

# Construction of Complex City Landscape with the Support of CAD Model

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Commission V, WG V/6

**Keyword:** 3-dimensional GIS, CAD model, Complex city landscape, visualization

## Abstract

As we know, today, GIS can't establish complex 3-dimensional landscape of city, the main reason is that GIS absent skillful modeling tools as these used in AutoCAD and 3Dmax. Although the main purpose of Virtual GIS is to establish beautiful and complex landscape, from the view of GIS, it's essential is Virtual Reality that using GIS data resource, it discard the majority of GIS features. In addition, many research works related to CAD model in 3-dimensional (3D) GIS also have been developed, but in these works, complex objects are still not taken into account seriously. AutoCAD and 3Dmax and et al software could establish beautiful habitation landscape, as we saw in many advertisements, however, GIS researchers usually consider situations much more about real geographical data and much more larger geographical areas.

In 3-dimensional GIS, many objects in city environment are disposed in simple way, for example, buildings are considered as box, and many others constructions and plants are even not considered, the difficulty of the problem is that spatial relationships representation and the management of huge data that fetched from CAD models. However, 3D GIS can't avoid represent detailed landscape especially in city environment, on the other hand, many objects in real world is so special and so complex, it's difficult for any data model to represent it automatically, but CAD models which established mainly by alternate methods could be used to represent these objects very well, hence at the present time, construction of complex city landscape must ask for CAD models support, so we put forward one solution:

Two types model should be used in 3-dimensional GIS: simple model and complex model, simple model could be automatically established, similar to many data models put forward by many 3D GIS research scholars; complex model is CAD model, its import from modeling tools, such as AutoCAD and 3Dmax et al, it's used as complement to simple model. All spatial calculation and disposal are based on simple model, complex model mainly used to give real landscape, while simple model and complex model could be used in mix way, such as LOD levels to accelerate visualization. In this paper, we mainly discuss construction methods of complex city landscape, including objects data modeling and data structure. At the end of the paper, one simple experiment is introduced.

## 1. Introduction

There are many research directions in 3D GIS fields, different research works has different needs to 3D visualization, the perfect result of 3D visualization is establish VR environment.

However, in order to satisfy GIS spatial analysis and operation, only simple model should be used in 3D GIS at least at the present time and near future. Verbree E. et al (1999) divided 3D GIS view into three types of visualization: plan view, model view

and world view, three types views respectively correspond to conventional map (2D GIS), simplified 3D representation and a full immersive and photo-realistic 3D display.

Actually, world view is fit to VR environment, it's not suit to 3D GIS, because the world view require much detailed model and photo-realistic images, it would cast huge data collection and modeling works, and the data is too large and too complex for 3D GIS to do management and spatial analysis.

However, model view is suit to 3D GIS, as objects in city environment are simply represented, and the data model suit to GIS spatial analysis and operation. But simple data model representation is difficult to represent complex landscape objects in city environment, such as sculpture, cloverleaf junction, ancient or special architectures and constructions, trees and etc., (in this paper, we define complex landscape objects as: objects that could not or difficult be represented by primitives or simple combination of primitives, such as box, cuboid, prism, cone, and etc., fig. 1 shows one sample of complex object) but these objects are also very important to city environment, its must also be represented in model view, in this paper we try to propose one approach to solve this problem.

## 2. Present works review

Actually many works have been done on 3D CAD city models, such as geometric models of Melbourne, and more detailed model was made in 1990 of city of Bath (Danahy J., 1999), but these earlier works are mainly focus on visualization, and it's established on the base of CAD system, it's absent GIS functions.

From the view of GIS, many research works also have been done, they mainly focus on the subject of 3D city model, e.g.: in order to establish 3D city models, Koehl M. (1996) proposed that 3D urban objects can be classified into two categories: the regular and the irregular shaped objects, 'the irregular shaped objects can be modeled with DTM algorithms, the regular shaped objects are a

combination of geometric primitives like the primitives of constructive solid geometry'. However, as many objects such as cloverleaf junctions have complex shapes, it's not easy to be modeled by DTM algorithms. Haala, N. and Brenner, C., et al (1997) put forward some approaches to generate 3D city models from Digital Surface Models and 2D GIS, but their works could only establish rough building models. Gruen A. (1998) and his research group developed a software named TOBAGO, which using a semi-automated approach for the generation of 3D building models, in this software, many predefined shapes are used to combine building objects, as those shapes and modeling tools are so simple, it's difficult to established complex buildings models.

We agree with term 'model view' proposed by Verbree E. et al (1999), when we are considering 3D GIS operation and analysis functions, model view is the best choice, actually above works are mainly relate to establishment of model view, many complex objects in city environment are ignored in these works or similar works.

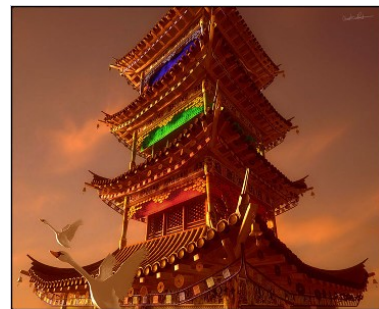


Fig.1. Sample of complex object

## 3. Complex objects

The real world is so complex when people try to fully move it into the computer space, although the present computer hardware and software could establish a very vivid digital area, but this area can't be too large, as computer can't sustain too large data amount and satisfy people's usual needs. But 3D GIS usually need establish very large area's landscape, for example one whole city, so 3D GIS can't use detailed model, it's must focus on the

utility of simple model, and using automatic modeling approach. Fig.2 shows 3D GIS established from 2D GIS, we could find that only simple buildings are established, many other objects are ignored.

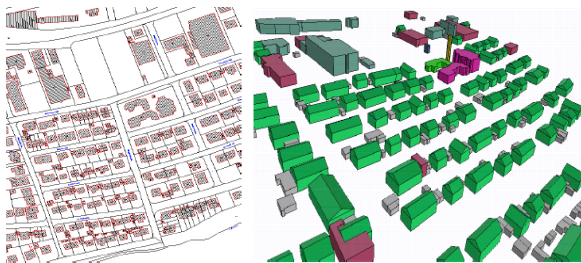


Fig.2. 3D GIS established base on 2D GIS (Anders, 1997)

In this paper why we call complex landscape is that we try to express these objects that was usually ignored in 3D GIS modeling and visualization process, we are not consider cases in VR environment. Accordingly, complex landscape comes from complex objects, now we firstly discuss modeling of some typical objects such as trees, bridges, complex constructions, sculptures and etc.

*Trees:* a vivid tree model is usually built up by fractal algorithm, but fractal model has too large data amount, so tree images are widely used in 3D GIS system. However, we are not refuse using fractal tree models, for example, we use them in very near viewpoints in order to emphasis visualization effects, combination of the tree images and it's fractal model is a feasible way.

*Bridges:* the most ignored objects are city bridges, but in city environment, there are many bridges, especially cloverleaf junctions, these objects are so obvious that we can't ignore them. Visualization of cloverleaf junction have been discussed by Chen J. and Sun M. et al (2000), although TIN model is a good representation, the modeling process is really rough, we think it's need CAD tools.

*Complex constructions:* many industry constructions, ancient constructions and some

special constructions are belong to complex constructions, people usually could recognize them by their appearance, it's need special modeling with the help of CAD tools.

*Sculptures:* as there were so many special and irregular shapes, we even can't speak out what is a sculpture looks like, a commonly used modeling method to this type objects is surface TIN model, these models are established by CAD tools, GIS can't establish these model, so its must load from CAD or other modeling tools.

In a word, its' difficult to establish these objects models using GIS system, we must ask for extra modeling tools such as CAD and 3Dmax.

## 4. Complex landscape Modeling

### 4.1 Modeling schedule

As we found in many 3D GIS research works, data modeling is the most important subject, the reason is that there were so many types objects over the real world. In order to divide models detail levels, Verbree E. et al (1999) divided visualization into three types: plan view, model view and world view, Koehl M. (1996) classified objects into two categories: the regular and the irregular shaped objects, But we think 3D GIS modeling should be classified into two types: automatic modeling and semi-automatic modeling according their establish mechanism.

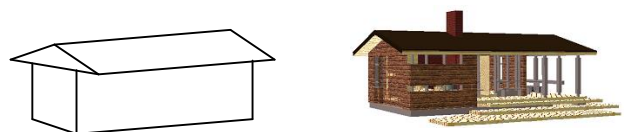


Fig.3. a) House expressed by CSG primitives b) House expressed by model established using 3Dmax

*Automatic modeling:* GIS is emphasis on spatial analysis and operation, for the convenient of utilities, data modeling requires object's data should be organized according to their spatial relationships, and data amount should also not be too large, so the data model must simple. On the other hand, simple data model is easily to be established automatically by 3D GIS systems. Many related works have been

done, such as: Brenner C. and Haala N. (1998), Schilcher M. et al (1998). In their works, 3D objects model could be established automatically from 2D GIS by add third spatial information. Simple data model usually established on the base of geometry primitives such as cube, cuboid, prism, cone, cylinder, frustum and etc. (see fig.3.a), however, data modeling that using these primitives is not always automatic, as works did by Gruen A. (1998).

*Semi-Automatic modeling:* if we ignore data collection, semi-automatic modeling is usually used in complex and detailed objects models (see fig.3.b), as these models have too many various irregular shapes and too complex for computer to establish in batches, and usually special modeling tools such 3Dmax and AutoCAD must be used in alternate style. As complex and detailed models usually have a large spatial data and photo-realistic textures to describe it, so the related data collection and management becomes the most challenge question (Danahy J., 1999). As much manual works are need in Semi-Automatic modeling process, it's not fit to 3D GIS systems, especially these systems that need frequent modification.

Obviously, automatic modeling is suit to 3D GIS, at least at the present time and near future, but automatic modeling can't solve complex objects data modeling, as reason we mentioned at the beginning of this paper, in order to solve this problem, we propose following approach:

Firstly, all objects model established automatically, to complex objects, they need two kind models, one complex model and one simple model, the simple model is to use shell shapes of complex model, it's used in operation and analysis procession, and could be established automatically; secondly, complex model or detailed model of complex objects are established by CAD tools using spatial data; finally, complex model of complex objects are loaded into system by edit way, its visualization could be controlled by system parameter or user operation.

Using these thinking, we could establish complex city landscape, however, the data management is still one big problem, it must be discussed here.

## 4.2 Data structure

Corresponding to automatic modeling and semi-automatic modeling, we divide objects model into two types: simple model and complex model, they defined respectively as follow:

*Simple model:* it's represented by sets of points and lines, or directly represented by geometry primitives such as cube, prism, cone, cylinder and etc., or combination of these primitives, it is actually a type of wire-frame model, no need image textures, and could be established automatically by GIS systems.

*Complex model:* it's also represented by sets of points and lines, or directly represented by geometry primitives or its combination, however, the representation is much more complex and detailed, in addition, texture images might be used in complex model, and modeling process must be done with the help of modeling tools.

As complex models are not suit to data process, such as calculation and operation, we must set up a simple model in data process instead of complex model for complex object. The shell shape of complex model is the best choice, e.g. for a fractal model of pine tree, a cone primitive might be the best choice. Therefore, for complex objects, it must have a simple model, the simple model is used in GIS analysis and operation process, simple model data is used in calculation, while complex model just used in visualization.

According to the above definition and comments, we could setup a data structure as in fig.4. Objects in a complex landscape could roughly be divided into three types: simple objects, complex objects and DEM, simple objects that could be represented by simple model, it's mainly used to data process; complex objects that could be represented by CAD model, it's only used in visualization process, however, complex models might not only be CAD models, they might be combined same as simple models besides the combination process is very complex, e.g. models of cloverleaf junctions. Point sets, line sets and primitive sets are composed of the basement of models; CAD models are imported from CAD tools, they are all managed in spatial database.

As complex objects have two types of model: simple model and complex model, it must need special disposal: simple model is loaded whenever the system is loaded, complex model is only loaded when visualization process is needed; once complex model is loaded, simple model becomes invisible, on the other hand, once calculation and operation process began, complex model becomes invisible to data process.

## 5. Experiment

We have developed one simple 3D GIS system

software, using this software we have constructed one simple complex scene (see fig.5), in this scene, several typical complex objects are included: several trees, one sculpture, several detailed

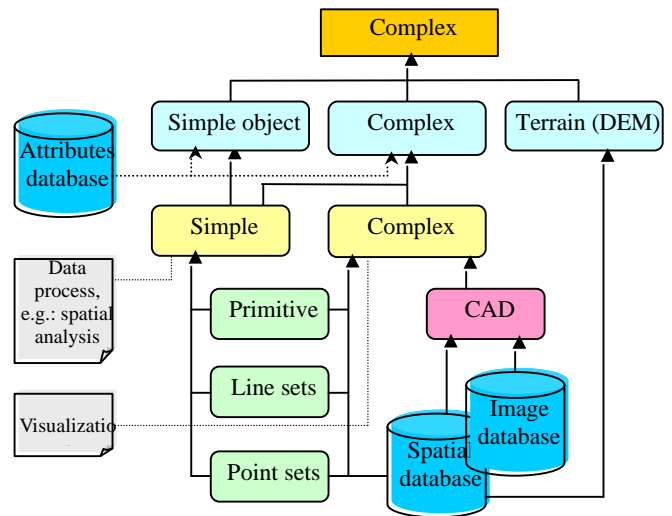


Fig.4. Data structure for complex city

buildings and cars, these models are built by CAD tools, we downloaded them from internet.

We just simply assign each of these objects a simple model represented by a cuboid, during query process, one cuboid is used instead of the complex model. In addition, real ground expressed using DEM is also imported in the scene, as the scene is a random construction, it seems not truthful, however, it could basically illustrate our ideas.



Fig.5. One simple complex landscape constructed using complex objects

## 6. Conclusion

As 3D GIS main purpose is spatial data handling, its data model can't be too complex and should be established automatically, however, some objects in the real world are much complex, it's difficult to establish model for these objects automatically, therefore, CAD models should be introduced into 3D GIS system in order to satisfy visualization, after all, 3D GIS can't avoid detailed visualization to the real world. One defect of the CAD model is its large data amount, however, rough CAD models are usually have few data amount, when CAD model's data amount is controlled by modeling process, they would not effect 3D visualization too much.

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