database and graphic technologies and robust programming languages. What is really needed is a system such that all data and functions can be accessed and manipulated in one seamless programming environment. “*GeoHistory*” has been implementing in order to build an open, seamless development environment. This paper will describe the design of “*GeoHistory*” as a SIS model and integration with its sub-components, such as “*GeoHistoryRepository*”, “*GeoHistoryQueryInterface*”, “*GeoHistoryVirtualInterface*” and provide an efficient method of documenting historical structures.

## 1. INTRODUCTION

The cultural heritage is the most important evidences regarding the past society and each object of these has valuable information about the past. Unfortunately each valuable element of the historical structures has been vanishing day by day through time, nature, and human effects. Hence, some precautions are needed for protecting these historical structures from the corrosion and human effects. There are also two Ottoman Fortresses, called “*Seddülbahir*” and “*Kumkale*” on Dardanelles, Turkey in the same situation, however, the project team working with these monuments believes that the fortresses can be restored and protected only when it has been fully measured, documented and stored in proper historical information and management systems. They were both built in the mid seventeenth century (1656-1659) at the entrance to the Aegean, on either side of the Straits by Turhan Sultan, the mother of the Ottoman Sultan, *Mehmet IV*. (Guney et al., 2002)

The Documentation Project of the Ottoman Fortresses, “*Seddülbahir*” and “*Kumkale*”, is a joint project undertaken at the Division of Geodesy, Istanbul Technical University (ITU) and the Department of History, Koç University; to explore a preparation of a multimedia supported four dimensional (4D) information system through internet to aid geographically-oriented the historical documentation of the fortresses. It is with this larger, long-term goal that the team of surveyors, architects, historians and archaeologists began in 1997 to working together on the project. The location of the fortresses is approximately  $26^{\circ}.199 E_{ITRF}$  and  $41^{\circ}.006 N_{ITRF}$  and the distance between the two fortresses is approximately 4150 meters. As “*Seddülbahir*” is located on the European side of the straits, at the southern end of the Gallipoli Peninsula. The fortress of “*Kumkale*” is on the opposite Asian shore, approximately five kilometers from Troy.

Fast developing technology in the area of geo-informatics makes the use of “Spatial Information Systems (SIS)” exciting to utilize and an opportunity to challenge much better decision making for many fields like history, archaeology etc. SIS can be

used to analyze any issue with a spatial component in these fields.

This paper demonstrates how a SIS project can be designed and managed for historical researches. This paper examines a variety of ways in which SIS application for a historical documentation project can be integrated with technological developments within the fields of database, visualization and internet.

## 2. SIS PROJECT OVERVIEW

The design and management of SIS-based historical documentation project of the two Ottoman Fortresses, “*Seddülbahir*” and “*Kumkale*”, is considered as a multi-purpose and multi-participants information technology (IT) project since each discipline in the project contributes to the study with its science domain and expects different outputs rather than other science domains, and the project has various purposes for the different level users such as decision makers, users, end-users.

After project team understood the context of the project, formulated the questions concerning the project with rich pictures and root definition and determined the expectations from the project the vision and mission of the project was created, and the strategic plan of the project was produced due to the requirements and the phase of analyzing. Flow chart of the stages and timings were constituted upon the strategic plan or SIS development process.

The vision of the project is to model accurately the “**life history of the fortresses**” within a SIS project to determine more accurately and efficiently the architectural changes from 17<sup>th</sup> century to the present day and to explore the natural, economical, social and political events, which have caused structural changes to the fortresses and surrounding buildings and environs. (Guney and Celik, 2004a)

The mission of the project includes: (Guney and Celik, 2004a)

- modeling “**GeoHistory**” as a comprehensive 4D geo-processing model for historical documentation research with the help of historians in the project team defining the problems and expectations,
- developing “Temporal (4D) SIS (TSIS)” of the fortresses since “life-history of the fortresses” changed continuously over time,
- developing “Object-Oriented SIS (OO-SIS)” of the fortresses to abstract the reality on a business model more effectively,
- developing “Virtual (3D) SIS (VSIS)” of the fortresses to allow the viewer to be immersed in the model, therefore increasing perception and realism,
- developing “Internet SIS (Web SIS) or distributed SIS” of the fortresses to publish SIS application through world wide web (www) due to cost-effectiveness and wide accessibility,
- developing “Integrated SIS” of the fortresses to utilize spatiotemporal object data model (ST-Object model),
- developing a web site of the project to manage the multi-participant SIS project on the Internet as an e-management, which transforms a data source into communication hub and an analysis tool effectively for project members and users to share information about the project and discover the fortresses and historical background of them.

The strategic plan of the project includes following stages: (Guney and Celik, 2004a)

- Making a project web site,
- Breaking the SIS project into its components,
- Data Modeling (database modeling and design),
- Nature of database, type of data, how stored etc. (database construction),
- Geo-Visualization,
- Publishing through Internet,
- Spatial Queries and Analyses,
- Integrating all components,
- SIS use and system maintenance.

### 3. SIS MODEL: *GeoHistory*

“**GeoHistory**” is temporal 4D (3D+Time) interactive SIS model with object-oriented approach based on multimedia application through Internet environment to model accurately and efficiently the life history of the fortresses.

GeoHistory is being designed as a SIS model to support the “life history of the fortresses”. This model addresses both issues, by providing an innovative data modeling methodology and an extension of the core functionality of an OO-DBMS, resulting in a Temporal Object-Oriented Database Management System, which provides the necessary basis for implementing and maintaining temporal applications for historical documentation of two Ottoman fortresses on Dardanelles.

Using the GeoHistory, the expected benefits can be the formalization of temporal object oriented data, efficient and flexible historical data management, data synthesis and analysis through temporal information retrieval.

The SIS model is an analytical tool whose forte is the representation of many data types in a single view. An integration of these two capabilities could equip the exploration art-historian with a very powerful decision making tool.

This SIS model, GeoHistory, which is an application with interactive interface on internet to manipulate the historical information, recreate and visualize the fortresses and the cemetery, consists of three modules: (Guney and Celik, 2004a)

- **GeoHistoryRepository** which is a data modeling and database component of the SIS project.
- **GeoHistoryVirtualInterface** which is a visualization component of the SIS project and the user accesses with web browser and walks around the fortresses in virtual environment.
- **GeoHistoryQueryInterface** which is an internet component of the SIS project and the user manipulates and displays the system.

Building 3D models, storing them and providing a user interface to visualize and manipulate them require new database and graphic technologies and robust programming languages. What is really needed is a model such that all data and functions can be accessed and manipulated in one seamless programming environment. “*GeoHistory*” is being implemented in order to build an open, seamless development environment. This paper describes the design of “*GeoHistory*” and integration with its sub-components, such as “*GeoHistoryRepository*”, “*GeoHistoryVirtualInterface*”, and “*GeoHistoryQueryInterface*” and provides an efficient method of documenting historical structures.

#### 3.1. Spatiotemporal Object Data Model and Database Component: *GeoHistoryRepository*

Organizing three-dimensional (3D) and time-dependent data in a SIS is a key issue when using SIS for documentation, preservation, restoration projects of historical sites to support decision making based on analysis of and reasoning on geographic data of historical phenomena. Hence, a SIS data model has to be developed and implemented to meet the requirements of different kinds of users like specialists of art-history, history, architecture, archaeology, etc. The multi-dimensional data model should be general enough to allow the integration of data types from each scientific domain in the project. (Guney et al., 2004)

Conventional SIS data models emphasize static representations of reality. Object data model of the fortresses seems adequate to research the fortresses. Problem appears, however, in modeling the phenomenon of “life history of the fortresses” since the phenomenon has been continuously changed over time. Since life history of the fortresses is dynamic information such a life history can only be modeled with the spatiotemporal object data model (ST-Object model) in temporal SIS. This paper proposes a data model “*GeoHistoryRepository*”, the development of this spatiotemporal SIS data model and its applicability to documentation of the 17<sup>th</sup> century fortresses to make queries involving spatial and temporal relationships.

“*GeoHistoryRepository*” which is an open-ending data model and database component of the “*GeoHistory*” is being developed for efficient SIS data maintenance and management. It makes use of a spatiotemporal object data model for describing various types of dynamic changes of SIS data, manipulating data in multidimensional space including time. “*GeoHistoryRepository*” is being developed as a dynamic SIS data model that recognizes the composite structure of historical data objects. At the heart of the system is a sophisticated object-oriented data modeling approach with the support of temporal approach.

This is the first version of the “GeoHistoryRepository” model, which incorporates historical buildings, utilities, and people such as the people had lived in the fortress and in the cemetery. The model includes topology rules for each feature dataset along with related domain value tables. The purpose behind this design is to help users manage these complicated, interdependent datasets in one cohesive model using an interface. SIS modelers in the project team produced several questionnaires for project team members to identify conceptually the key themes/data and primary issues to analyze which will be designed in the data model as an initial task in developing data model “GeoHistoryRepository”.

Figure 1 shows a part of the conceptual SIS data model for Historic Architecture. The fundamental unit for historic architecture is the “*architectural changes*”, which is the first type of feature described in a historic architectural survey. Conceptual design was conducted with the “Sybase Power Designer” graphical tool and “Unified Modeling Language (UML)” was used as a modeling language. Some examples are a residential place (within the fortresses and out of the fortresses, settlement); a market (with its associated fields and buildings); a war area (with its weapons and towers and bonets); a religion lot (with its mosque and associated cemetery); a cleaning complex (with its hamams).

“GeoHistoryRepository” is being designed as a process-oriented spatiotemporal data model based on three domains which extends the concepts both of spatial and temporal data modeling. Its general framework uses a set of geometry-based spatial objects to represent reality (spatial modeling aspect). Thematic characteristics are represented as attributes of spatial objects (semantic modeling aspect). Temporal information is associated with time-stamping events or processes (temporal modeling aspect). Major advantage of this model is that three domain’s objects dynamically link together with the aspects of location, attribute and time centered. Spatiotemporal queries and analytical methods are performed in this spatio-bitemporal model which handles information about valid time and transaction time in SIS and allows for retroactive as well as post-active changes. (Guney et al., 2004)

Three domain-oriented spatio-bitemporal data model, GeoHistoryRepository, is being developed to capture the discrete changes of objects through time interval, from 17<sup>th</sup> century to now. The discrete changes of a historical object during a time interval can be seen as snapshots of that object, taken in time points of this time interval. Versions of the same façade of “Kumkale” in different time of the same period are shown in the Figure 4. Changes occur to attributes of a phenomenon, behaviors of an event, or mechanisms of a process.

Most of phenomena in the 17<sup>th</sup> century Ottoman fortresses are dynamic that has changed discretely over time. The value of time is represented by the number of years for example After the World War I, the fortress was damaged and re-constructed. The shape of most buildings within the border of the fortresses architecturally changed. In this study, purposed spatiotemporal applications based on the “GeoHistoryRepository” as follows:

- Geometrical (or topological) changes of historical objects over time
- Positional changes of historical objects over time
- Change of historical object attribute (spatial attribute) over time (variations in attributes over time)
- Any combination of the above changes

The major drawback is the lack of a tool facilitating conceptual data model design and its associated implementation. That UML is a CASE tool used for designing an object-oriented data model may provide new release for users to define their own domain-specific classes and functions.

The goal is to develop a SIS data model for a 3D historical documentation with spatial and non-spatial data under the same architecture and to implement a complete database system based on this data model. The next component explains a graphical user interface which allows interaction with the data in “GeoHistoryRepository”.

### 3.2 Visualization Component: GeoHistoryVirtualInterface

That “GeoHistoryVirtualInterface” is being developed to build an architecturally-accurate 3D model in a computer-generated environment which specifies 3D virtual re-construction of the fortresses and the objects in the fortresses enables a user to interact with the objects in the scenes. Virtual Tour Guide, called GeoHistory tutor, in the “GeoHistoryVirtualInterface” is being designed to talk to visitors in English pointing out historical, artistic and architectural facts of the objects.

“GeoHistoryVirtualInterface”, which is a Graphic User Interface (GUI), uses 3D internet modeling language VRML/GeoVRML to create and reproduce some accurately modeled 3D scenes that could be viewed over the web and to explore the potential of 3D visualization of reality. If the feature selected by user has related image and/or sound data, they can be displayed and played using the GUI. Some semantics such as hierarchical transformations, light sources, viewpoints, geometry, animation, fog, material properties, and texture mapping are being integrated to the scenes of the fortresses and the objects in the fortresses. Additionally, real time navigation techniques through “GeoHistoryVirtualInterface” such as fly-over, walk through are being designed to promote the interactivity. (Guney and Celik, 2004b)

“GeoHistoryVirtualInterace” uses programming Java in combination with VRML for 3D modeling, rendering, and dynamic interaction capabilities (*provided by VRML*), complete programming capabilities, and network access (*provided by JAVA*), which extends the ability to interact with the model and to animate objects within the scene really only limited by the creators imagination.

“GeoHistoryVirtualInterface”, which is an “External Authoring Interface (EAI)” linking Java applets or applications to the 3D VRML/GeoVRML scene, is an interactive user interface between the encapsulating HTML browser and the embedded VRML browser, and is used as a dynamic geo-visualization tool through the Internet. It provides to access nodes and event structure from outside of VRML browser instead of comprehensive node access within VRML browser via a Script node that is another alternative using “Script Authoring Interface (SAI)”. This interactivity enables Java applet to build and update dynamically the data in VRML, and in turn, the applet’s data can also be dynamically updated through the VRML interface. (Guney and Celik, 2004b)

The connection between the data in Java applet and the nodes in the geo-spatial world in VRML file is implemented by EAI. The changes in Java applet can affects the 3D geo-spatial world built in VRML file form. And the event occurred in VRML world can be detected and processed in Java applet side. 3D spatial analysis such as selection, 3D buffering, and near can be

performed on Java applet, and its result is visualized in VRML world. The result may also be presented in textual (numerical) or graphical form in “GeoHistoryVirtualInterface” as a GUI. (Guney and Celik, 2004b)

“GeoHistoryRepository” being developed based on spatiotemporal object-oriented database management systems provides a database programming interface (DBAPI) which is generated by Common Gateway Interface (CGI) scripts to extend a database with user defined data types, and functions such as VRML and to allow database access from within “GeoHistoryVirtualInterface”. VRML documents are used to portray 3D graphics (spatial data). The approach for the integration of database technology and VRML let the users to query, modify and interact with remote spatial databases in the concept of 3D SIS. The multi-tier client-server architecture provides to complete queries, visualize results and explore 3D models.

The user has access to the VRML document with a click option and can visually choose an object (e.g. turkish bath). The first click on the door of the Turkish bath will allow the user to enter inside. The second click on the indoor will show the architectural plan and the gravure of main part of Turkish bath. The third click on a button will display the achieve information about the Turkish bath, and so forth. In such an example, network analysis might be realized using CGI scripts in each mouse click. Query-Result sections will be integrated using CGI and Java scripts.

Figure 3 displays how VRML files produced in the project. Figure 4 shows the methodology and technologies used for developing the “GeoHistoryQueryInterface”. Figure 5 presents a capture of “GeoHistoryQueryInterface”.

### 3.3. Internet Component: *GeoHistoryQueryInterface*

Access to spatial data and interactive database applications with querying capabilities over the internet is growing rapidly. Internet has already been one of the important developing platforms of SIS, the function of SIS has been extended by Internet, and furthermore it becomes a kind of new SIS architecture. The current paradigm shift involves the migration of application software from individual desktop computers into an internet-based client/server architecture. (Guney and Celik, 2003b) As a result, it is seen large-scale development of SIS applications that can be accessed by a great number of users through a web browser interface. Internet SIS is a network-centric SIS technology that uses the Internet and the World Wide Web as a primary means of providing access to the functionality (i.e., analysis tools, mapping capability) of SIS and to the spatial data and other data needed for various SIS applications. (Guney et al., 2004)

Major advantages of web-based SIS system: (Brotten, 2003)

- SIS client software is not required since SIS software is installed only on the server. Therefore, SIS access is free of charge (unless a charge is imposed on the server connection). However, some map servers may require installation of a plug-in to run the software.
- The client interface is the web browser. All the user needs for access a web browser such as Netscape or Internet Explorer with a connection to the Internet.
- The end user does not need special SIS training or skills.

The internet has brought SIS, high quality maps and virtual 3D applications to any internet user's web browser, which has

changed the science of SIS in recent years. Web distribution of SIS is related to the forms of 2D or 3D web mapping. Current forms of output for 2D maps from SISs are many and include bitmap, gif and pdf. An attractive format is VRML for distributing 3D SIS output. VRML browsers work as plug-ins for common Web browsers and are currently available for most platforms.

“GeoHistoryQueryInterface” module based on the multi-tier client/server web SIS architecture is an interactive geo-query tool designed to promote the usage consisting of a large geo-database, “GeoHistoryRepository”, with querying capabilities that includes the ability to output results in a map-based format using a SIS. This web-interface developed contains an application that enables query and extraction of the information belonging to fortresses and interactive mapping.

## CONCLUSION

This study is focused in the reconstruction of the fortresses of “Seddülbahir” and “Kumkale” and the cemetery of “Kumkale” in the virtual environment. This application helps the project members, architects, archeologist and art historian to centralize database, predicts the cultural heritage after recreation and provides history information for people who are interested in. Therefore, this study is very interesting for tourists and people who are trying to discover the past.

The modules of “GeoHistory”, “GeoHistoryRepository–GeoHistoryVirtualInterface–GeoHistoryQueryInterface”, is being linked each other with hyperlinks and internet programming like scripts of Java, PHP and worked together on web. Whilst the project has been successful in that it hides the size and complexity of the system behind an easy to use interface, the real success of “GeoHistory” has been the development of a SIS optimized for use over the Internet that integrates various technologies in a model. Once completed the integrated SIS of the fortresses can be used to discover the fascinating past of these historic structures, and to discover the present problems that face these cultural heritage sites.

In developing the system, GeoHistory, the system providers are utilizing various visualization and interaction techniques, web and database technologies adequate for this specific SIS application of historical documentation. In addition, by evaluating its usefulness in its final field of application the providers hope to define techniques that could also be used in other SIS projects.

It can be concluded that the usage of temporal SIS instead of conventional SIS will be unavoidable and dominant within SIS market in the near future.

Both the production of maps and the development of the SIS of the fortresses have been realizing in the laboratory of “IGS-ISTA Satellite Observation and Processing Laboratory” in Istanbul Technical University. Any one who is interested in the project can follow the progress and other publications on the integrated SIS project with the project web address “<http://www.seddulbahir-kumkale.com>”.

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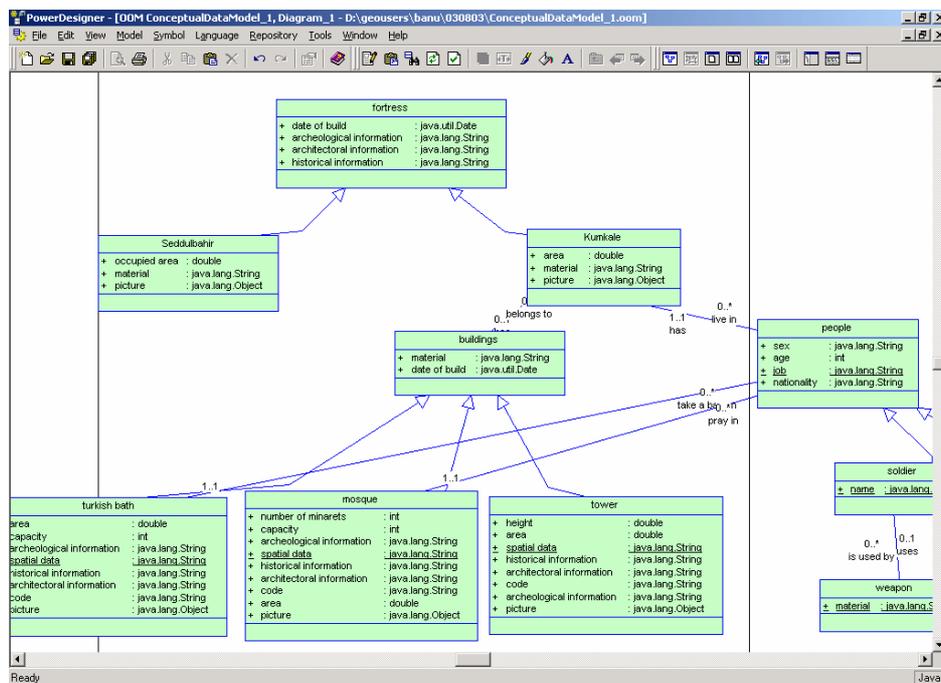


Figure 1. Conceptual SIS data model for Historic Architecture in UML.



Figure 2. Versions of the same façade of “Kumkale” fortress.

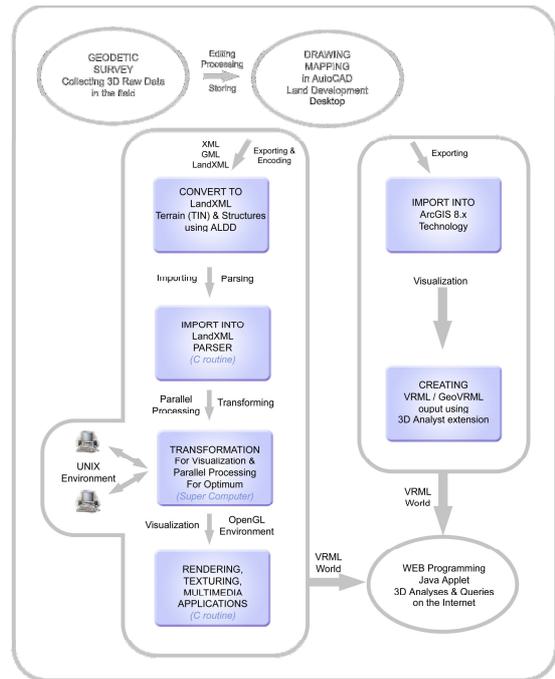


Figure 3. Methods of building VRML files

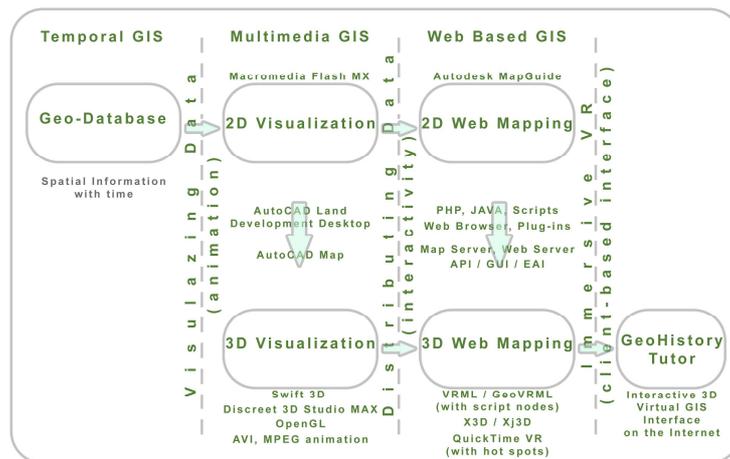


Figure 4. Methodology and technology used for developing “GeoHistoryVirtualInterface”

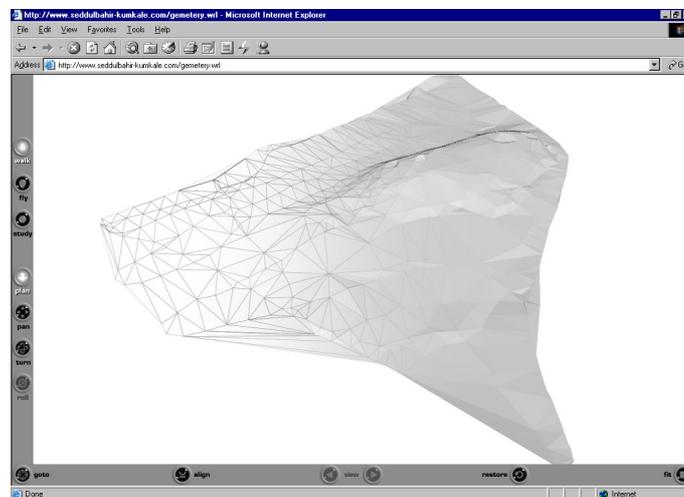


Figure 5. Capture of “GeoHistoryVirtualInterface”