Abstract

Visualization of large realistic forests, various countries, floods, fire spreads and landslides is very difficult and requires using of perfect modern graphic methods which allow rendering them as scenes in real time. This paper describes the creation of 3D visualization tool for visualization of natural disasters. A lot of international projects oriented on natural disasters utilise grid computing and within grid solution raises requirement of visualization service for presentation of the results. Such service requires unified standards like integration of input data formats and especially creation of unified visualization tool. It should integrate visualization requests of any kind of application oriented on computing of natural disasters. In case it is grid computing it has to be established also submit workflow, which controls execution of this visualization service. Development of all executable modules and solution of all above mentioned grid computing specific problems was subject of our scientific work presented in this article. The 3D visualization tool as well as submit workflow were tested on the applications solved in project MEDIGRID and on natural disasters applications solved in our institute [12].

Keywords

3D visualization tool, virtual reality, natural disasters, fire, flood

Introduction

The natural disasters like fires, floods and landslides become subject of science in research institutions more and more frequently. Topic of a lot of projects is how to prevent such disasters. Many applications from this area are using different kinds of simulation tools, which are producing output data for displaying the results of the computation. The purpose of 3D visualization tool is to display results of various simulations of natural disasters like fire spread in time, its intensity and erosion or floods in time or landslides as well. The output of the tool is terrain covered by ortophotomap or it is only shaded according to the altitude. On such prepared terrain is displayed the simulation of the fire spread in time, its intensity and erosion, flood water spread in time and so on. They are visualized statically or dynamically by adding red faces for the fire, blue faces for the water and brown faces for the landslides. Output of the tool can also be the files representing the virtual reality of natural disaster. For example in case of fire the spreading red faces are replaced by virtual fire. Similarly in case of flood the blue faces are replaced by virtual water and so on. 3D visualization tool was tested by output from applications, which were solved in our institute and also by data from applications in project MEDIGRID. Particular demonstrations in this article are from fire in part near Mediterranean Sea at south. Exactly in Marseille industrial port at south east. The second is from large fire in Krompl a region, which is part of Slovensky Raj. Flood demonstrations are from Povazie, the region around the river Vah. The tool is always actualised according to the needs of new applications.

Related work

There are several tools solving the visualization of natural disasters. However, these tools lack common criteria for visualizations, unification of data formats, and a common approach to visualisation. The integration of formats and a common solution for visualization of natural disasters, which has been solved in our tool, provided the opportunity to create a visualization service for grid applications aimed to natural disasters. As the applications computing natural disasters work with big amounts of data, grid computing is used frequently. Using a 3D visualization tool in a grid visualization service could be considered a big contribution. This has been proved by increasing interest of experts working on international projects. Searching for new facilities of preventing natural hazards, they are continually seeking to integrate the existing applications. One of them is the visualization service with it’s submit workflow.

Creating 3D visualization tool

3D visualization tool consists of modules which was necessary to create. Each module is UNIX shell script in which is prepared starting of executables. The modules are divided into three
groups according to what kind of output 3D models is the group generating. The functionality of each group is described by appropriate schema. (schema 1, schema 2, schema 3). This segmentation requires building the types of 3D models.

- Models of terrain or model of environment
- Models of simulations
- Virtual reality models of terrain and simulation (fire spread, flood, landslide etc.)

**Models of terrain or models of environment**
The first group of modules in the 3D tool is designed to creation of 3D terrain models and environment models. For 3D models of this type were created modules: CONVERTOR, TERRAIN, IVFIX and IVTOWRL. Function of these modules is described by Schema 1 (see fig.1)

![Fig. 1 Schema 1](image)

Most frequently used formats of input data for terrain are:
ARC/INFO raster ASCII grid [2], GRASS raster ASCII grid [4], ESRI Shape files vector data [3]. The input formats for image textures are general image formats like JPEG, GIF, PNG, TIFF etc. and corresponding general ASCII image coordinates formats are JGW, TFW, PGW etc.

General image formats like JPEG, GIF, PNG and TIFF [6] are used as textures for ortophotomaps in our tool. Image formats JPEG, GIF, PNG and TIFF are geo-referenced by image coordinates in JGW, TFW or PGW files.

Data in one of mentioned formats are geo-referenced data [1], which have defined their location in physical space. They are commonly used in the area of GIS and other cartographic applications. Mentioned formats have different syntax. Input data are converted to singular format by one of modules named CONVERTOR (see Fig. 1). Then data can be exported to the TERRAIN module. Terrain module computes vectors and creates quad mesh for terrain models. Then modified IVFIX [5] module creates Indexed face sets in ivfile format. Indexed face sets files are converted by module IVTOWRL, to Virtual Reality Modelling Language VRML (files with extension wrl). We created IVTOWRL module according to the requirements of 3D tool. The final model of terrain is VRML file TERRAIN.wrl. It means that from input files: TERRAIN.asc, picture.jpg and picture.jgw is the 3D tool able to create 3D model of terrain. All modules are UNIX shell scripts by which is activated running of executable files.

**Examples** of terrain created by the tool:
1. **Krompla locality** (see fig.2) on which in year 2000 was large fire. This fire application is currently solved in our institute [7].
2. **Povazie** (see Fig.3) from grid computing flood application which is also solved in our institute [8].
3. **Marseille industrial port** (see Fig.4) terrain from fire application generated in EU project MEDIGRID EU 6FP RTD GOCE-CT-2003-004044 [9].

![Fig.2 Krompla locality - terrain covered by ortophotomap](image)

![Fig.3 Povazie - terrain covered by ortophotomap](image)
Models of simulations

The second group of modules in the 3D tool is designed to generation of Models of simulations. The following modules were created: CONVERTER, CLASSIFIER, COLOR SOTER, TIME SORTER and VIRTUAL SORTER and GENERATORS for static or for dynamic outputs. Process of creation of simulation models is described by Schema 2 (see Fig. 5).

A lot of scientific institutions concern with disaster applications and early prediction of them. Disasters like fire, flood and landslides are usually computing and generating by lot of systems. They describe not only the spatial and temporal behaviour of fires (fire spreading rate and direction), but can quantify and often even display various fire characteristics (e.g. fire intensity, flame length, etc.), which can be useful for the purposes of fire effects analysis. For flood and landslide it is similar. They can be used for simulation of various fire, flood or landslide scenarios in a certain region under different conditions to test the management response for the disaster event (prevention)[14]. Most suppression decision support systems are based on disaster behaviour prediction and make it possible to test the effectiveness of different types of suppression strategies and tactics, taking into account the existing fire fighting infrastructure and specific conditions that affect the fire fighting (e.g. location of water sources, Fire Fighting Headquarters, road network, etc.))[7]. In dependence on above mentioned qualifications, 3D visualisation tool provides different outputs of simple and quick visualizations. In disasters like flood, fire and landslide is usually found the starting point of disaster and also propagation in time. For example simulators for fire simulation like Farsite [8], Behave or FireStation are generating for each point of terrain’s grid expected time of fire spread. Similarly flood simulators are generating for each point of terrain’s grid expected time of flood propagation and for landslide similarly steps in time. Our tool sorts these points according to the time and places to them red faces for fire, blue faces for flood and brown faces for landslide. It starts from point with lowest time till the last one with highest time.

Input data for second part of 3D tool are output data from simulators in different formats. Module CONVERTER converts them to singular format. Than data can input to CLASSIFIER module. CLASSIFIER sorts data and exports them to COLOR sorter and TIME sorter and some of them which are used for Virtual models to VIRTUAL sorter. Data from sorters input to GENERATORS. Generators are producing simulation models. Generator for static outputs produces Static models. Generator for dynamic outputs produces Dynamic models. Final visualization consists of terrain model and some of simulation models. For example visualization of fire spread in time (see fig. 7) consists of TERRAIN.wrl and Firespread.wrl files. Flood in time (see fig.6) consists of TERRAIN.wrl and Flood.wrl files. Intensity of fire can be displayed statically (see fig. 9) or dynamically together with fire spread in time (see fig.8).
Various fire or flood characteristics (like fire intensity, flame length, erosion, etc.) together with terrain model create static visualization. For example files TERRAIN.wrl with Erosion.wrl. Fire intensity (see fig.9), Fire erosion (see fig.10).

Mentioned static and dynamic visualizations are suitable for applications in which output data are changing very frequently because by our tool it is possible to visualize the input data very quickly. This type of visualization is also suitable for grid computing applications, which are processing large data.

**Virtual reality models of terrain and simulation**

The third group of modules in the 3D tool is designed to generation of virtual models. The following modules were created: DATA SORTER, VIRTUAL TERRAIN SORTER, VIRTUAL SIMULATION SORTER and several needed GENERATORS. Process of creation of virtual models is described by Schema 3 (see fig. 11).

Outputs from Virtual sorter (Schema 2) together with Special data for Virtual models are exported to DATA SORTER. It sorts the data and exports them into VIRTUAL TERRAIN SORTER or VIRTUAL SIMULATION SORTER. Data from sorters are inputting to GENERATORS. They are producing a lot of virtual models like for example
virtual terrain or forest, virtual buildings, virtual fire, or virtual flood.
To create virtual models, 3D tool needs **Special data for Virtual models** which can be variable. For example for generating virtual forest special data are **Grown maps**, or for generating some buildings they are **Project documentation** etc.
Following example demonstrates using of mentioned part of the 3D tool for creation of Virtual forest fire. Firstly was created virtual forest from Grown maps which were provided us by forestry. For generation of virtual forest was used forest grown simulator Sibyla. This software was developed by Forest faculty in Zvolen in Slovakia.
Sibyla system (see fig 12) is composed of ten modules. One of them is Forest GENERATOR (see fig 13). Input data are values from Grown maps. There is included all needed information for creating of each quad of virtual forest. Huge database of textures included in Sybila enables to create different looks of the forest (morning, day, evening, etc.) (see fig.14.1-2).

Then by using the 3D visualization tool the same terrain which was firstly covered by ortophotomap is now covered by just prepared virtual forest. (See fig.15).
In the end red faces were replaced by virtual fire textures using Virtual fire generator module. (See fig. 16.1-2).
By similar methods using different modules of 3D tool is possible to create also virtual floods or landslides or some other natural disaster visualizations. Example of virtual flood visualization (see fig. 17).

By creating models of large forest scenes and real forest fire scenes or large flood were used graphic methods, which allow rendering such scenes in real time. In 3D tool modules are applied all last modern graphic methods (LODS, transparent textures, Billboard clouds etc).

Final models from 3D visualization tool are files in VRML format and can be displayed by VRML browsers and viewers or they are displayable in CAVE too (See fig. 17).

In collaboration with Institute of Graphics and Parallel Processing of Johannes Kepler University Linz we are able to view some of the Virtual scenes in Cave system.

Conclusion

3D visualization tool has several advantages. Integrates input formats, which are currently most frequently used.

3D visualization tool provides for natural disasters applications different levels of complexity of the visualizations from simplest and fast to very complicated virtual scenes.

Output files are in format VRML (Virtual Reality Modelling Language), which are displayable by commonly available applications like internet browsers, Freewrl, Blaxxun contact, Cortona client, Openwrl, VRED an also in CAVE etc.

3D visualisation tool can be used as Visual service for a lot of grid computing natural disasters applications. [13].

References


