

DEVELOPMENT OF A BROWSER FOR TRAFFIC LINE AND TERRAIN LANDSCAPE

Zuxun Zhang^{a, c, *} Shunyi Zheng^{b, c} Jianqing Zhang^{a, c}

^a School of Remote Sensing Information engineering, Wuhan University, 129 Luoyu Road, Wuhan 430079, China

^b National Lab of Information Engineering for Surveying, Mapping and Remote Sensing, -
Wuhan University, 129 Luoyu Road, Wuhan 430079, China

^c Supresoft International Inc. 3-2# Building, Guandong Science Park, No.2 Guanshan Road, -
Wuhan, 430074, China, (zxzhang, syzheng, jqzhang)@supresoft.com.cn

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ABSTRACT:

Landscape after construction of traffic line plays an important role in evaluating the visual effect of designed traffic line and the suitability of plan and vertical designs. This paper presents a method to create the overall three-dimension model combined by both the virtual traffic line model and around photo-realistic terrain model. In the overall three-dimension model, the traffic line model is created with data of plan, profile and cross section design, whereas model of terrain outside traffic line is built with digital terrain model and orthophoto. Therefore, the overall three-dimension model can show realistic landscape after construction of traffic line to the most extent. A browser in 3D environment for traffic line and terrain landscape has been implemented based on the method combining the virtual reality and visual reality described above.

1. INTRODUCTION

3D visualization of landscape after construction of traffic line plays an important role in evaluating the visual effect of traffic line and the suitability of plan and vertical designs. With visualization, potential errors can be avoided, which would usually only show up after a project is finished. If a consulting or designing firm uses this tool to show a potential client the final product before an engineer even starts a calculation, which may determine if a roadway is plausible and feasible, it would give the client an excellent representation of what the final design would look like. For example, a structural engineer can create full models to test strength and help with design, an environmental engineer can use the model for hydrology analysis and determine if the roadway is environmentally responsible, and a design could be fully determined even before the ground is broken. The significance of visualization in civil engineering including traffic line design and construction has already been deeply known. For example, in highway design departments of China, the "scene graph" is one of design documents, which must be submitted (Jiang, 2000). Therefore, to meet the requirement, it is necessary to create and browse the landscape after construction of traffic line, which is not only geometrically correct, but also visually realistic.

The remainder of this paper is broken up into three sections: using 3D Design and Measurement Platform (3DMP) to design the roadway, building the overall 3D model including roadway and terrain, and developing a browser for the overall 3D model.

2. DATA SOURCES AND DATA PREPARATION

2.1 3D visualization design and measurement platform

3D visualization of design procedure is also one of our main research subjects. It is widely known that 3D stereo model of terrain could be built by using stereo ortho-images including an orthophoto and its stereo-mate. Such 3D stereo model not only can be viewed stereoscopically, but also can be measured and the measure accuracy can reach a very high level almost same as original aerial image (Baltsavias, 1996). In addition, with the development of digital photogrammetry, the ortho-images can be produce automatically and rapidly. So a 3D Design and Measurement Platform (3DMP) has been built based on large 3D stereo model produced by mosaic ortho-images (Zhang, 2001). Domain-specific 3D design systems can be created on the basis of 3DMP through adding specific design functions. Design system for traffic line is one of them. The traffic line design data, needed in latter sections, could be produced in such 3DMP system.

2.2 Data for 3D Visualization Design

The key to perform 3D visualization engineering design is to build 3D stereo model of terrain which combines the ortho-images and DEM and have stronger measure performance than 2D map. Such 3D model can be built with stereo ortho-images.

Stereo ortho-image (including an orthophoto and its stereo mate) is an relatively old, but still currently and forward bethinking technology, which is similar as maps in many respects, but has a number of definite advantages over maps. To produce stereo ortho-images, DEM and original aerial-images are required.

For decades, stereo photogrammetry has been widely used in highway and railway departments for roadway design

* Corresponding author.

and improvement. However, photogrammetry products that have been used are only line map and DEM. After line map and DEM are obtained, the valuable image document is stored in archives and no one pays attention to it. In order to take full advantage of the image document, stereo ortho-image for 3D design is generated firstly, then orthophoto as texture is produced to create photo-realistic visualization effect.

2.3 Design Procedure

The majority of traffic line design is completed on 3DMP. There are several sections in the design procedure as following:

(1) Importing data and building a 3D design environment (Figure 1).

Relevant inputs for 3DMP include DEM, stereo Ortho-images and parameters needed in coordinate transition. Contour line and other vector information can be superimposed on such 3D-design environment if necessary.



Figure 1. 3D design environment (This figure only shows an orthophoto which, together with its stereomate, can be viewed stereoscopically.)

(2) Horizontal alignment (Figure 2)

Horizontal alignment is to locate the plan position of the proposed roadway, which consists of straight lines, transition curves and circular curves.



Figure 2. Horizontal alignment

(3) Vertical alignment (Figure 3)

The main portion of vertical alignment is to use the vertical profile of the existing ground to design and improve the vertical alignment until it balances cuts and fills and matches the existing ground reasonably closely.

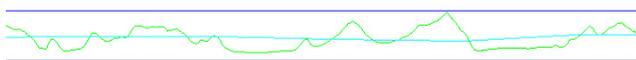


Figure 3. Vertical alignment

(4) Cross section design (Figure 4)

Cross section design is to use some templates, which virtually run along the horizontal and vertical alignment to create the surface of the road. There are several things to keep in mind when drawing a template. Ditches, curbs, and many other things, which make a cross section unique, can be drawn manually. Instead of manual way, a default template has been

used, which is defined in 3DMP and quite simple, no ditches, or curbs just a section sloping down towards the sides of the roadway. In this stage, the positions of bridges and tunnels also need to locate.

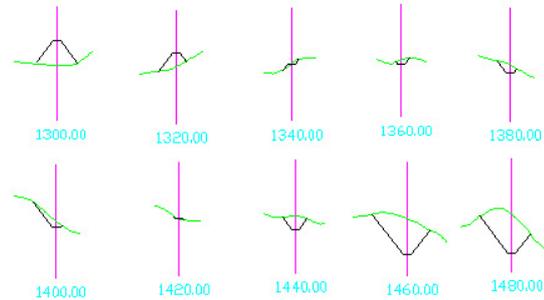


Figure 4. Cross section

(5) Rendering (Figure 5)

When the design finished, the places, which should be cut off or filled on, should be rendered with some suitable texture. 3D effect of traffic line proposed can be viewed, including cuts and fills, position of bridges or tunnels. However, such 3D effect can only be viewed from one direction, from up to down, which limits the inspection of the design from all aspects. This is exactly the reason to develop the browser of traffic line and terrain landscape continually.

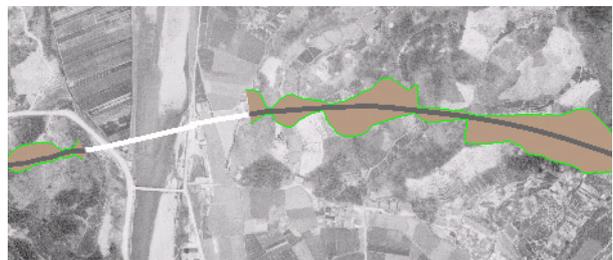


Figure 5. Rendering

3. BUILDING OVERALL 3D MODEL

In order to implement visualization of landscape including proposed traffic line, it is necessary to construct an overall 3D geometric model that consists of traffic line and terrain. Objects in such model include terrain, roadbed of traffic line, bridges, buildings, trees and so on, which can be classified into two categories. The first category includes ground and objects lying on ground such as roadbed, lakes and rivers and others, which can be represented by digital terrain model (i.e. TIN) and their boundary. The second one includes objects extruding out of ground, such as buildings, bridges and trees. For the second category, specific models need to construct.

3.1 Traffic Line Model

In order to produce 3D model of traffic line, roadbed part can be constructed by merging basic engineering data produced

by 3DMP (Figure 6), and the model of bridge is created with position and other design parameters by other programs. Basic engineering data include: (1) Horizontal Curves and Lines; (2) Profiles; (3) Cross-sectional information; (4) Super-Elevation (selective along the cross-section); (5) Periodic and unique

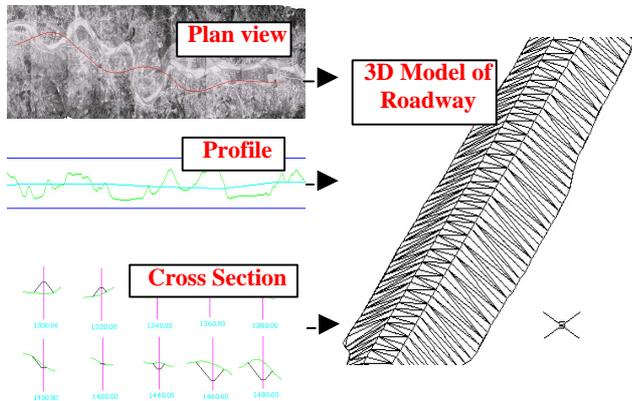


Figure 6. Traffic Line Model feature placement such as landmarks and poles.

3.2 Terrain Model

To accurately recreate real world landscapes, virtual rendering is being accomplished with two basic datasets: (1) digital elevation models (DEMs), and (2) orthophoto. Using these real-world data has the potential to generate not only geometrically correct but also visually realistic models in a more automatic and faster manner than the labor-intensive, time-consuming graphic-based detailed contents. As described above, it is not difficult to obtain these data because stereo photogrammetry has already been widely used in highway and railway departments for decades. With respect to objects extruding out of ground, such as buildings, trees, specific models for them need to establish.

3.3 Merging Traffic Line Model and Terrain Model

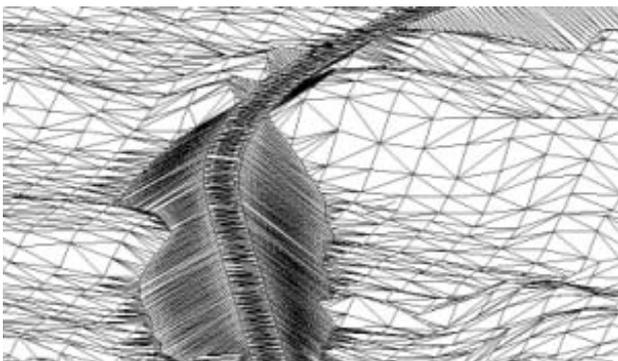


Figure 7. Wireframe of the overall 3D model including traffic line and terrain

This step is to actually create the terrain surface with the traffic line tied into it. To do this, a specific program has been developed, which finds where the traffic line lies, and deletes the points, where traffic line and terrain overlap, replacing the old terrain points with the new traffic line points, thereby

making a seamless surface (Figure 7). To achieve geometric correctness, proper registration and integration of the models of bridges, buildings and other objects are required, and to achieve visual realism a large number of images from various types sensors, such as video cameras and digital color cameras, sometimes must be prepared.

4. IMPLEMENTATION OF BROWSER FOR TRAFFIC LINE & TERRAIN LANDSCAPE

The above sections show how to generate three-dimension visualization environment. The final result is an overall 3D model stored as TIN (Triangular Irregular Network) in an AutoCAD DXF file with the points of existing landscape and proposed roadway. In this section, it is introduced that a browser has been developed so that the final model can be input into it to view and browse the visualization results.

However, there is no doubt that the final overall 3D model is often too large for real-time interaction or even visualization and walk-through. Therefore, some measures have to be taken to reduce this problem:

(1) Applying an efficient polygon simplification method, which simplifies the polygonal geometry of models depending on the amount of evaluation values to be displayed. The focus is to generate simplified models of a height field from the original model. The simplified model should be quite similar as the original model, using as few triangles as possible. After simplification, bigger triangles appear in flat terrain areas, and smaller triangles in rough terrain areas. Because the processing of simplification is done off-line, once while rendering of the simplified terrain is done thousands of times, the speed of simplification is unimportant. Due to wide use of rectangle grid DEM, good effect of simplification has been achieved, which significantly improves the speed of rendering.

(2) Applying an efficient and precise visibility computation technique, which determines the visibility for all parts of the model from a given viewpoint. Objects and surfaces outside the view frustum are culled away. Thus, the number of triangles to be displayed decreases dramatically.

(3) Level of detail (LOD) technique has been fully used. The general idea is to visualize terrain model, whose resolution is high close to the viewpoint, while progressively decreases according to the distance from the viewpoint. The different model is provided at different frame, since the viewpoint changes its position continuously. Therefore, TIN extraction at variable resolution has been performed in real time. The performance of the browser has been improved enormously since LOD technique is used.

(4) Applying the Mip mapping technique to improve the efficiency of processing and mapping texture. The general idea is to use fine texture when close to the viewpoint, while the level of fineness of the texture progressively decreases according to the distance from viewpoint.

After several approaches described above are used, the rendering and visualization speed of this browse has been dramatically improved almost irrelevant to the amount of data, which is only limited by the space size of hard disk.

In this browser, Landscapes are rendered as perspective views using actual elevation, orthophoto and actual design data, such that they depict realistic scenery to the most extent. The term "virtual reality" denotes the proposed roadway and "visual reality" denotes the real terrain here. The browser provides the tools for users to interact with a simulated environment in real

time. The user can drive its viewpoint along the roadway, viewing landscape features from different perspectives and different directions through operating a keyboard, or a mouse, or a joystick. During the processing of viewing, other multimedia information such as sound can be recorded along with the scenery changing to produce animation or film files.

several dozens kilometers, sometimes even over several hundred kilometers. For real-time rendering, it seems that it is impossible without special measures to improve rendering speed.

Up to now, we only implemented a prototype system for 3D modeling and visualization of traffic line and terrain. In

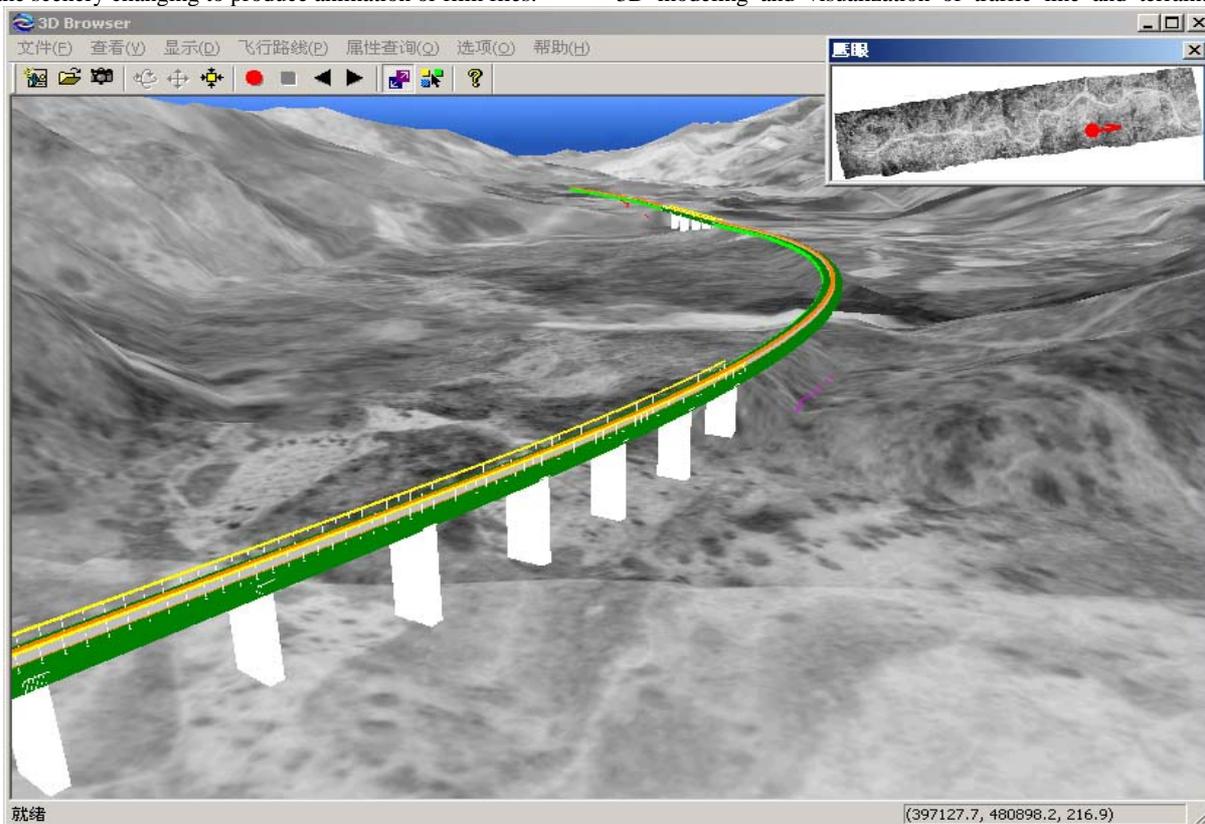


Figure 8. Main User Screen of Browser

5. CONCLUSIONS AND FUTURE WORK

This paper demonstrates and describes the process involved in creating and visualizing a 3D simulation of landscape with proposed traffic line on a personal computer. It describes not only the technical aspect of representing a roadway as a model on the computer, but also the actual design and calculation processes involved in a roadway. In the mean while, a browser of 3D model as well as some relevant programs has been developed. The browser provides multimedia data viewing capabilities to design engineers and other people who concern the proposed roadway. It allows a highway agency to examine road and roadside structures before the road is constructed. Individuals who are versed in roadway design will find that it is very useful tool in visualization. This browser has following potential applications:

- (1) Roadway design analysis tool
- (2) Design evaluation for planners
- (3) Public involvement and awareness
- (4) Driving simulation

In addition, according to the process of implementation of the browser, a claim can be made: large and complex visualization environment requires a combination of techniques to ensure real-time rendering. A highway or railway is usually

order to let it become a widely used practical system, challenges, in both data collection and modeling, remain and are subjects of the future work. Some of those are:

- (1) Acceptance of multi different data formats. Now in China, many roadway design systems exist, which have very strong design functions, but lack visualization ability. Directly reading the design data produced by them and producing visualization results are undoubtedly very meaningful.
- (2) Fast modeling. Now modeling is still a labor-intensive, time-consuming job. There are several ways to make the modeling process rapider and smoother, such as building model library for some unique features like landmarks, poles, and automatically modeling with actual design data for some proposed objects like bridges, tunnels and rails.
- (3) Integrating programs more tightly. In the experiments, beside the browser, some other programs are required. They should be integrated more tightly for more convenient use.

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