# DEVELOPMENT OF AUGMENTED 3D STEREO URBAN CITY MODELLING SYSTEM BASED ON ANAGLYPH APPROACH

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**ABSTRACT:**

In general, stereo images are widely used to remote sensing or photogrametric applications for the purpose of image understanding and feature extraction or cognition. However, the most cases of these stereo-based application deal with 2-D satellite images or the airborne photos so that its main targets are generation of small-scaled or large-scaled DEM(Digital Elevation Model) or DSM(Digital Surface Model), in the 2.5-D. Contrast to these previous approaches, the scope of this study is to investigate 3-D stereo processing and visualization of true geo-referenced 3-D features based on anaglyph technique, and the aim is at the prototype development for stereo visualization system of complex typed 3-D GIS features. As for complex typed 3-D features, the various kinds of urban landscape components are taken into account with their geometric characteristics and attributes. The main functions in this prototype are composed of 3-D feature authoring and modeling along with database schema, stereo matching, and volumetric visualization. Using these functions, several technical aspects for migration into actual 3-D GIS application are provided with experiment results. It is concluded that this result will contribute to more specialized and realistic applications by linking 3-D graphics with geo-spatial information.

**KEY WORDS:** 3D Stereoscopic, Anaglyph, OpenGL, Landscape, Quickbird, DEM, Urban City Modeling

## 1. INTRODUCTION

3D geo-processing is regarded as one of important tasks for advanced approach linked with remote sensing and GIS (Huttner, *et al.* 1999; Willneff, 2005; Lee and Kim, 2006; Nurminen, 2006).

The stereoscopic is an important technique for representing three-dimensional visual information or creating the illusion of depth in an image. Thus, the stereoscopic is widely extended in recent industry issues such as scientific visualization, entertainment, games, multimedia and art.

The stereoscopic in 3D GIS with feature modeling and rendering system is used to remote sensing or photo-grametric applications for the purpose of image recognition, feature extraction, modeling and visualization. The most cases of these stereo-based application deal with 2-D satellite images or the airborne photos so that their main targets are the generation of small-scaled or large-scaled DEM (Digital Elevation Model) or DSM (Digital Surface Model). Further, the construction of an anaglyph image, using static paired-images, is widely reported in the view of 3D image generation.

Unlike those, the scope of this study is to investigate dynamic 3-D stereo processing and visualization of true geo-referenced 3-D features based on anaglyph technique, and the aim is at the prototype development for stereo visualization system of complex typed 3-D GIS features. So, we tried to represent how to create augmented 3D stereo urban city modelling and anaglyph using OpenGL, a standard 3D graphic API.

## 2. METHODOLOGY

We tried to design and develop augmented 3d stereo urban city modelling and rendering system based on anaglyph approach. For this purpose, the following aspects are emphasized on: data preparation, 3D graphic API, and stereoscopic method.

In the data preparation, we considered the image processing for DEM and high resolution satellite image data such as KOMPSAT-2 and 3, and Quickbird. In the 3D graphic API, we use stable and standard API of OPENGL. In the stereoscopic method, we tried to use the most robust and low-cost one among well-known stereoscopic techniques.

### 2.1 Data preparation

In this study, we used actual data sets, not virtual data: space-borne satellite images, DEM, and 3D feature models acquired from various sources. Recently, as space-borne high-resolution imageries are widely used for remote sensing applications, these images reveals complex types of feature on surface, and it makes new approaches in 3D urban application with remote sensing. With these, DEM is also scaled to high-resolution scaled for geo-matching with these images (Figure 1).

By the way, the definition and model of 3D geo-features are not simple. Some cases are needed man-made features and natural features, and other cases do one of either, dependent on a given application tasks. Ervin and Hasbrouck (2001) summarized 3D feature modelling schemes in the landscape modelling perspectives.

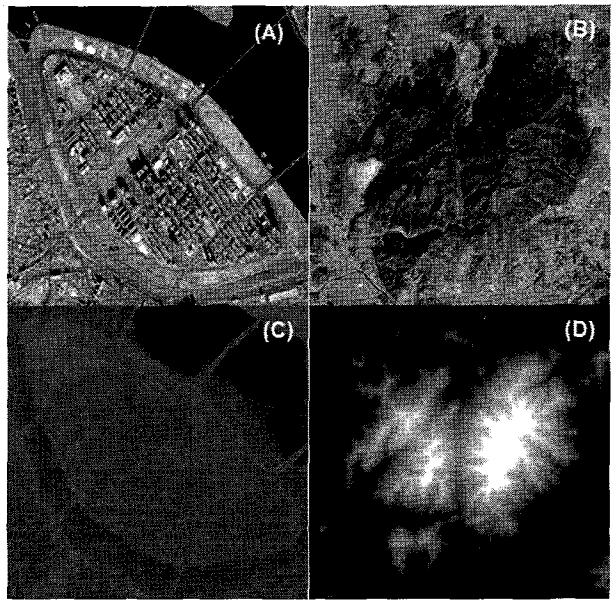


Figure 1. Satellite image date sets and DEM for the use of 3D dynamic anaglyph modelling: Spatial resolutions of 1 m and 10 m, respectively.

### 2.2 3D Graphic API

OpenGL is 2D/3D graphic API that can control graphic hardware. It provides core pipeline functions that can process more easily complicated 3D information. OpenGL has a low-level rendering function that offers geometry primitive of point, line, and polygon. As well, OpenGL can embody special effects functions such as a RGBA color type and lighting, shading, blending, fog, texture mapping, color filtering, accumulation buffer function to help more realistic rendering process and a base environment for stereoscopic processing (Figure 2).

So we used OpenGL 1.5 Library for 3D graphic process about 3D stereo urban city modeling & rendering system. And it provides independency of operating system, royalty free, and connection of OpenGL|ES (Embedded System).

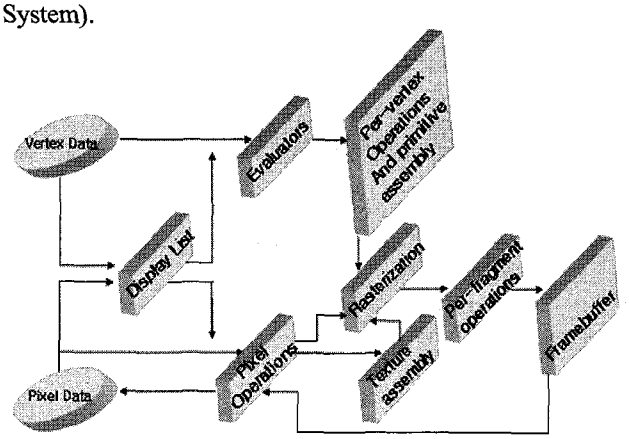


Figure 2. OPENGL graphic pipeline, excerpted from Woo(1999) and Knaus (2003).

### 2.3 Stereoscopic Methods

Stereoscopic displays use a technique to create the illusion of depth in a photograph, movie, or other two-dimensional image, by presenting both eyes two slightly different images (Shapiro and Stockman, 2001). The effect that allows us to see depth is due to parallax. The four methods can be used for this purpose.

(1) Head-mounted displays – It is a helmet or glasses with two small LCD displays with magnifying glass, one for each eye. The technology can be used to show stereo films, images or games, and it can also be used to create a virtual display.

(2) LCD shutter glasses – It can be used to see the monitor or output device that alternately displays different perspectives for each eye. It becomes dark when voltage is applied, but otherwise is translucent.

(3) Polarized glasses – It can be seen two images. This is projected superimposed onto the same screen through orthogonal polarizing filters. The viewer only sees one of the images, and the effect is achieved through one for each eye.

(4) Two-colour anaglyph – It can be easily used to create stereo graphics in which the left and right eye images are made up of two independent colours. By wearing glasses with red-blue filters, each eye can be achieved the stereo images.

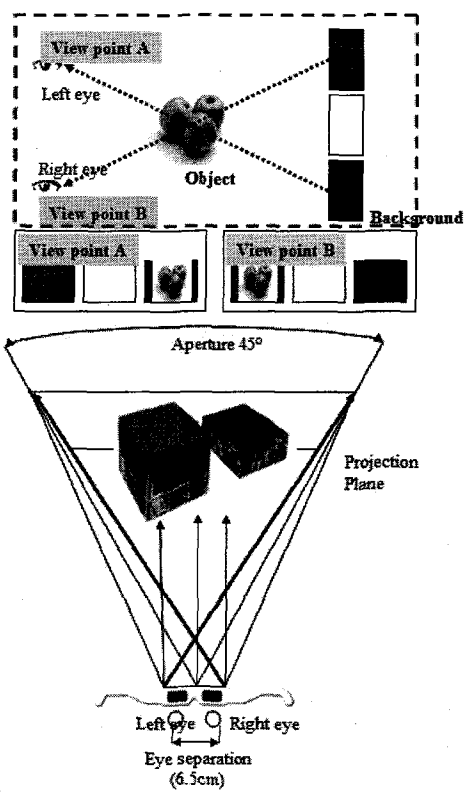


Figure 3. The principal of anaglyph and its application to urban modelling.

Among them, although anaglyph, which is a straightforward way of presenting stereo pair images to appropriate eye, is the "old fashioned technique" of creating stereoscopic images, it is still powerful, effective, and offer many advantages such as low-cost using red-blue, red-cyan or red-green glasses and easy implementation algorithm (Figure 3).

Anaglyph primarily requires that two scenes are presented independently to our each eye. That is, method for rendering stereoscopic needs to be rendered twice, once for each eye position. The two resulting scenes need to be filtered and combined before being presented to the user. While, to dynamically generate two resulting scene composed of many types of complex features, double buffer memory is needed to filtered image storages and rendering processes, by using accumulation buffer scheme.

## 3. IMPLEMENTATION AND RESULT

In this study, we implemented a dynamic 3D urban anaglyph modelling system. Using this, 3D urban landscape is more realistic and immersive. Especially, used data sets are general GIS data and space-borne images, so that its application is more affordable to general GIS users and urban planner with satellite images.

Figure 4 represents this scheme, taken into account 3D urban modelling system.

This stand-alone system provides 3D modelling system for urban city modelling, and 3D anaglyph processing in this system is provided as add-on functions with separate user interface. This system also provides 3D feature generation functions: building, road, facilities, and other man-made utilities.

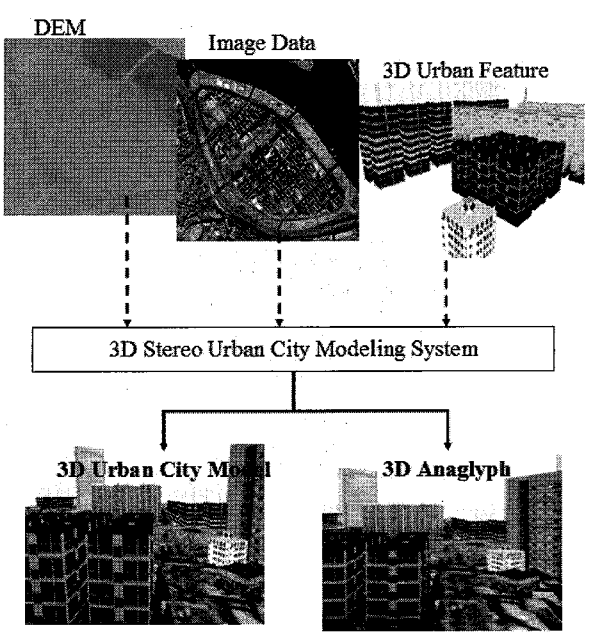


Figure 4. Applied scheme using this system: data I/O, and rendering for original Scene and stereographic Scene

Table 1 shows experiment model and results: one high condensed urban area with the high resolution satellite imagery and one mountain area with the mid-resolution space-borne imagery.

Figure 5 (A) and (B) show 3D anaglyph rendered scenes in the downtown region, Seoul. These scenes are viewed from different eye position or view point in the same 3D model with draped satellite image on DEM. In this process, eye position is automatically processed in order to generate dynamic 3D anaglyph. Figure 6 show another case for the mountain region, Seoul. This scene is one example which is computed from arbitrary eye position.

Table 1. Experiment model and results

| | Type A | Type B |
|---|---|---|
| Points | 1,056,784 | 37,748,736 |
| Triangles | 2,113,568 | 75,497,472 |
| Image Resolution | 1024x1024 (10m)<br>2048x2048 (10m) | 6144x6144<br>Quickbird |
| Region | Mt.Gwanak, Seoul, in Korea | Yeouido, Seoul, in Korea |

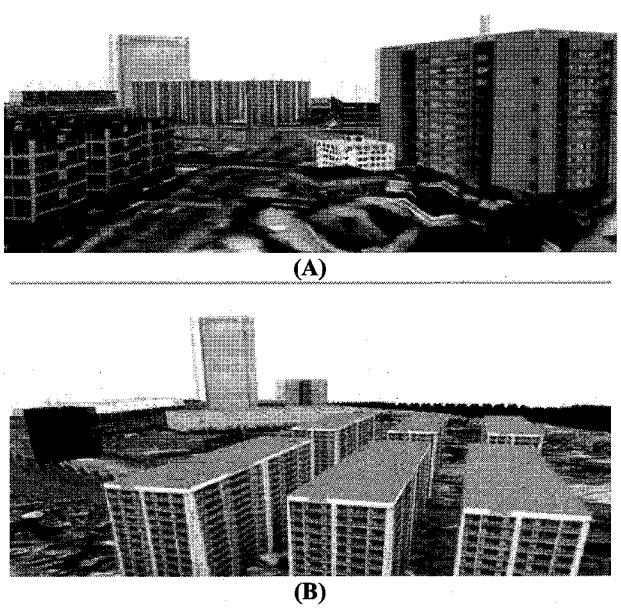


Figure 5. Anaglyph rendered scene in the Yeouido region, Seoul of Figure 1 (A) and (B)

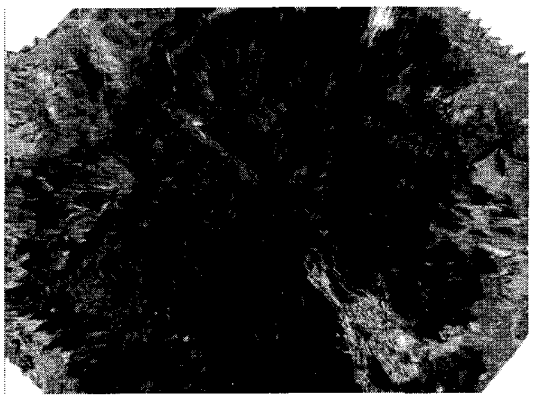

Figure 6. Anaglyph Rendering Scene in the Mt.Gwanak of Figure 1 (B) and (D)

## 4. CONCLUSIONS

This study is to develop an augmented 3D anaglyph system for 3D urban modelling and rendering. The main focus in this system is dynamic 3D anaglyph processing and realistic scene can be produced by the space-borne high resolution imagery with DEM. OpenGL API is used to system implementation for this dynamic anaglyph. We examined two model case studies with actual data sets: highly condensed downtown area and mountain area. From these experiments, this system can help users and scientists who want 3D visualization with multiple aspects.

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