Visualization System for Earth Environmental Data Base

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Abstract

The earth's environmental problems have attracted serious attention worldwide. Various kinds of environmental data, such as remote sensing data, have become available for examining. Although this data is crucial to understanding such problems, there has become an over-abundance in variety of size, format, and filetype which makes it difficult for researchers to handle. We feel that earth environmental researchers should not be burdened by such cumbersome tasks. Therefore, we are developing a digital library for earth environmental information and a VRML based data visualization system for it. Even now, content-based image retrieval systems have many problems attributed to the degree of difficulty in implementing them. Thus, we are trying to visualize this data so that researchers can utilize it more efficiently, effectively, and easily.

A great advantage for VRML users is that people can see environmental data from any perspective above the earth and with any resolution easily. Also by using MPEG-movie, users can observe the changes of data drawn from time series files.

1. Introduction

The alarm rang loud and clear almost three decades ago that mankind was capable of, and was well on his way to killing out planet. Unchecked advantages in technology and production, which should great promise in raising our standards of living, ironically became the evil agents of destruction which threatened out very existence.

Environmentalists, scientists, and others who became enlightened as to the woeful plight of earth first sounded the warning, then began to look to technology and information as our only hope of averting our seemingly inevitable extinction. Their exhaustive investigation to find the cause and effects of the earth's problems has led to the gathering of vast amounts of environmental observations.

State-of-the-art techniques such as remote sensing, became indispensable tools for collecting information. This information, which assimilated and assembled properly, holds a critical key to the earth's futures. Man is now well within his means to right the wrongs of his unbridled and ruinous past.

Recently, a new problem has arisen regarding the huge amounts of information now available to researchers. This has been caused by the great variety of size, format, and filetype of this information. American vice-president Albert Gore has said that much of this information lies dormant and unused. Earth environmental researchers have become overwhelmed by the handling and keeping of this data. Scientists have been finding it quite difficult to use content-based retrieval systems.

In this paper, we will describe out digital library for earth environmental information and a VRML (Virtual Reality Modeling Language) based data visualization system for use with this library.

Instead of the system currently in use, we are trying to visualize the data so researchers can view it more easily, via the WWW. Because of the user-friendly nature and international popularity of the Internet, we feel that even those who are not computer specialists will be able to draw information from even the most obscure sources with relative ease.

Our interface is based on VRML, which makes it possible for users to see environmental data from any angle of perspectives and with any resolution by using a WWW browser and a VRML viewer. The user can virtually hover anywhere in the sky above the earth and gradually approach any area of the planet they desire. Also by using MPEG-movie, one can observe animated changes in data provided by times series files. We are able to serve about 1,000 kinds of data which has a volume of about 40GB(uncompressed) or about 12GB(compressed).

2. Designing and Implementation

As mentioned above, environmental data has so much volume that it needs a high performance server and a huge scale database system to service users easily and efficiently.

Our system design and implementation is as follows:

2.1. System Hardware and Software

- WWW, File Server: Sun Enterprise450(UltraSPARC-II x 4,512M memory)
- File System: Sun StorAdge A5000(250GB DiskArray)
  StorageTek D3 tape Jukebox(80TB)
  NCL Communications 8mm Tape Jukebox(10TB)
- HTTP Server Software: Apache-1.3.0 on Solaris 2.6

2.2. User Requirement

- WWW Browser based on JAVA 1.0 or higher
- VRML Viewer based on VRML2.0

2.3. System Structure

Our system structure is as follows;

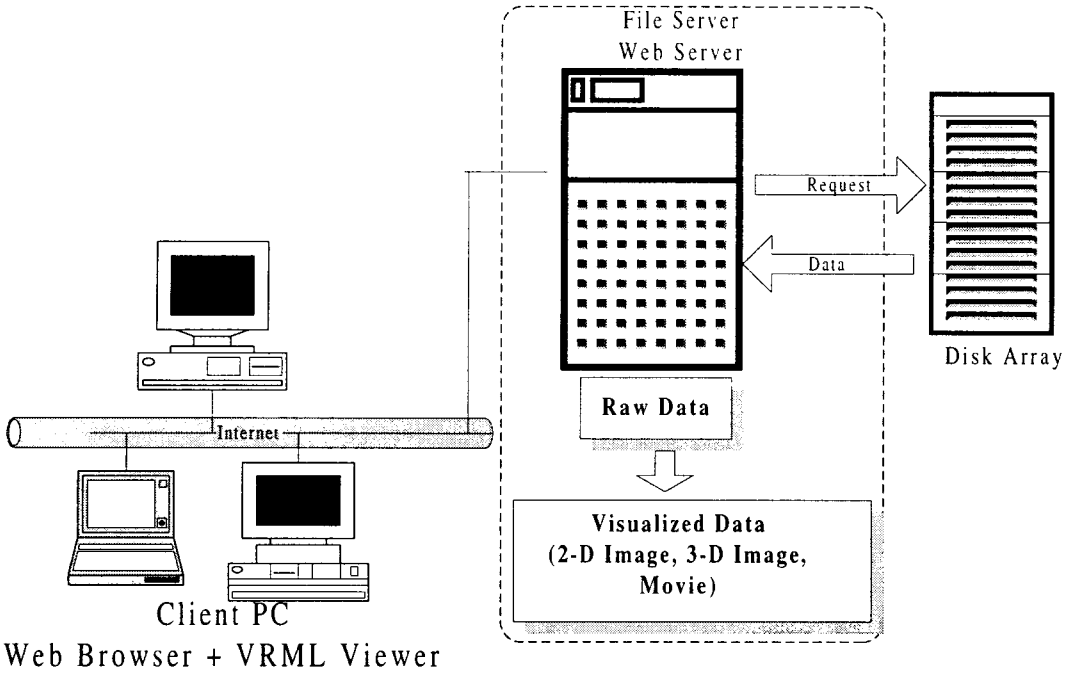

Figure 1 System Structure of Earth Environmental Data Base

Users access our server through the Internet. When our server receives a request, it searches and brings data from our filing system, calculates, then generates visualized images from raw data. This information is then sent back to the client's browser.

2.4. Available Data

- Global Data Sets for Land-Atmosphere Models
  - 600 kinds, 20000 files, 20GB(uncompressed)
- GSWP: Global Soil Wetness Project Data
  - 500 kinds, 10000 files, 10GB(uncompressed)
- GTOPO30:Global 30-Arc Second Land Elevation Grid Data
  - 40files,1.8GB(uncompressed)
- ETOPO5:5 Minute Land and Sea Elevation Grid Data

The total amount of our storing data is about 35GB. Several times this amount will be possible in the near future.

2.5. System Features

2.5.1. User-friendly Interface

We are servicing a user friendly interface using WWW, Java, and VRML. Operation

of this can almost be completely achieved with the simple use of a mouse. Graphical pages further aid understandability.

2.5.2. 3-Dimensional VRML image

Using VRML provides some great advantages as follows;

- Any Viewpoint

User can get various perspectives from any viewpoint, as if circling the globe in any orbit, enabling researchers to be virtually ubiquitous.

- Any Resolution, LOD(Level On Detail)

Observations of large areas from long distances don't usually require high resolution. Such information would be too voluminous and time-consuming to transfer. When more specific areas are focused upon, LOD enables our system to adjust and send more precise and higher resolution data.

- 3 dimensional imaging

When using a 2 dimensional image, a user can get only one perspective on a point of interest. With VRML, we can represent one more value using height information For example, users can observe land elevation data(represented by height information) and temperature data(represented by color) simultaneously.

2.5.3. Unified management of various data

In our system, we can handle various kinds of data with one program. When we store a new type of data, our program understands the data's header part, resolution type of number(integer or float, as a negative or positive number), image depth, and other information included in that data. In addition, we store both high resolution data and low resolution data for rapid response. Moreover, when the amount of high resolution data is too much, we can separate the file into parts, and use only that which pertains to the users' request.

2.5.4. Static image and time series movie

Users can get not only raw data and static images, but a time series movie as well. They can also get movie data mapped on earth with VRML. Users can also make simple adjustments in order to specify area, resolution, format, and time period and interval for movie. Using movie makes it quite helpful for understanding the dynamic changes through time, and for predicting future conditions.

2.5.5. Huge amount of file system

Such kind of data has so much volume that it needs a huge scale of file system. We are using a high performance disk array system(about 250GB) with a high speed interface(Fiber Channel, 100Mbit/sec) and we will use a tertiary file system. In order to implement tertiary storage, we are designing a hierarchical file system

using memory and disk array. The user will then be able to access more than 100TB of data contained in the tertiary system with the ease of accessing only one file system.

3. Examples of visualized image

Some examples of our Homepage we describe on this paper are as follows:

URL: http://hiroo.tkl.iis.u-tokyo.ac.jp/DV/

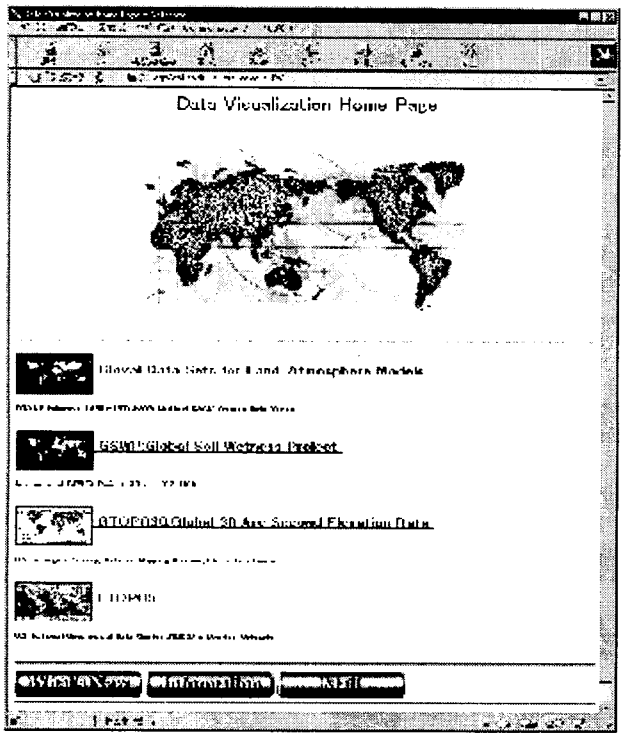

Figure 2 Top Page of our system

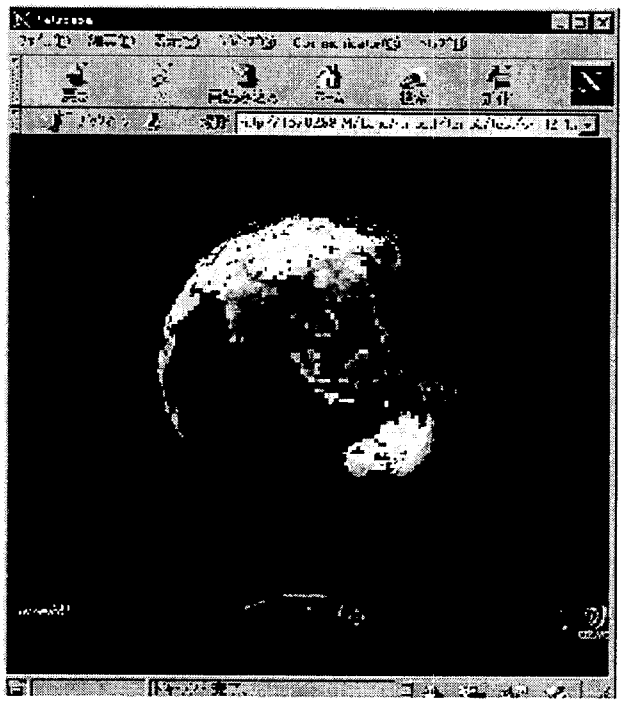

Figure 3 Texture mapped temperature data using VRML(user can see from any vantage point)

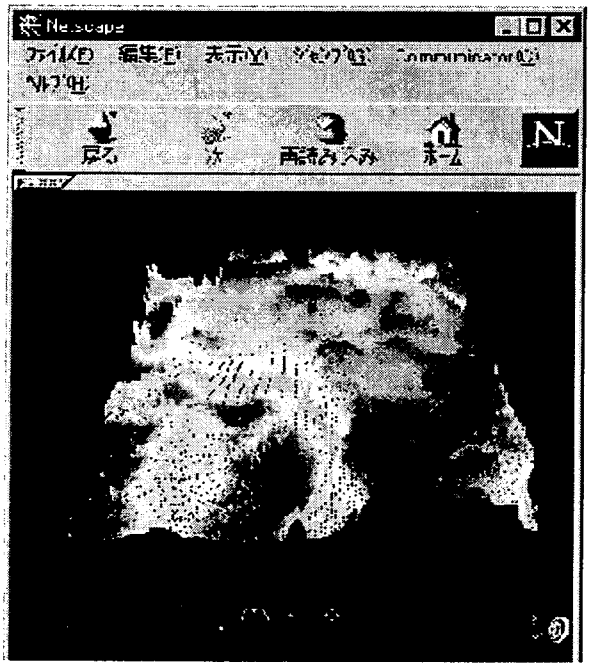

Figure 4 Elevation data at Africa

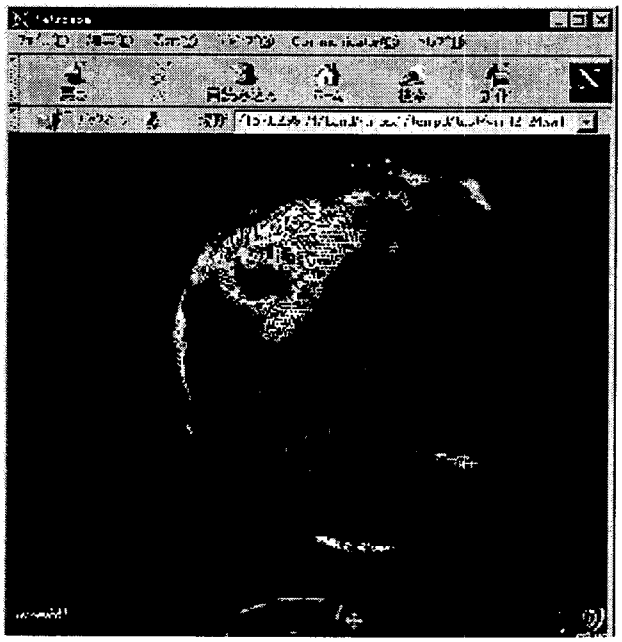

Figure 5 Surface Pressure

Figure 2 shows our top page. Figure 3 shows mean temperature data mapped on the earth. On this page, the user is able to virtually "travel" to obtain nearly infinite perspectives of the earth by navigating with a mouse. Figure 4 shows elevation data with height information, and Figure 5 shows whole world surface pressure data using a mesh image.

Unfortunately, we cannot show time series movie and 3-D navigation of VRML images on this "paper". We welcome you to experience this on our Homepage.

4. Conclusion

In this paper, we have described our digital library for earth environmental information and a VRML based data visualization system. Users can visualize their desired data as a 2-D image, 3-D image, movie, etc. with ease. Especially when using VRML, users can see data from any angle and with any resolution, even under a slow network environment, because of the use of LOD.

However, there are still some problems to solve. One of them is how to examine large amounts of data. For it, we are planning to introduce a tertiary storage system and some file management system for huge amounts of files, such as Oracle software. Another problem is creating a way to improve the contents. We will be able to store more kinds of data, and reexamine a more effective visualization method with VRML.

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