Proposal for a Virtual 3D World Map

Kostas Terzidis
University of California at Los Angeles
School of Arts and Architecture
Los Angeles CA 90095-1467

ABSTRACT

The development of a VRML scheme of a 3D world is proposed. The objective is to provide a prototype framework for Internet client-users to

a) Learn how to "plug-in" their own 3D models,
b) View and interact with the models using existing communication software on PC-based hardware, and
c) Search for other models on the basis of geographical locations.

The framework utilizes multiple levels of detail, data abstraction, interaction with HTML format, and build-in code animation. A case study is implemented to provide an example of a four level (territory-city-block-building) hierarchy for creating, visualizing, and searching.

1. INTRODUCTION

The last few years, the development of sophisticated modeling and realistic rendering techniques combined with the emergence of the World Wide Web (Internet) led to the development of a virtual reality environment. This environment allows users from all over the world to access information on any subject, at anytime, about almost anything. Initially, information was provided in the form of two-dimensional multi-media layouts also referred to as "home pages". Recently, through the development of faster networks and more capable client machines "home pages" can be extended into the third dimension. This technology is referred to as Virtual Reality Markup Language (VRML). The effects of such technology may soon become apparent especially in the visual-based businesses: product design, advertising, motion pictures, electronic games, architecture and urban planning, etc.

2. THREE-DIMENSIONAL INTERNET

One of the main advantages of web-visited virtual reality is its availability over the network. At anytime and from almost anyplace, information can be viewed, criticized, evaluated, and exchanged. The same information can be viewed by different people at the same time and be criticized, modified, and re-distributed. In addition, because of the nature of graphics, information can be viewed from many different points in real-time providing a totally different experience to the user compared to a mere color picture.

Currently, the information provided over the Internet is presented mainly in two dimensions. The Hypertext Transfer Protocol (HTML) supports many forms of multimedia files but people who develop home pages prefer to present their information in the form of text, images, sounds, and movies. The reason for that was that these kinds of files were a) able to transfer faster and b) processed more efficiently by the end machines (clients). With the development of 3D protocols for transferring information of a geometric nature (VRML) and a significant increase in the processor power of the average personal computer, 3D models became available for viewing. Modelers and viewers were developed to support users with tool for experiencing 3D movement. Information can be presented in 3D either as abstract entities (i.e. bubble diagrams) or as 3D models that correspond to the physical world (maps, buildings, streets, etc.) Currently, when one looks for information the searching is done on the basis of words and keywords. The search engines available today look for matching letters over large amounts of data and return the requested links. Information is not visualized within space and/or as a correspondence to the physical world but rather is viewed as long lists of text and images.

Many researchers have proposed or developed urban simulation models, few of which are implemented to run over the Internet. They are generally local applications with hard-coded information and extremely large databases. Ligget and Jepson [2][3] have developed an urban simulation system based on flight-simulator technology. Fukai [1] has developed a construction information system on the Internet but its main purpose is to link 3D models to construction documents. Since the World Wide Web is relatively new in the area of architecture only a few educational or commercial applications are found. McCall and Johnson [4] have developed a hypertext system, called PHIDIAS, that supports collaborative design. Various Internet based urban simulation companies, such as planet9[1] or construct[2] have attempted to address the issue of virtual cities, but the quality and detail of their representation is not quite realistic yet.

If one looks at the structure of the Internet today one will experience a vast amount of information structured in no particular way. It is mostly a vast distributed database of text and images. Although much of this information corresponds to physical reality it cannot be visualized that way. For example, Universal Studios has a particular geographical location where it exists physically but one may look for that type of information only as a

---

[1] See http://www.planet9.com

[2] See kttp://www.construct.com

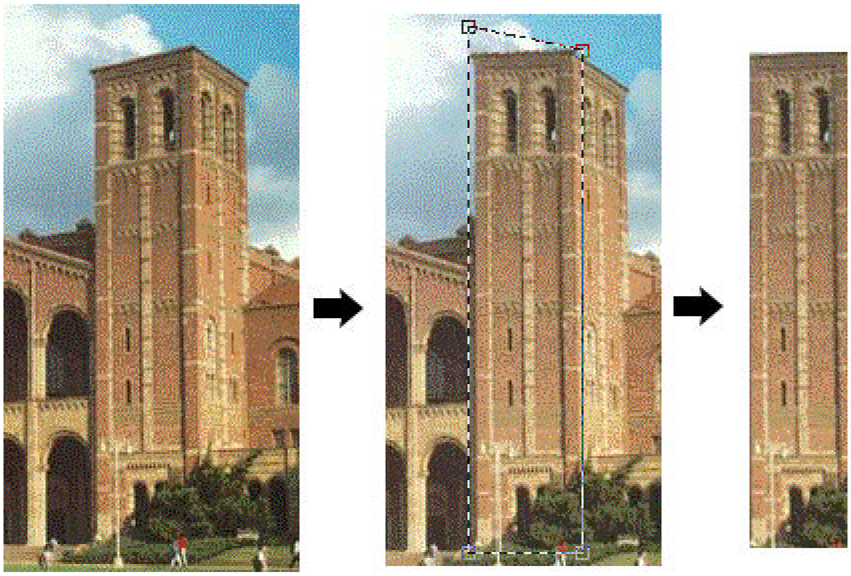
text-basis. Now that 3D information, protocols and viewers are available over the Internet it would be an interesting project to look into the possibility of creating a virtual world that corresponds to the physical world we live in and investigate into the potential and implications that such a world would have.

3. DATA REPRESENTATION

A system for efficiently modeling and simulating urban environments has been implemented at UCLA. It is based on technologies developed for web-based virtual reality. The system combines relatively simple 3-dimensional models with aerial photographs and street level video and sound to create a realistic (down to plants, street signs, and graffiti) model of an urban neighborhood. This models can then be used for interactive fly and walk-through demonstrations over the Internet on any computer platform.

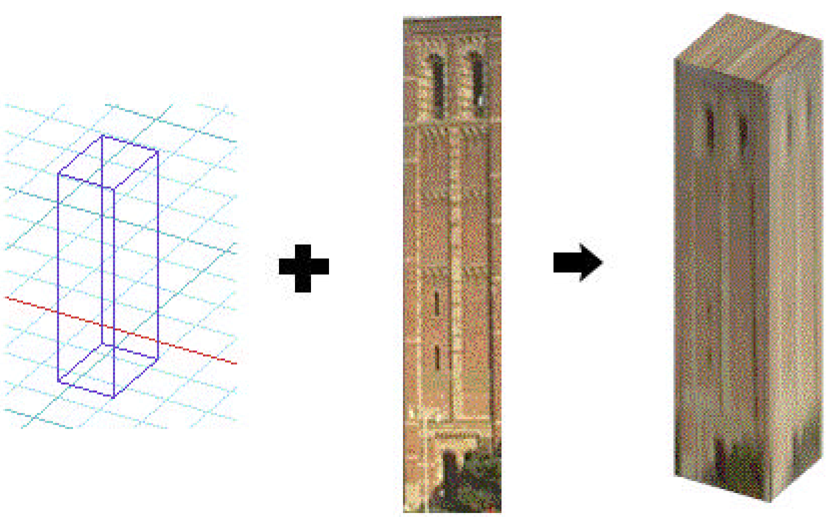
The system implements a methodology that integrates existing systems such as (Computer-aided Design) CAD and (Geographic Information Systems) GIS with web-based visual simulators such as VRML to facilitate modeling, displaying, interacting with, and evaluating alternative proposed environments. It can be used by the users themselves to visualize their neighborhoods as they currently exist or to visualize how some urban area might appear after some built intervention. The system can also be used to simulate a completely new development. It uses relatively inexpensive hardware/software.

The methodology for constructing a VRML representation of a building is described as follows:
Pictures of the building are taken from well-lit angles. These pictures are digitized, and them photo-processed to correct the perspective. The are then clipped to contain only the image map of the elevation.



The geometry of the building is measured either from on-site measurements or from plans and elevations provided through the city planning offices. An alternative technique is under development that utilizes photogrammetry to automatically construct simple geometrical models from aerial pictures. In any case, the objective is to produce a simple volumetric model of the building.

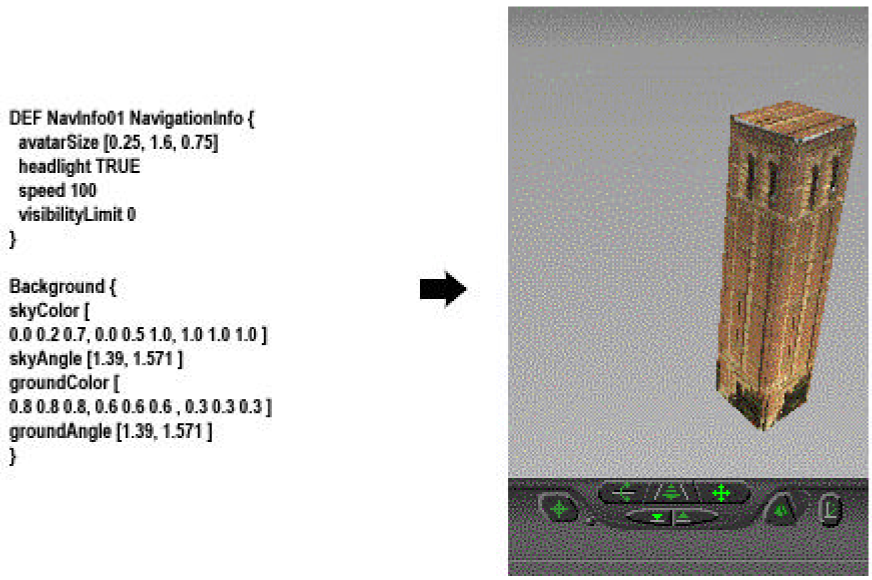
In the next stage, the image map of the elevation is mapped to each surface of the volumetric model. The textured model is then converted to a virtual reality modeling language format (VRML).



At this stage, VRML features are added to the model. Some of these are:

Sound recordings of guided tours about the building, music files, or simple sound recordings of people in the building.

Information about the building in the form of text displayed on the screen as the mouse is moved on top of each building.
Hyperlinks to other (Hyper Text Markup Language) HTML or VRML files that are related to the building. Examples of HTML files are spreadsheets with facilities management information about the building, or links to services that this building provides such as tickets, forms, invoices, etc.
All this information is displayed through an Internet browser as shown below:



4. TECHNIQUES

One of the main challenges of the proposed scheme is to develop the best possible interface for visualizing 3D information over the Internet on simple inexpensive personal computers. For that purpose a series of techniques for modeling efficiently virtual reality projects producing relatively small and easy to handle files incorporating new techniques for interaction have been developed. Specifically, the following techniques have been used:

File optimization.
Models are optimized to use the least number of polygon needed, the least number of points or subdivisions on each polygon, and the minimum resolution for the image maps.

Levels of detail (LOD) on-demand.

Detailed versions of the same scene can be loaded only when needed by setting trigger or proximity sensors. These sensors cause scenes to be loaded only when they are needed so that they do not overload the system.

Data abstraction
Important objects or groups of objects can be pointed out by using brighter materials or eliminating the presence of background data. This is done by accessing the nodes of VRML and setting their parameters.

HTML to VRML communication and vice-versa
Using Java classes and scripts a library of interface connections has been produced allowing interaction between hypertext commands and VRML nodes. This allows text in HTML to affect nodes in VRML and vice-versa, VRML nodes to cause HTML frames to appear.

Built-in-code animation.
Animation sequences are produced that are part of the object code and do not appear in the VRML code. This technique allows animations to be produced "on the fly".

5. SCHEME

A scheme for a 3D VRML-based database of models is proposed. It provides the main guidelines, protocols, and structure of a 3D world so users can plug-in their VRML model. The framework provides a prototype of a 3D model of the United States to be used as a navigating, searching, and learning tool. The objective is to create a VRML version of the United States territory, with cities, building blocks, and streets so that individuals, companies, or organizations can place their own 3D home pages at their corresponding geographical location. The project may resemble a search engine. The only difference would be that the users would navigate to their target geographically as opposed to through text. Users will be looking for something on the basis of its physical location in the US. This will enable users to find information and to visualize it in its actual location. Of course this does not eliminate the use of text-based searches but rather complements that. The advantages of such a search is that:

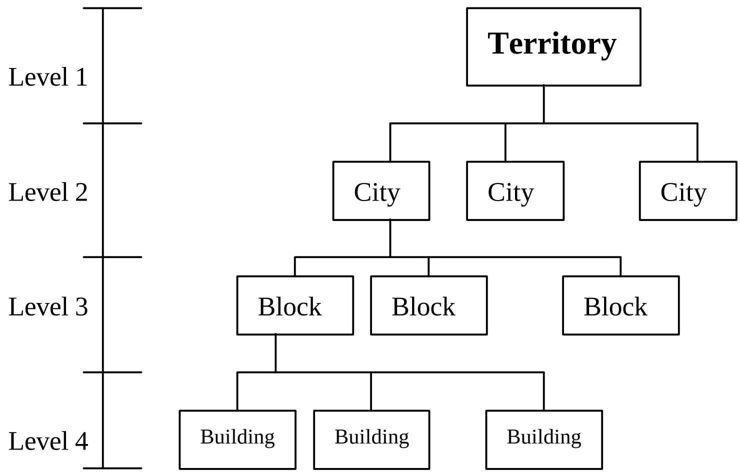
- Information corresponds directly to physical space
- Information can be visualized and remembered easier
- Updates on the physical environment corresponds directly to the virtual environment

The scheme is implemented through a case study. In this case study, a specific example is implemented in order to show how the general scheme will work. In particular, a four-level scheme for building, viewing, and searching faster and more efficiently through large 3D databases has been developed. The interface for searching has been developed experimentally in four levels of detail:

- The overall territory (United States)

- The city level (Los Angeles)
- The building block level (UCLA)
- The building level (Royce Hall)

The structure of the levels of details described above is shown below:



Each of these levels will be discussed in the following sections.

4. CASE STUDY

As discussed earlier in the previous section, the plan is to develop multiple levels of detail for searching faster and more efficiently through large 3D databases. The interface for searching will be developed experimentally in four levels of detail. Each of these levels is discussed in the following sections:

4.1. Level 1 (US Territory)

A 3D model of the United States in VRML 2.0 format has been developed. The model includes:

- all interstate, U.S. highways, and major routes,
- territories for each state
- all major cities

The model is presented as a combination of VRML and HTML frames that communicate through External Authoring Interfaces (EAI). These interfaces consist of the following functions:

- Viewpoints for all major cities
- Animated viewpoints for every road
- Voice narratives explaining directions and giving hints.
- Hide/Show for all elements and/or groups in the model
- Environmental conditions (day, night, sunset)

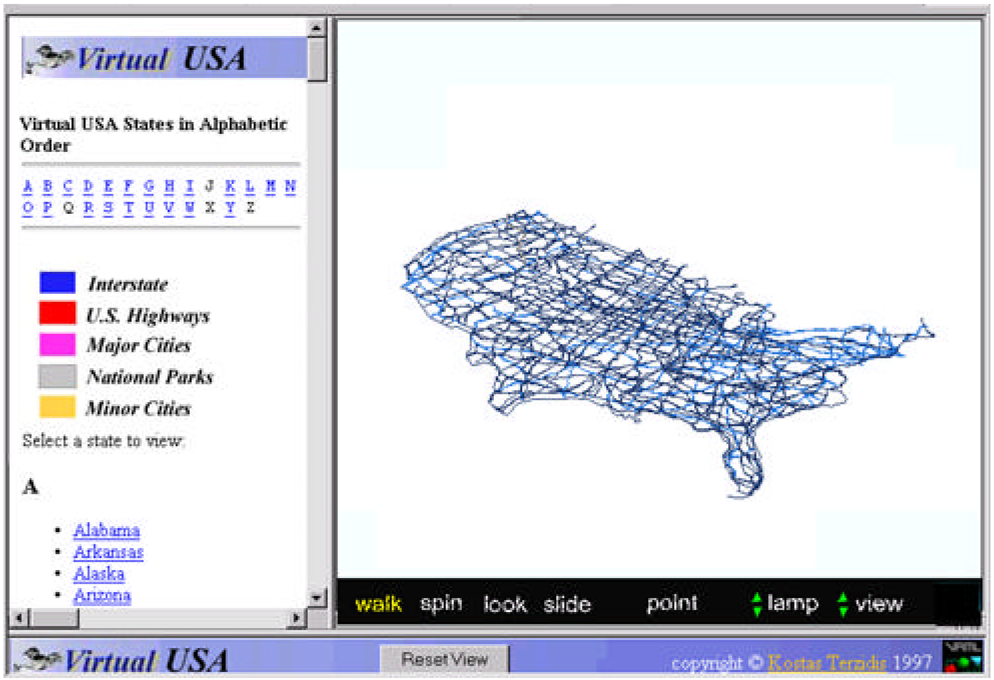


Figure 4.1-1. Interface for the United States territory

4.2. Level 2 (City)

On a second stage, proximity triggers have been implemented that load externally referenced detailed versions of major cities (in VRML terminology referred to as *inlines*). As someone approaches a major city, another VRML model of that city is loaded and the user continues the navigation on within the newly load city on higher resolution.

A 3D model of Los Angeles in VRML 2.0 format have been developed. The model includes:

- all interstate, U.S. highways, and major routes, and streets
- territories for each sub-city
- all major satellite-cities

Each model is presented as a combination of VRML and HTML frames that communicate through External Authoring Interfaces (EAI). These interfaces consist of the following functions:

- Viewpoints for all major cities

- Animated viewpoints for every road
- Voice narratives explaining directions and giving hints.
- Hide/Show for all elements and/or groups in the model
- Environmental conditions (day, night, sunset)

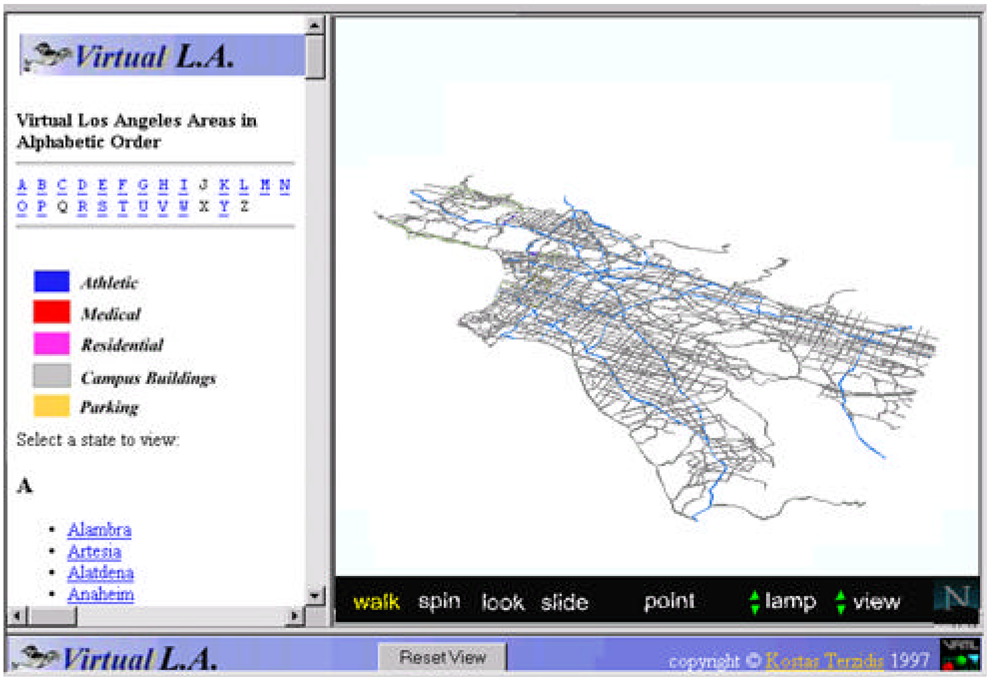


Figure 4.2-1. Interface for the Los Angeles area

4.3. Level 3 (Building Block)

On a third stage, proximity triggers are implemented that load externally referenced detailed versions of sub-areas within the eleven cities mentioned earlier. These areas are: downtown areas, Universities, Shopping Malls, Stadiums/Golf courses, and Museums. As someone approaches an area of a city, another VRML model of that area is loaded and the user continues the navigation on within the newly loaded area on higher resolution.

A 3D model of three areas within the Los Angeles basin have been developed: UCLA campus, Beverly Hills shopping area, and the Getty museum complex. Each model includes:

- All streets, and buildings within the area (in volumetric format)
- Street fixtures, billboards, and trees

Each model is presented as a combination of VRML and HTML frames that communicate through External Authoring Interfaces (EAI). These interfaces consist of the following functions:

- Viewpoints for all major cities
- Animated viewpoints for every road
- Voice narratives explaining directions and giving hints.
- Hide/Show for all elements and/or groups in the model
- Environmental conditions (day, night, sunset)

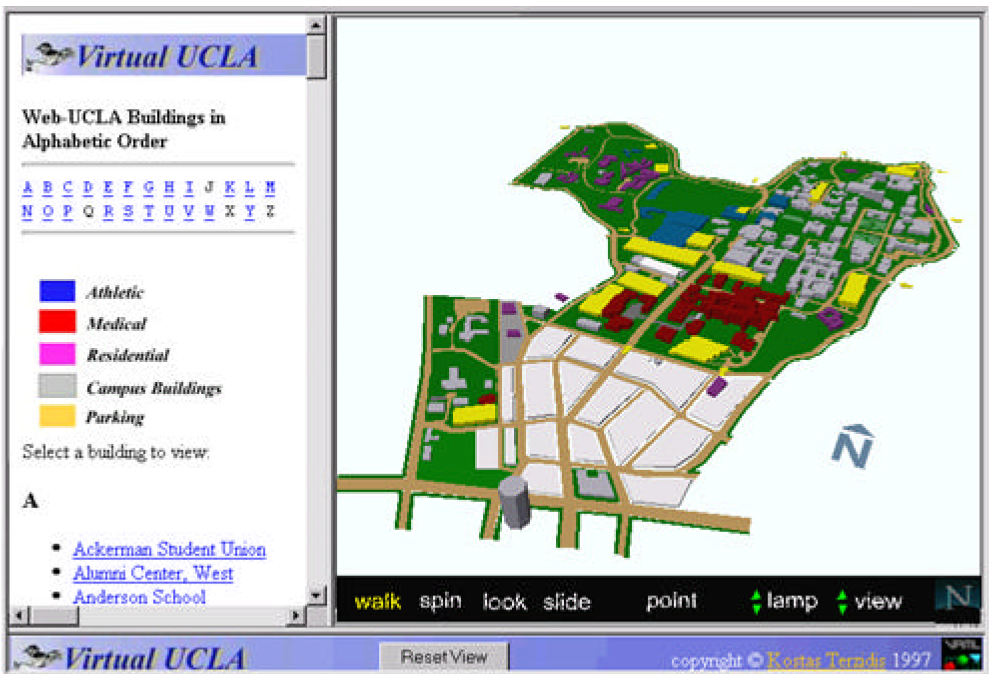


Figure 4.3-1. Interface for the UCLA campus

4.4. Level 4 (Building)

In the fourth level, proximity triggers are implemented that load external referenced detailed versions of buildings within the building blocks mentioned earlier. The buildings are skyscrapers, housing units, institutions, athletic facilities, industrial plants, etc. As someone approaches a building block, another VRML model of that building are loaded and the user continue the navigation on within the newly loaded area on higher resolution.

A 3D model of four buildings within the city of Los Angeles are developed: the Getty Museum, UCLA's Medical Center, UCLA's tennis center and UCLA's Royce Hall. Each model includes:

- Floors, roofs, walls, doors, windows, stairs, and textures.

Each model is presented as a combination of VRML and HTML frames that communicate through External Authoring Interfaces (EAI). These interfaces consist of the following functions:

- Viewpoints for all major views
- Animated viewpoints for every point of interest
- Voice narratives explaining directions and giving hints.
- Hide/Show for all elements and/or groups in the model
- Environmental conditions (day, night, sunset)

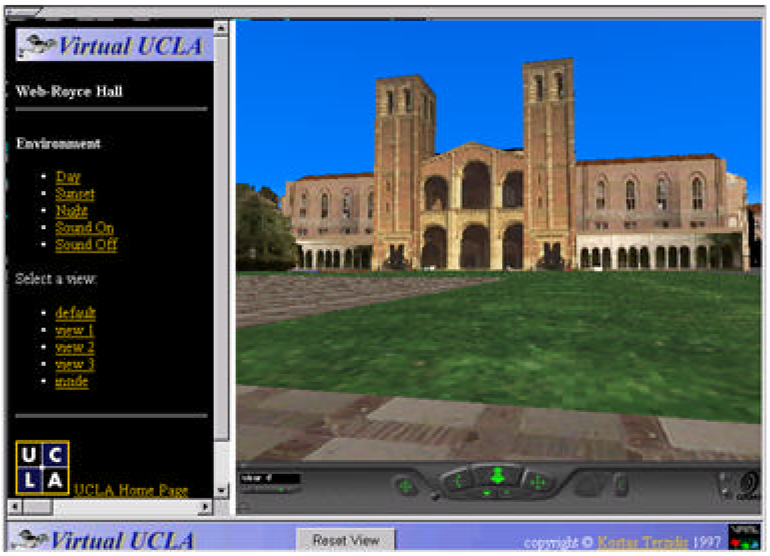


Figure 4.3-1. Interface for UCLA's Royce Hall

5. SUMMARY

A fast, efficient, and friendly ways of interaction with the Internet is provided. The combination of 3D worlds with 2D text-based homepages offers an impressive, unique, and attractive possibility for experiencing the Internet in a different way.

Some of the applications that this technology can offer are:

- Movie and Cinema Theaters
- Virtual Malls
- Architecture and Urban Design
- Tour guides and Events

One of the main advantages of VRML is the ability to interact with constantly updated information provided on the Internet. On a single CD-ROM environment users may be experiencing higher speeds and faster responses their information however is bounded within that particular CD-ROM. No information can come in or out.

REFERENCES

[1] Fukai, D.(1997)PCIS: a piece-based construction information system on the world wide web, *Automation in Construction* **6**, pp.287-298

[2] Liggett, R. and W. Jepson (1995) An Integrated Environment for Urban Simulation. *Environment and Planning b* **22**, pp.291-305

[3] Liggett, R. and W. Jepson (1995) Implementing an integrated environment for urban simulation: CAD, visualization and GIS. In A. Koutamanis (ed) *Visual Data Bases*. Avebury.

[4] McCall R. and E. Johson (1997) Using argumentative agents to catalyze and support collaboration in design, *Automation in Construction* **6**, pp.299-309