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DEVELOPING SAVE; A WEB BASED APPLICATION FOR RISK COMMUNICATION USING VIRTUAL REALITY FOR EARTHQUAKE ENGINEERS: TOWARDS COMMUNICATION TO THE PUBLIC

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SUMMARY

Rapid growth computer technologies, especially the Internet provide human beings new measures to deal with engineering and social problems which were hard to solve in traditional ways. This paper presents a prototype of an application platform based on the Internet for civil engineering considering building an information system of risk communication and disaster mitigation for metropolises.

INTRODUCTION

Traditional computer applications in civil engineering are mainly for analysis, design and construction of buildings and other structures, which are basic components of social infrastructures. No doubt computer technology has been promoting productivities in the engineering aspect, but few successful efforts have been made in solving social and human related problems, such as disaster mitigation in cases of earthquakes, fires etc.. On reviewing state-of-the-art computer techniques and relative applications, this paper discusses problems and challenges concerning implementing an information system of disaster mitigation for metropolises. Then, the paper presents a prototype of an Internet oriented platform with an initial implementation using Virtual Reality (VR).

A BRIEF REVIEW

In addition to conduct numerical computations, one of the most important and exciting technology for engineering application might be man-machine interface, or most commonly called user interface (UI) or graphical user interface (GUI). Tremendous efforts have been made to achieve good communication between human beings and computers since the initial work of computer graphics from later '60. Virtual Reality (VR), which becomes more popular recently, is one of the most important technologies Donale [1]. VR through the Internet has been noticed as an important technique for human-computer interaction

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Shackel [2]. Efforts have been made to promote human interactions with computer based systems more effective and smooth using techniques including VR Agah [3].

Engineering oriented applications have also employed VR technique for presentations and interactions. Reference Ryken [4] used a CAVE (CAVE Automatic Virtual Environment) to implement an interactive finite element analysis (FEA) system, which can provide an easy way to access numerical results visually. Reference Wasfy [5] implemented a virtual wind tunnel for dynamic visualization of CFD (Computational Fluid Dynamics) using immersive virtual environments. VR utilized in landscape visualization has great potential to generate practical panorama representation to serve architects Danahy [6]. Reference Honjo [7] introduced a system for landscape design using Virtual Reality Modeling Language (VRML) on the web. To combine with web based Geographic Information Systems (GIS), Reference Dodge [8] discussed about to build virtual cities on the web with a project of Virtual London.

While virtual reality aims to create pure artificial world, another useful technique named augmented reality (AR) supplements the real world with coexisted computer-generated virtual objects Azuma [9]. Reference Billinghurst [10] showed an interesting application, the MagicBook, which has potentials in education as well as engineering applications. Some techniques for refining the user interface of mobile augmented reality systems were presented in Reference Höllerer [11].

As the VR technology becomes mature, especially with the promotion of the Internet based technologies such as VRML, which allows navigation and simple interaction with 3D world on general PCs, people are thinking more about simulations of the real world and society. Reference Schroeder [12] examined a multi-user virtual environment over the Internet, the Active-worlds, which allows people to build their own world and can simulate geographic and social interactions in a simple level that reflects to the real world. As an example of engineering applications, Reference Christiansson [13] described concepts of the virtual building from design, construction and maintenance perspectives. The virtual building was defined as "a formalized digital description of an existing or planned building which can be used to fully simulate and communicate the behavior of the real building in its expected contexts". It can be seen that continuous endeavors are needed to achieve the target.

In a brief, techniques for user interface, such as VR, are more popular, powerful and affordable. On the other hand, the popularity of the Internet makes unprecedented opportunities for distributed communications between men and machines.

Traditional applications in civil engineering, such as structure analysis and design systems take GUI technique from Computer Aided Design (CAD) as core parts of applications Zhu [14]. Though a lot of details from analysis, design and construction are involved in applications, it is difficult to reuse and share the data resource as it is expected by implementing the virtual building. To separate data resource from applications based on web environment and techniques might be a good attempt to promote both a versatile data resource and flexible applications.

To build an application platform for disaster mitigation in metropolises, state-of-the-art computer techniques, notably the Internet and VR technologies, as it can be seen from the above review, provide more opportunities for making a complex system which is capable to solve both engineering and social problems.

TOWARDS DISASTER MITIGATION IN METROPOLISES

Computer applications in civil engineering are relatively less advanced comparing with other areas, such as mechanics. This does not mean that problems in civil engineering are simple. In fact, engineering codes, which design and construction works base on, ‘filter’ excessive complexities from nature and structures by statistics and past experiences and simplify design procedures. But natural disasters, such as earthquakes, fires, floods etc., again and again teach people more that their experiences and efforts are insufficient to protect social properties and human lives.

To take severe earthquakes as an example, catastrophic economic losses around the world are huge and increasing in last decade. The 1995 earthquake in Kobe, Japan (Fig. 1) and the 1999 earthquake in Chi Chi, Taiwan, for instance, caused losses about $120 and $10 billion respectively. Loss estimates for a repeat of the 1923 Tokyo earthquake exceed $1 trillion EERI [15]. Metropolises are vulnerable under attacks of severe earthquakes. The disaster causes not only damage to buildings, structures but problems in society.

Earthquakes, as a kind of natural catastrophe, are of low frequency but high consequence. It is difficult to accumulate experiences. Though proper handling of seismic behavior of a building or a structure is essential, it is still quite a local issue on concerning disaster mitigation for metropolises. During the 1995 Kobe earthquake, the traffic service system in the emergency situation experienced substantial difficulties as considerable damage happened in elevated bridges (Fig. 1) CHBNE [16]. Collapsed buildings can also block roads. Fires during the earthquake may ruin several areas within a city for lack of emergent rescue (Fig. 2).

Fig. 1 Collapse of Timber Houses in 1995 Kobe earthquake

All the above-mentioned issues will cause losses of lives directly or indirectly. During an earthquake, city infrastructures such as power supply, electronic communication etc. might be out of their functions. Communication with the public becomes quite important for saving lives and keeping order of the society. To find efficient ways for communication should be a problem.

On conducting an information system of risk communication and disaster mitigation for metropolises, following basic targets are set so far as concerned for the application platform:

1) High precise simulation for natural disasters (such as earthquake generator according to faults) and structures (such as recreation of damage and collapses of structures)

2) Integrated applications and data which can represent major factors of infrastructures for a living metropolis

3) Be capable of providing and distributing information, which is useful to and can be easily, accessed by estate owners, city administrators and the public, establishing mechanism to communicate with the public.

The platform is targeted to provide information for all the stages of before, during and after disaster happenings in metropolises.

Fig. 2 Areas damaged by fires during the Kobe earthquake

PROTOTYEP OF THE APPLICATION PLATFORM

To achieve targets of the application platform for disaster mitigation, nowadays advanced computer technologies, as reviewed in previous part of this paper, can help people to cope with engineering and social problems which were hard to solve in traditional ways. A distributed application platform based on the Internet is a reasonable solution for hosting such a complex system with versatile resources. Furthermore, the Virtual Reality (VR) technology, which becomes more mature, can play an important role on performing 3D detailed presentation for various purposes.

It can be seen, to establish an information system of risk communication and disaster mitigation for metropolises, a complex system is needed. To meet targets set for the application platform, following functions are concerned for implementation:

1) Data management, to collect and to keep updating data (geographical, structural data etc.) with unified format.

2) Precise simulation of physical phenomena and consequences, including ground motion, structure seismic response, fire etc. in both macro and micro levels.

3) Evaluation of damage and economic losses based on simulations from scenarios.

4) Presentation and communication, to show results to different audiences (such as professionals, governors, estate owners and the public) with different methods; to collect information from the public.

5) Integration of the system, to bring all the above together for a living system.

6) Robustness, performance of the system and ways of communication during occurrences of disasters

Fig. 3 illustrates concepts of this platform. Each functional parts are liked together without considering their physical locations. General audiences have their entry point at a web server with web browsers and client-end applets and applications; while professionals can utilize resources along with the platform, such as to access databases, to invoke dense computations and to cooperate with others.

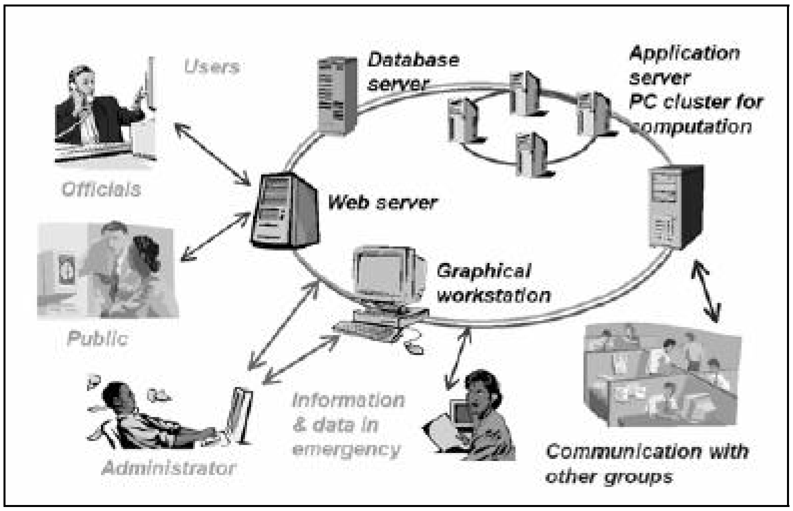

Fig. 3 A perspective view of the distributed platform

The above picture shows still simple and basic ideas for conducting the system. To introduce the Internet into the system is not only for it can integrate resources and applications for a collaborative solution but also for it can be an effective way of reciprocal communication in a society.

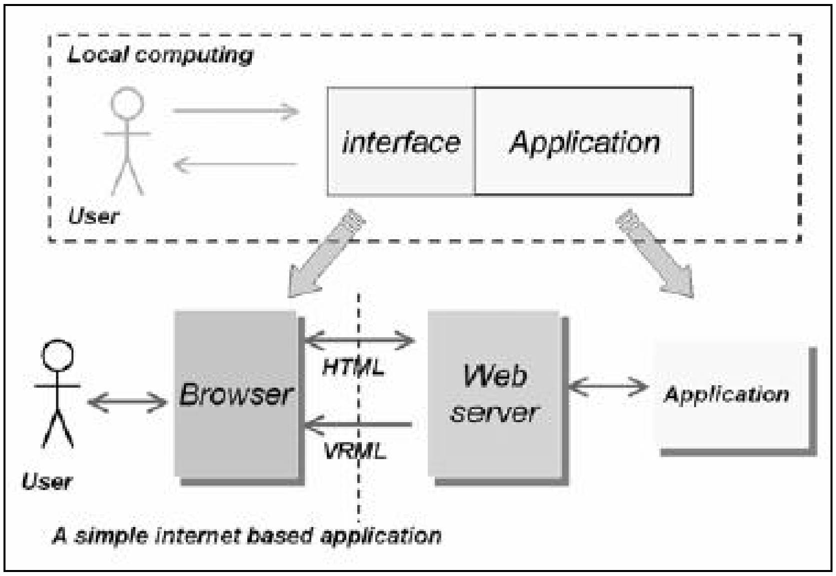

Fig. 4 A simplified application prototype

Traditional applications (such as a seismic analysis program) provide solutions, as shown in the upper part of Fig. 4, by local computation, which means both user and machine are in a same physical location. To shift traditional applications into a web-oriented environment, generally speaking, interfaces should be separated from the main applications and the interface for output should be able to perform on the client end (Fig. 4). This makes it possible for people to access applications from the web.

In a complex system, no single application can complete the task for final solutions. Fig. 5 shows a distributed environment based on the web. For communications between applications at server's part and also between client-end applets/applications and server applications, XML (Extensible Markup Language) will play an important role. XML has been claimed the most exciting and significant thing to hit the Internet since HTML. XML is a metamarkup language by providing arbitrary structures for one to make his/her own markup language. For sharing data among applications for seismic analysis, a special XML, which might be called Structure XML or StructureML, can be initiated for purposes of structure analyses, damage evaluation, result presentation etc..

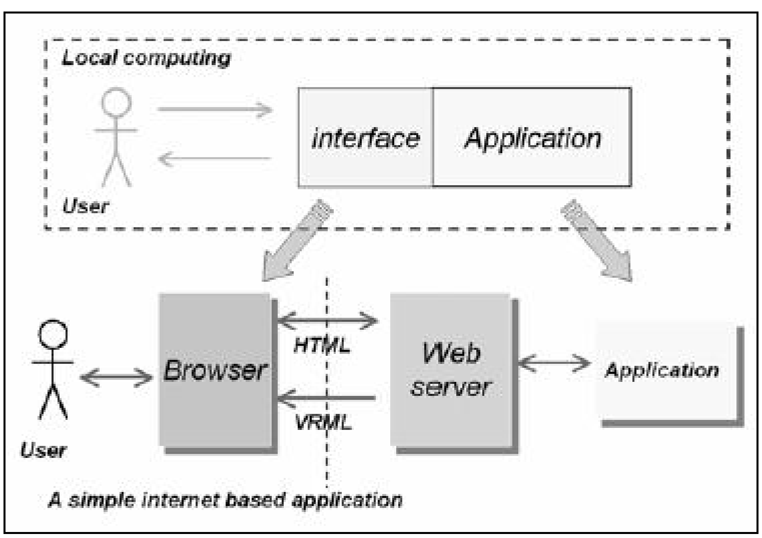

Fig. 5 Distributed applications on web

SIMPLE IMPLEMENTATIONS WITH VR

As a first step towards developing this platform, a post-processor of a dynamic structure analysis program has been implemented with VR based on simple web application.
The term of Virtual Reality originally referred to Immersive Virtual Reality, which means that users become fully immersed in an artificial 3D world that is completed generated by computers. Nowadays, the term VR is also used for applications without fully immersive. The boundaries are becoming blurred.

A practical way to perform VR, especially along the Internet, is to use VRML, which stands for Virtual Reality Modeling Language [17], [18]. VRML is an open standard for 3D multimedia and shared virtual worlds on the Internet (ISO/IEC 14772-1: 1997). It is the de facto standard for sharing data between CAD (3D modeling) and animation programs. VRML is a text based scene description language. It is not a programming language but can have scripts, like JavaScript.

VRML can be used to present structures and to convey 3D scene from the Internet. Fig. 6 shows a VR device to simulate the SAVE models in 3D. The SAVE models can be displayed interactively using a web browser with a VRML plug-in too.

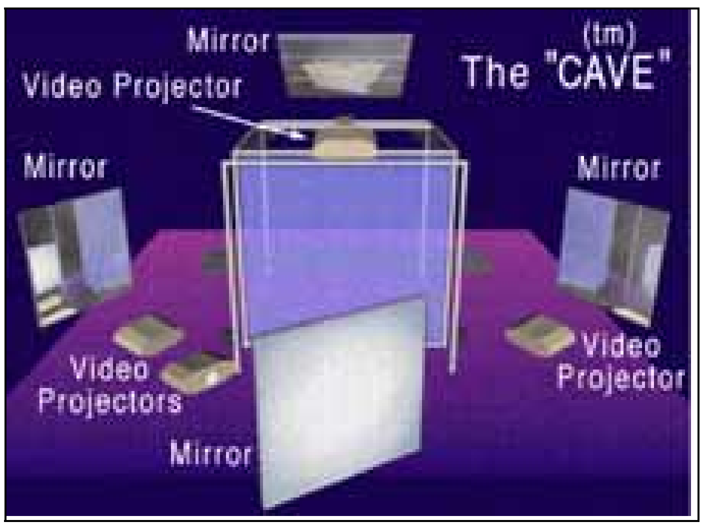

Fig. 6 CABIN is a set of big screens that can display SAVE in real 3D world (installed at Tokyo University, IML)

Animations of vibration due to earthquake in SAVE can be seen through a VRML viewing tool, such as a web browser with VRML plug-in (Fig. 7, 8). Good results are obtained on promoting seismic response presentations using VRML. Users can navigate through the scene to find more details of seismic response of the bridge, which are difficult to be acquainted by traditional 2D charts.

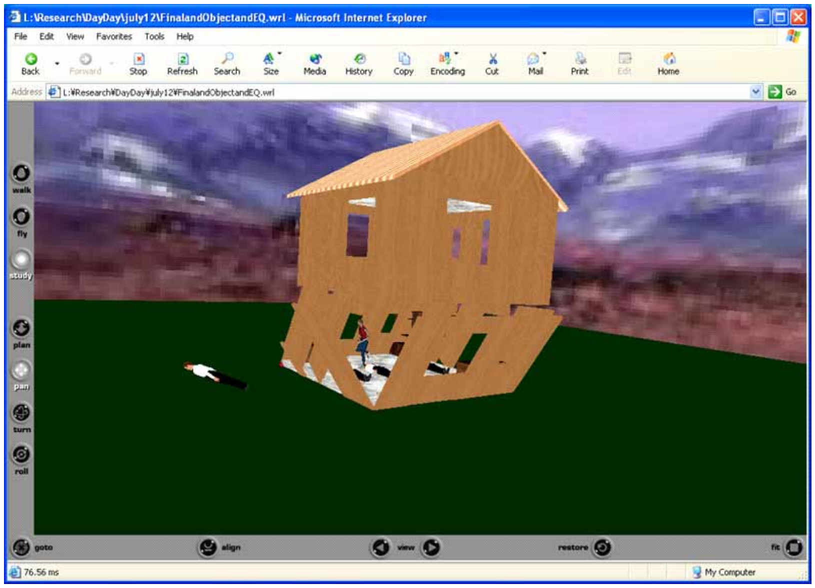

Fig. 7 Seismic analysis of a Timber House

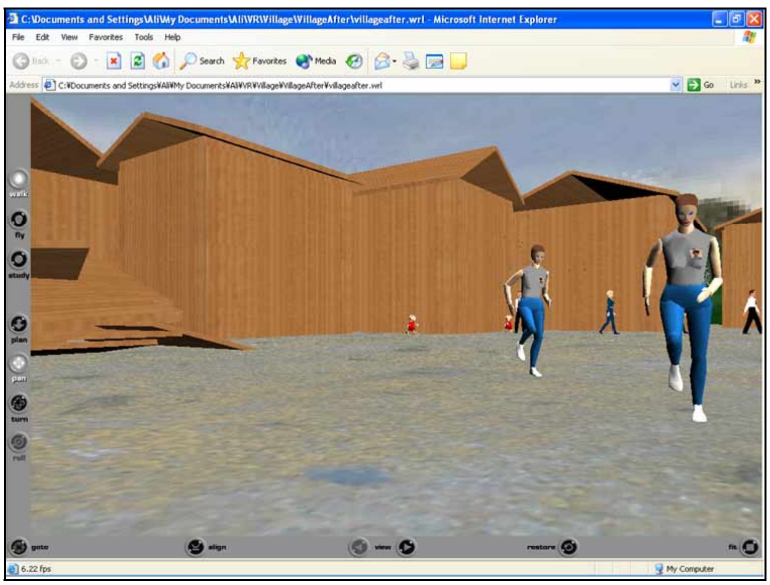

Fig. 8 Seismic response presented using VRML through Internet Explorer

CONCLUSIONS

Upon reviewing relative computer techniques and discussing demands on conducting an information system of risk communication and disaster mitigation for metropolises, this paper depicts challenges faced by engineering professionals to solve not only engineering but economic and social problems. To meet this multidisciplinary task, the paper presents a perspective of solutions with a distributed application platform based on the Internet and VR technologies. Techniques to shift traditional engineering applications to web environment and to share data according to XML have been discussed. As a first step towards this platform, simple implementations with VR have also been demonstrated.

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