PORTABLE AND DESKTOP 3D WEATHER DATA VISUALIZATION SYSTEMS IN UNIX AND NON-UNIX ENVIRONMENTS

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ABSTRACT

The current research is aimed at designing a 3D weather data visualization system which is self-contained and self-sufficient, can function with or without a network connection to other computers, and has its own data visualization software, processing units, and data storage units. A desktop workstation and a portable laptop computer are being used for evaluating such a design.

The design uses a commercially available visualization system having library modules and user interfaces to build weather data analysis tools for displaying 3D graphics: iso-surfaces, contours, volumes, vectors, etc. These tools can be saved as a project that can be executed on computer platforms running UNIX and Windows operating systems. Research topics to be presented are: comparing performances of two computer platforms; integrating visualization and web techniques for interactive and cooperative visualization practices; presenting a visualization case study with mesoscale model generated data.

1. TODAY'S COMPUTATIONAL ENVIRONMENT

There are different computers and operating systems available today. We may simply categorize computers by platforms, by operating systems, or by implemented software systems. These can be categorized as being UNIX or non-UNIX, or whether they are portable or stationary units, as illustrated in Table 1. The stationary desktop-unit has been exemplified by most UNIX workstations, while the personal computers are notable for being stationary or portable. It is interesting to note that there are almost no portable UNIX systems available. In the past, UNIX and non-UNIX users were conceived as two different groups of people. However, the recent trend promoted by the World Wide Web and the advancing technologies makes the distinction between these two types of users disappear.

	UNIX	*Non-UNIX*
Portable	(SUN, etc.)	Personal computer, Mac
Desktop	SGI, SUN, HP, IBM, etc.	Personal computer, Mac

Table 1: Portable and Stationary Categories for UNIX and Non-UNIX Operating Systems

The available visualization systems shown in Table 2 are either commercial products such as AVS, Data Explorer and Explorer or non-commercial freeware such as Vis5D, and VTK (Schroeder, 1997). Table 2 shows that visualization systems are platform independent.

	UNIX	*Non-UNIX*
Portable	(NA)	AVS, Data Explorer, Explorer, Vis5D, VTK, etc.
Desktop	AVS, Data Explorer, Explorer, Vis5D, VTK, etc.	AVS, Data Explorer, Explorer, Vis5D, VTK, etc.

Table 2: Available Commercial and Non-Commercial Visualization systems

2. DATA VISUALIZATION SYSTEM DESIGN CONSIDERATIONS

It may be a common practice to design a visualization system with the following considerations:

1. Can it handle multi-dimensional visual objects?
2. Can it function with or without a network connection?
3. Does it have its own visualization software and computing power?
4. Is it a UNIX or Non-UNIX operating system?
5. Is it portable or desktop?

The first three questions will constitute the basic considerations for the design of a visualization system, and the fourth and fifth questions the preferences or availability of a visualization system. However, it may be more important first to address the issues of performance, connectivity, portability and interactivity. We shall examine these issues as follows:

2.1 Performance

Ten years ago, a typical visualization study was done with a supercomputer and a high-power workstation (Chen, 1989). The current high-end personal computers process at clock speeds exceeding 200 MHz, while previously this speed could only be achieved on supercomputers. At present, a typical personal computer has a cache memory of 32 megabytes and above, and a storage unit of one gigabyte or more; previously these were available only on workstations or supercomputers. Today, a personal computer can perform data visualization on the level of a workstation without significant degradation in performance and graphics quality. As a consequence, the performance issue is no longer platform dependent.

2.2 Connectivity

In the past the Internet was only available to computers using the UNIX operating system. Today personal computers are accessible to the Internet as well. This added connectivity provides personal computers with an easy access to large quantities of data from other computing platforms, or it can generate equally large amounts of graphics and visualization data for other computer platforms with high-speed connections.

2.3 Interactivity

Software systems that used to be available to workstations only are now available to personal computers as well. A typical example is OpenGL. OpenGL provides the rendering algorithms, which used to be available to the UNIX world only, but are now available to the personal computer world as well. A computing algorithm such as volume rendering, which requires a high-speed CPU, can also be performed at the personal computer level. This makes the design of a visualization system not any different from that of a workstation. Personal computer user interfaces include as much as what has been provided in the UNIX World before. Above all, the personal computer provides a rich set of user interfaces for developing applications. Therefore, in considering a visualization system, the personal computer can actually exhibit a good design.

2.4 Portability

The strength of the high-end personal computer lies in its availability as a portable system. This portability is missing in the UNIX environment, and it has already been discussed. The portable unit has its own data processing unit, data archive storage and software. The portable unit is independent and can be used individually as well as a connecting unit.

3. A DESIGN EXAMPLE AND ITS APPLICATIONS

In this research a functional prototype has been completed using the design concept and considerations discussed in Section 2. The prototype used here for demonstration is a portable meteorological data visualization system.

3.1 System description

This system uses a laptop personal computer with a Windows 95 operating system and an AVS/Express visualization system. AVS/Express is used for designing end-user products, and it features library modules ready for the user's implementation. This design uses library modules and a user interface kit to build weather data analysis tools; it can display 3D graphics: iso-surfaces, contours, volumes, vectors, streamlines, etc.; and it can save a project that can be executed on computer platforms running UNIX and Windows operating systems.

3.2 Applications

The system designed is applied to build a data visualization system for a numerical weather prediction model—Mesoscale Model version 5, MM5 (Grell et. al., 1993) from the National Center for Atmospheric Research (NCAR). The same model has been used for previous research studies conducted by the author (Chen 1996, 1997). This model has been used for data generated by supercomputers and workstations. The generated data consist of (hourly) velocity, temperature, pressure, water vapor, cloud water, rain water, etc.

The visualization techniques have been developed by using the AVS/Express network editor. These techniques have been used previously. They are using basic visual objects, for example, iso-surface and iso-volume for scalar parameters such as temperature and water vapor, and vector display for vector parameters such as winds. Examples are the cloud water field iso-surfaces as shown in Figure 1, and the wind vectors in Figure 2. A composite analysis showing more than one field is being used in the present study for tracking a weather system development. An example is shown in Figure 3.

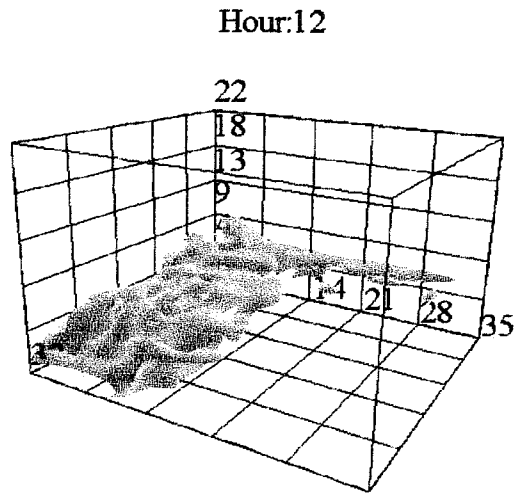

Figure 1 Cloud Water Iso-Surface

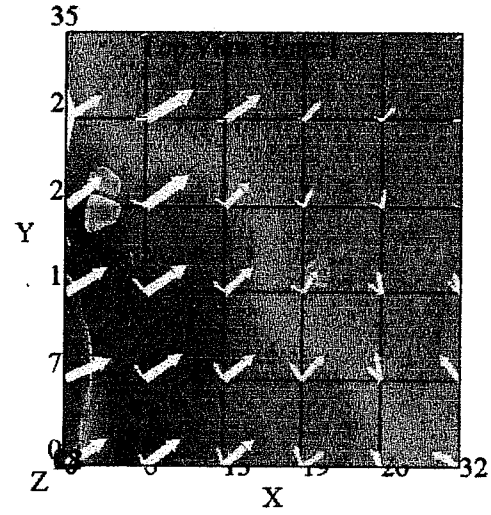

Figure 2 Wind Vectors on Layers 1 and 13

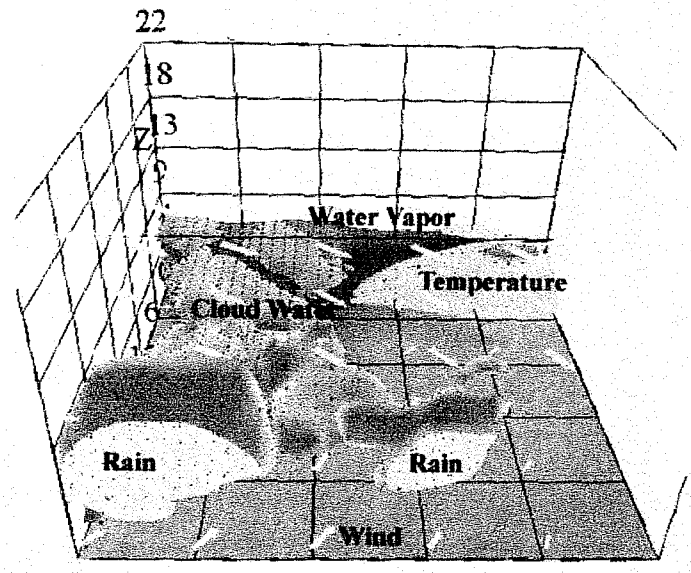

Figure 3 Composite Analysis.

The same composite analysis was conducted in previous studies (Chen 1996, 1997). However, it must be pointed out that improved efficiency of the visualization system and better computing power have made the composite analysis much more feasible than before. The previous studies showed that even while using a high-end UNIX workstation with an older version of AVS/Express, the composite analysis was not easy for an interactive visualization with displayed multiple parameters.

The playing of a time-animation of the composite visual objects while executing an AVS/Express project was also slow, as noted in the previous studies. Composite time-animation was done with the recording of a sequence of images produced by the AVS/Express project (or network). The images were then played as a flipbook, using a technique such as GIF89a (a GIF file consisting of time-sequenced images) or Java animation applet. An example of GIF89a can be found on a web site (Chen, 1997b).

It is now possible to do a time-animation while executing an AVS/Express project. With a portable personal computer, an interactive visualization session can be done even though it shows a slight hesitation during an animated sequence. To illustrate the expedience of the personal computer visualization system, a live demonstration of a time-animation has already been shown at the workshop in November, 1997.

For a superior efficiency, a time-animation flipbook can be constructed using AVS/Express image processing and display modules. In the future, a new animator will be featured for recording the animation to a web accessible file such as AVI.

4. PERSONAL COMPUTER SYSTEM VERSUS UNIX WORKSTATION SYSTEM IN WORLD WIDE WEB ENVIRONMENT

Previously, scientific visualization was conducted mostly by trained professionals with very specific research and application purposes in mind. The computer software and hardware used were mostly based on UNIX operations because the computers used are mostly UNIX workstations.

The World Wide Web provides access of information and data that is available to users other than trained professionals and to computers that are not restricted to UNIX workstations only. Personal computers are also becoming acceptable for professionals conducting visualization. The population in general is now using personal computers. The changes in information and data access also stimulate the changes in the design of computing-visualization systems. With these system requirement changes, we will have to pay attention to information generation, access, and dissemination.

4.1 Information generation

A personal computer could be used in the current research to generate weather visualization data. However, MM5 was coded for UNIX workstations exclusively, and it is not portable to the Windows or personal computer UNIX (Linux) systems. In the future, a public domain software system such as MM5 might become available in the personal computer environment. A personal computer can definitely generate the necessary data for visualization.

4.2 Information access

The current research uses ftp to access generated time-dependent raw (grid) data from a UNIX workstation. A previous research (Chen, 1997) has shown that a web page can be designed for accessing these data.

4.3 Information dissemination

The current visualization system can generate web compatible files including: animation in GIF, QuickTime, or AVI movie formats; image files in GIF or JPEG formats; and VRML object files. Webpages can be designed for displaying these files or for users to download these files.

5. FUTURE OF COMPUTING-VISUALIZATION

Future computing-visualization systems may not be confined to a single computer platform and a unique operating system, or a unique software system. Rather, they will be a mixture of all computer platforms, all operating systems, and all software systems that will coexist for a while. They will have to go through an evolution, so that the systems will fit the need of the users.

5.1 Computing platform and software evolution

The difference between a workstation and a personal computer lies mostly in their operating systems: namely UNIX and Windows. However, a personal computer can now execute software systems previously designed for UNIX. While theoretically a personal computer can implement UNIX, it is not compelled to do so. Many visualization systems, including AVS, VTK, Vis5D, are available in multi-platforms, and operate equally well on all platforms. The executional efficiency lies with the computer processing power, and not with the kind of platform.

5.2 Data visualization scenario

The future visualization may be completely different from that of today. A new Web based operating system, possibly from the fusion of the UNIX and Windows operating system with user interfaces based on Java and VRML, may favor the way visualization will be conducted in the World Wide Web environment.

A weather simulation-visualization scenario in the future may present itself as follows:

- A user may access a set of simulated weather data from an agency or an institute
- The user may start a visualization session by sending requests through a web page inquiry, or may start the visualization session locally at the users computer
- The visualization session will produce pictures, movies, and user compiled text information, and these data will be disseminated by the user through the Internet to other users

6. CONCLUSIONS

It is possible to design a visualization system using a portable computer comparable to a workstation system. The design criteria are processing power, interactivity, connectivity, and portability. The design calls less for operating systems or computer platforms. Future visualization systems will evolve around the advancement of the World Wide Web technology

7. ACKNOWLEDGMENT

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