

Using 3D Visualization to Optimize a Road Construction

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Abstract

The main purpose of this work presented in this paper, is the possibility to optimize a road construction using visualization in 3D, in a scale 1:1. With virtual reality technology, we can visualize 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 groups 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 in order to save the modifications after the road is over, which have a very high cost as an impact.

Keywords: Visualization, 3D road, MultiGen, Creator, OpenFlight, Scenegraph

1. 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. This infrastructure is an important prerequisite for the country's cohesion and for exchanges with other countries and economic prosperity. 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. [1]

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 (normes VSS). Of course, quality of work depends on the planning, organization 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 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 3D visual simulation of a construction process, integrating all construction plans. Visualization 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.

2. Application A5 and How we did ?

Our application is a real time one and is demonstrated with a real life case study in a road project named A5. 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 realize an amount of visualization (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 visualizing our application. This process is given in the figure below.

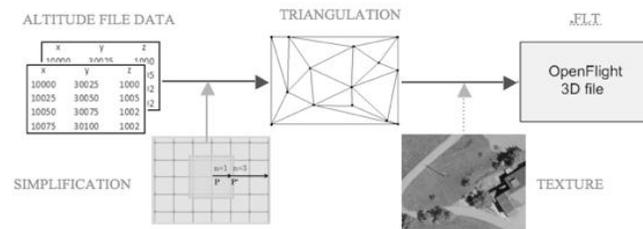


Figure1: The Process of Realizing of an Amount of Visualization

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. It adds special characteristics to the data structure like Degrees of Freedom (DOF) and Levels of Detail (LOD). [2]

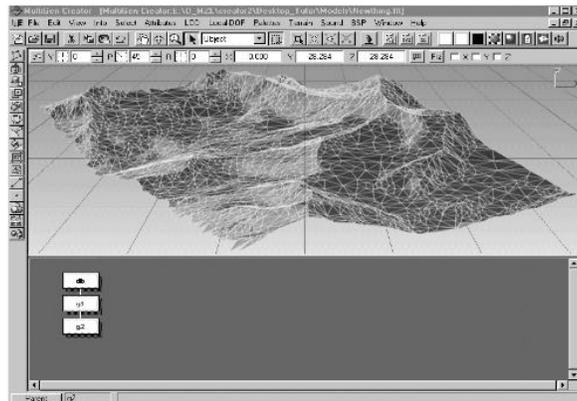


Figure 2: MultiGen Creator User Interface

By adding any graphical item to the model, MultiGen Creator inherently constructs the database structure. This structure describes the hierarchical link between faces, polygones, 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 Open Flight format. Creator and Open Flight are double precision, allowing as much accuracy as necessary when describing complex objects and very large area databases. [2]

2.1 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. The scenegraph of our application is given in the Figure 3. Applying the scenegraph, we realised a high visual performance of our application. To visualize it, we used Open Scene Graph. Open Scene Graph is based around the concept of a scenegraph providing an object-oriented framework on top of OpenGL. It is an Open Source, cross-platform graphics toolkit for the development of high-performance graphics applications. [3]

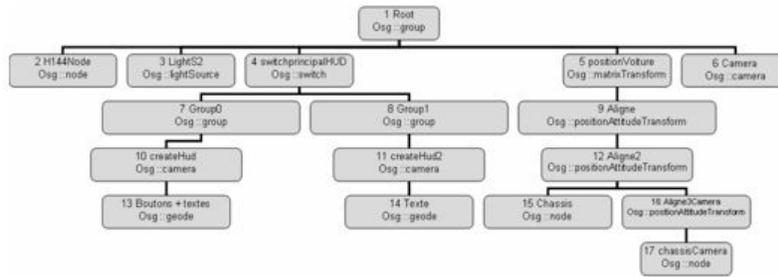


Figure 3: A Scenegrph of A5 Visual Simulation

2.2 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 height! Once constructed, there are too much efforts and costs to modify these constructions. Another example is the non adapted position of ventilators in tunnels which 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 the human sometimes dislikes whatever is prohibited. Exceeding the speed allowed is an usual event. 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.

Having the possibility to drive in and visualize in 3D a whole road environment, this gives a chance to displace these signs in a right place. In our applications, 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. Once we are sure that everything is in its place, we can show it to the architects, technicians and civil engineering groups in order 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.

In our application, besides the modelization with textures and visualization of roads and their environments, we added the interactivity in real time through a driver of a virtual car.

2.3 Car Dynamics

As an input device we used force feedback steering wheel with three pedals. For sound, we choosed the Open AL, which is a cross-platform 3D audio library used in many types of audio applications. Car dynamics is controled by motor engine Ageia PhysX, which takes care of solid dynamics, fluid dynamics and collision detection. But to have better performance in visualization, we had to adapt the source of the code. For example, displacing the car ahead. Below, in Equation (1), you can see the adapted equation we implement to find the best distance of displacing the car virtually.

$$D = v * \Delta t + \frac{1}{2} * A * \Delta t^2 \text{ [m]} \quad (1)$$

- D - distance of displacing,
- v - vehicle speed,
- Δt – time,
- A - vehicle acceleration.

As about user interface, we can see (Figure 4) and control all vehicle parameters, directly on to the interface of our application. Integrating all this, we made an immersive visual simulation that is safe alternative to evaluate feasibility or to test physically the still non-realized road environment. Another good point of visual simulation is that we can visualize the different solutions of a specific situation and comparing them we are able to choose the best one.

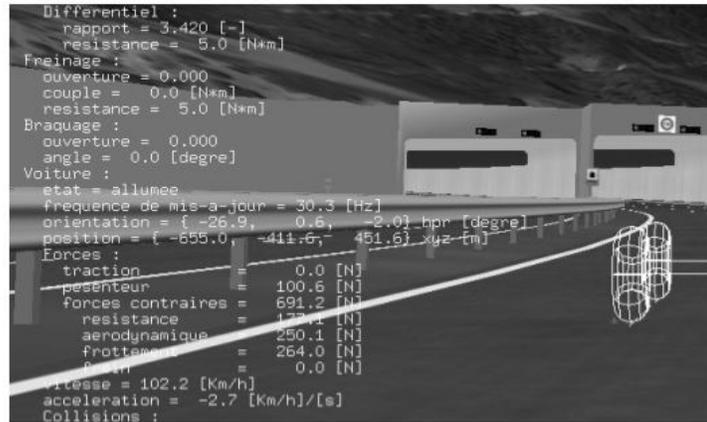


Figure 4: A Snapshot with Some Parameters of the Vehicle Running on A5

3. Conclusion

Our objective was to develop an application improving the visual simulation may optimize a road construction. Charged from Federal Department of Roads Office, we did the application named A5 and we found some technical difficulties in construction plans. The civil engineering group was very satisfied because they traditionally used two dimensional visualization techniques. Making an experience through virtual 3D road environment, with the interactivity in real time, helps to have efficient construction scheduling and plans before starting the construction of the road. Running well, our application presents a high degree of virtual reality.

References

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