

Optimisation of a road construction using 3D visualisation

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ABSTRACT

The main purpose of this work presented in this paper, is the possibility to optimise a road construction using visualisation in 3D, in a scale 1:1. With virtual reality technology, we can visualise the whole road and the environment around. Therefore the possibility to control the position of traffic signals, SOS telephone cabs, noise-protection road walls, safety exits, tunnels height or eventual bridges during the virtual visit of the road. In the same time, we can control the visibility of the road by driver, from start till the end of the road. Doing this, we can help architects, technicians and civil engineering group to modify their plans before they start to construct the real road.

In this sense, we can contribute to make the work properly from the beginning, instead of doing several interventions to modify the road that are usually done once the road is over. Of course, the cost of such interventions is very high and in the same time the traffic is stopped.

Concretely, we realised the A5 highway application. Besides the modelisation with textures and visualisation of the road, we added the interactivity in real time through a driver of a virtual car. This application run very well, presenting a high degree of virtual reality.

INTRODUCTION

Located at the heart of Europe, Switzerland is dependent on modern transport infrastructure and efficient communications and networks. It presents over 71000 km roads, 3100 bridges and 250 tunnels [1]. This infrastructure is an important prerequisite for the country's cohesion and for exchanges with other countries and economic prosperity. In Figure 1, is given a map that shows a network of european roads traversing Switzerland [2]. The decisions taken by Federal Department of the Environment, Transport, Energy and Communications are prepared in the various federal offices like: Office of Energy, Office of Communications, Roads Federal Office, Office of Transport etc.



Figure 1: A map with european roads traversing Switzerland

Indeed, after published announce for a road construction, the Federal Department of Roads Office (FEDRO), get the offers from several road constructors. This department works closely together with engineers consortium and cantonal civil engineering departments for the construction, operation and maintenance of roads.

Then the work is attributed to contractors and several sub-contractors. Each road constructor has to respect the rules of road (norms SIA and VSS). Of course, quality of work depends on the planning, organisation and coordination of works. The architects are used to design their concepts in a formal way, due to their standards, without taking care of the civil engineering details. Civil engineering has different tools to construct a road. A lot of constraints have to be considered, especially

- safety in roads
 - variable message signs
 - emergency call telephones SOS
 - wide protection gallery against falling rocks
- safety in road tunnels
 - ventilation, escape facilities, traffic flow , traffic management, escape facilities in twin tube tunnels, regularly spaced cross connections, self closing doors, high capacity massive smoke extraction system, traffic signalling equipment lighting of road infrastructure, etc.

Due to the complexity of the management process and inherence of the traditional planning tools, construction managers are still having problems to get accurate results.

In this sense, we were motivated to find a good solution. We proposed to build a three dimensions visual simulation of a construction process, integrating all construction plans. Visualisation is already recognised as one of the most important tools for achieving this purpose. The simulation might assist a planner and the construction managers in a better perception of a project. They can visualise the road and it’s environment before the real construction of the road. Being there virtually, they can find and modify the eventual errors. In this way, they can reduce the cost of the construction and optimise whole process.

APPLICATION A5, WHAT AND HOW WE DID?

Our application is a real time application and is demonstrated with a real life case study in a road project A5, which is a highway between Neuchatel and Yverdon-les-Bains. Creating a real time application program, we took care of an important database which stands in the

- image generator performance (polygons-per-frame textures)
- visual database as a geometrical representation (polygones).

To realise an amount of visualisation (example: a piece of terrain) we do need the altitude data file which is simplified and then triangulated to create a mesh. Then, we can texture these surfaces with the corresponding images that are taken from reality. In this way we have an OpenFlight 3D file format which we use for visualising our application. This process is given in the figure below.

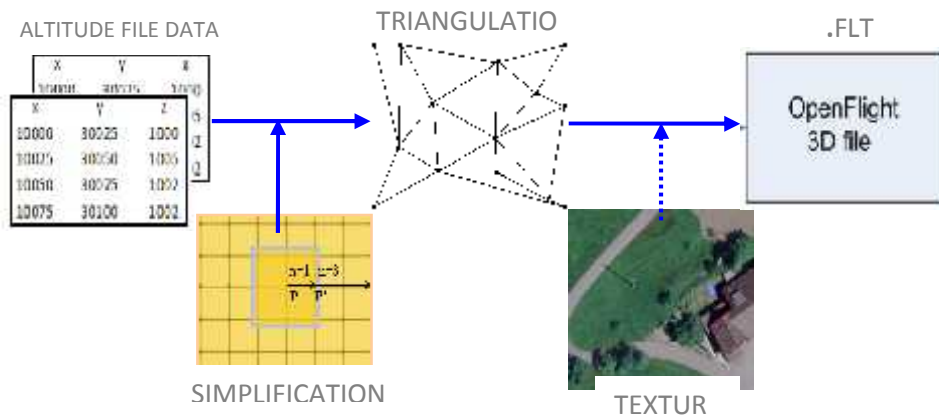


Figure 2: The process of realising of an amount of visualisation

To create a realtime 3D models for visual simulation, we used MultiGen Creator. Creator is a software package designed specifically to easy construct, to import, structure, edit, prototype, and optimize model databases for use in both large scale visual simulations and entertainment environments [3]. It adds special characteristics to the data structure like Degrees of Freedom (DOF) and Levels of Detail (LOD).

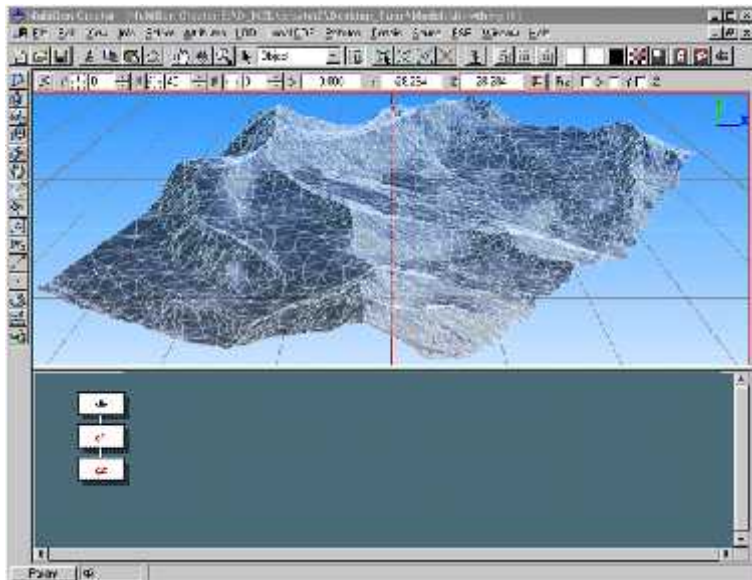


Figure 3: Multigen Creator user interface

In the figure below, we can see three levels of details: LOD 1, LOD 2, LOD 3. The polygon mesh is more dense near the point of view P. With different levels of degree, we can still preserve the visual quality by reducing the number of polygons in order to have more efficient realtime rendering.

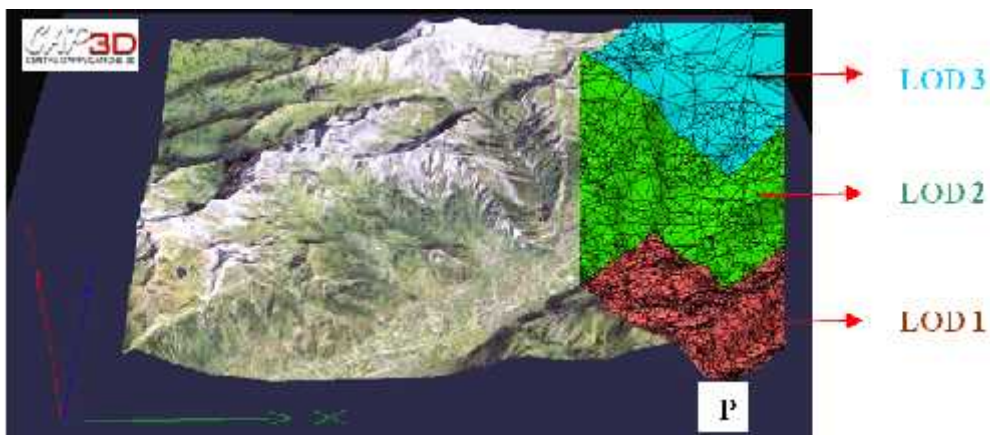


Figure 4: Creating the terrain model with Multigen Creator

By adding any graphical item to the model, MultiGen Creator inherently constructs the database structure. This structure describes the hierarchical link between faces, polygons, objects, nodes, groups and database nodes. We can observe it in a lower part of user graphical interface of Creator.

To store the information, MultiGen Creator uses the public domain OpenFlight format. Creator and OpenFlight are double precision, allowing as much accuracy as necessary when describing complex objects and very large area databases [3].

SCENEGRAPH

To reduce memory budget of our application and to increase the speed of execution, we use the scenegraph to describe the virtual 3D worlds. The scenegraph is a spatial representation of a graphical scene which defines a logical relationship between various entities of the virtual 3D environment. Applying the scenegraph (Figure 5), we realised a high visual performance of our application.

To visualise the application, we used OpenSceneGraph. OpenSceneGraph is based around the concept of a scenegraph providing an object-oriented framework on top of OpenGL. It is an OpenSource, cross-platform graphics toolkit for the development of high-performance graphics applications [4].

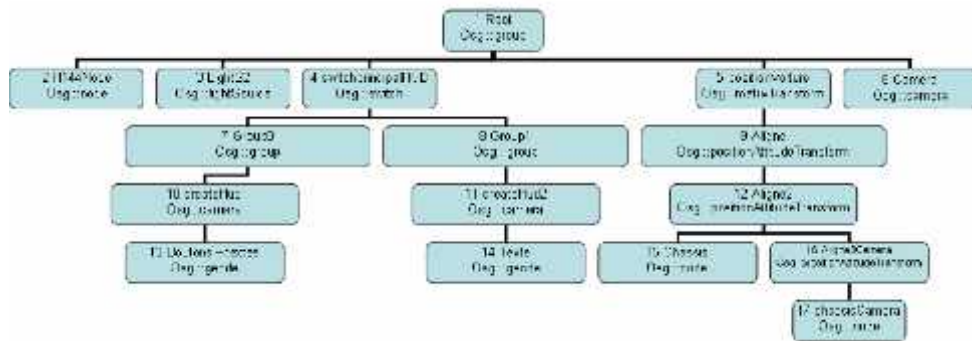


Figure 5: A scenegraph of a visual simulation

TRAFFIC CONTROL SIGNS

Traffic control signs are placed respecting the rules of traffic. As we mentioned above, there can be a clear mismatch between plans from sub-constructors offices. For example, from plans coming from two different offices, we found that they placed an emergency call station (SOS telephone) behind a protection wall of two metres high! Once constructed, there are too much efforts and costs to modify these constructions. Another example is the non adapted position of ventilators in tunnels. Position of ventilators is very sensitive in the sense that ventilation and extraction systems must reduce the build-up of smoke and evacuate it as efficiently as possible. Or the non adapted position of safety traffic signs, for example the speed limit sign. The speed limit should be considered as an integrated requirement to be respected all of the time. But, unfortunately, exceeding the speed allowed is an usual event today. In this case, the driver may not observe all of safety traffic signs. And of course, sometimes this leads to an accident with hard consequences. So, having the possibility to visualise a whole road environment and virtually driving in, gives a chance to displace these signs in a right place. In our application A5, we can move

traffic signs in a position we like. The exactly position of a traffic sign is given on a top of display in X,Y,Z coordinates, it's distance from the starting point of highway and the vector of translation . This situation is shown in figure below [5].



Figure 6: Displacement of traffic signs on a highway A5

Once we are sure that everything is in its place, we can show it to the architects, technicians and civil engineering groups to modify their plans before they start to construct the real road. In this way, from the beginning, we can contribute to make the work properly, instead of making interventions afterwards, modifying the road that are usually very expensive.

INTERACTIVITY

After the modelisation with textures and visualisation of whole environment of road, we added the interactivity in real time, through a driver of a virtual car.

As an input device we used force feedback steering wheel with three pedals. For sound, we choosed the OpenAL, which is a cross-platform 3D audio library used in many types of

dimensional visualisation techniques. Making an experience through virtual 3D road environments, with the interactivity in real time, helps to have efficient construction scheduling and plans before starting the real construction of the road.

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