

# Combinative Representation of TLS Point Cloud and 3D Virtual Reality for Cultural Heritage Preservation Planning

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## ABSTRACT:

A method for representation of 3D VR by combination of 2D and 3D models is. It improves the process of 3D scene building by importing of models from TLS point cloud data and it is supposed to be an efficient way to represent 3D scene of constructions, especially for historical buildings. The preconditions and process of this combinative representation are expatiated. We also carried out a simple test which is brought forth in it.

## 1. INTRODUCTION

Concerned to cultural heritage preservation within urban planning and constructing, our interesting points always are the heritage objects themselves and the relations with objects near-by, particularly the ones (such as buildings and roads) in the region to be planned for reconstruction. In order to focus on these for heritage preservation, we attempt to represent detailed 3D models of heritage objects, simplified 3D models of constructions near-by and images of subordinate constructions around the heritage objects. According to the practicability and advantage of a procedure for representation to combine the laser scanning point cloud model with virtual reality technique, a case of the combination is studied for historical buildings preservation in urban planning and constructing. The combined representation will improve the visualizing efficiency of 3D model from the scanning point clouds in a scene reconstruction.

## 2. 3D MODELS OF HISTORICAL BUILDING

The laser scanner technology is to facilitate demand for creating 3D models of historical objects as it produces 3D points directly and provides dense 3D information. By this way, we can achieve orthographs, models and VR displays of the objects in a short term. For an individual heritage building or a small-scale group of buildings, we make use of terrestrial laser scanner (TLS). Many cases have proved that TLS is befitting to satisfy the accuracy and detail requirements of the unique structures of Chinese heritage buildings, such as complex wooden structure and the special external architectonic elements, as it can provide us much more detailed information of the heritage buildings. The information is considerable for not only modeling and reconstruction, but also documenting and deformation monitoring.

However, mass data of point clouds make themselves difficult for storing and representing in scene reconstruction. There already are some approaches for fast representing as follow: (1) Debase the accuracy of the models; (2) Using simple models with texture; (3) Using detail of level (LOD) technology. Approach (1) and (2) are meaningless to representation of highly accurate point cloud model, and (3) gives unapparent contribution. Therefore we attempt to represent point cloud model combined with other models in the 3D virtual reality of scene reconstruction.

## 3. METHODOLOGY

### 3.1 General

Following the OO (Object Oriented) thought, we treat all the data as models in VR scenes. They can be divided into 2D models (vectorgraphs and images) and 3D models (terrain and constructions) according to their geometry properties, though they have relations with each other. (Figure 1.)

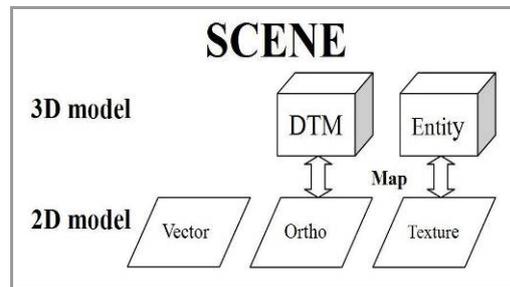


Figure 1. Model Relation

We attempt to combine model from point cloud data to other two model types for VR scene reconstruction in four data layers: DTM, terrain orthographs, Vector files and entity models. The gradation of scene creation is form bottom to top, and each layer overlaps on the former one. (Figure 2.)

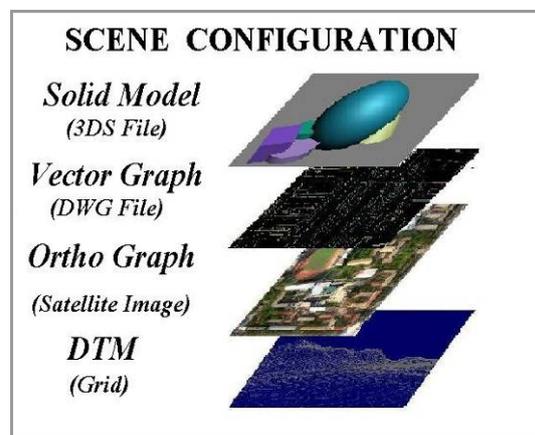


Figure 2. Scene Configuration

### 3.2 The Four Data Layers

DTM data are derived from topographic maps, aircapes, satellite images, and even airborne lidar point cloud data. Format of this model is usually grid or TIN network after altitude value interpolation process. We use grid DEM file from topographic maps after interpolation for the testing. ( DTM in Figure 2.)

Digital orthograph is loaded after registration. In fact, it is cling to the DTM just as texture mapped to. As a result, the DTM is rendered by tortuous orthograph and it makes the terrain looks more real in scene. We use satellite image for testing. ( Orthograph in Figure 2.)

Digital vectorgraph is used to express the subsidiary terrestrial objects near the heritage buildings and 2D entities that close to the ground, instead of entity models. This part is the most flexible one in scene, where the advantages of CAD platform show up. It can be converted into raster image for terrain or stretched into simple 3D models for entities. It's also the link and access between the two layers near. We use .DWG file for testing. ( Vectorgraph in Figure 2.)

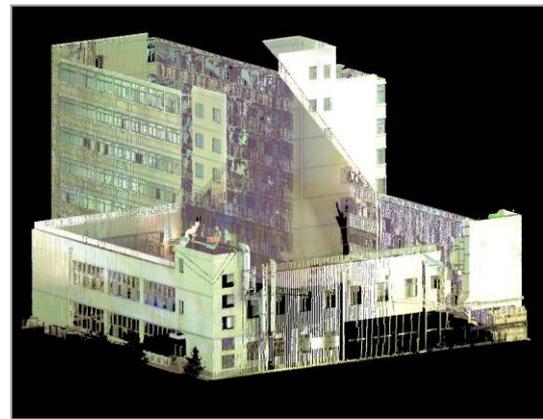
3D solid models contain two parts: one is the detailed models of the cultural heritage buildings converted from point cloud data, the other is the simplified models of the less important entities near the historical objects converted from extensive files. The Individual detailed models, which are the accurate polygonal models can be used for surveying, have high details and refined texture, but the simplified models don't. Both of them must be loaded base on the DTM base. ( Solid model in Figure 2.)

### 3.3 Point Cloud Data Modeling

Point clouds come from laser scan data directly. They must be converted into images and then to 3D models for representing in scene reconstruction. The conversion process reads and aligns the scanned data information, and creates a corresponding 3D image using an interpolation process in at first. Then a highly accurate polygonal model which contains scans aligned is created. The polygonal mesh is adapted to the object's curvature, and it is possible to control the triangle size, smooth the input data by removing digitizer noise, and significantly reduce the model size while respecting the object's shape.



(a) Front view



(b)Side view

Figure 3. Point Cloud Scans

### 3.4 Combination

There're two basic preconditions to ensure the combination, which are the formats of DTM model and point cloud model must converted into solid models in order to be processed as entities. In fact, the accesses of these two are the same way that is how to build solid model from network model essentially.

DTM data is always in grid format as a network (Figure 4.). This network is just a NURBS (non-uniform rational B-spline) surface in CAD for display, but it must be converted into solid model in combination. We add a polygon as the base in the same size under the network and link their edges with closed polygons to convert the network into a solid model (Figure 5.). DTM must be loaded as the base of both scene and coordinate system. Here we generate DTM from DEM and set the origin of the coordinate system in centre of this site.

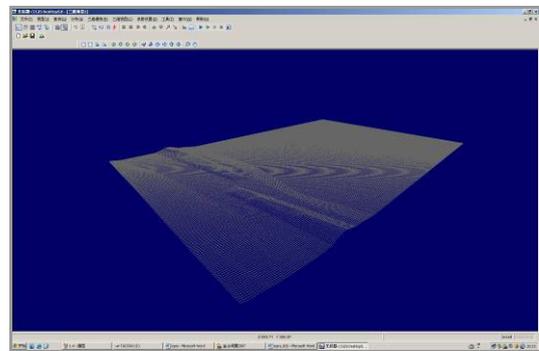


Figure 4. DEM grid model

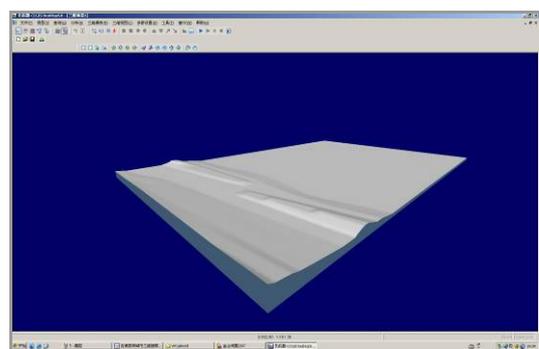


Figure 5. DTM solid model based on DEM grid

The conversion process in Cyclone reads and aligns the scanned data information, and creates a corresponding 3D image using an interpolation process in at first. Then a highly accurate polygonal model which contains scans aligned is created. The polygonal mesh is adapted to the object's curvature, and it is possible to control the triangle size, smooth the input data by removing digitizer noise, and significantly reduce the model size while respecting the object's shape.

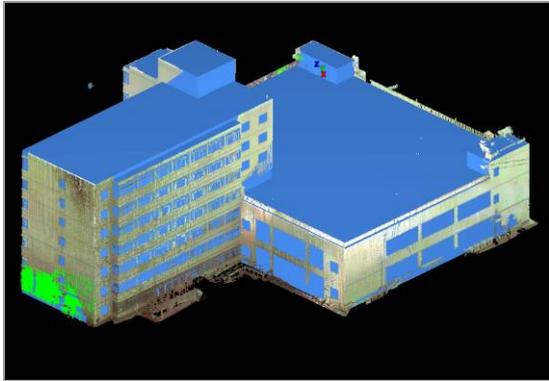


Figure 6. Surface Model from point cloud

After exporting the highly accurate polygonal model into a universal format for CAD system, we just adopt the surface model. Finally, we export it into CAD or 3DMAX to build solid model and map the textures that after certification, then the detailed model will be acquired from point cloud data (Figure 7.). During all these converts, reference frame should be unified for better precision.



Figure 7. Solid Model with Textures in 3DMax

CAD platform is chosen for modeling and processing of constructions, because almost all the model formats, including 2D and 3D, could be unified and compatible within it. In respect that, we choose it to be our modeling platform and convert all the data formats to it.

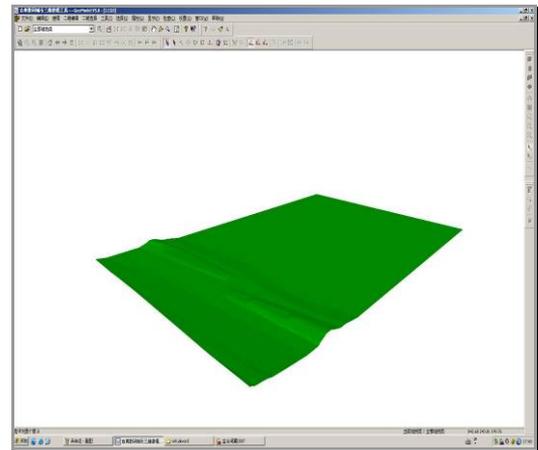
### 3.5 Representation and Testing

Combinative representing procedure is based on the loading models of these different layers of data without pretreatment as different classes of terrain entities. Each type of data is modeled individually and all the models are represented according to priority from bottom level to top level. As a result, all the layers of data are partitioned into two types, the 2D image data and 3D model data.

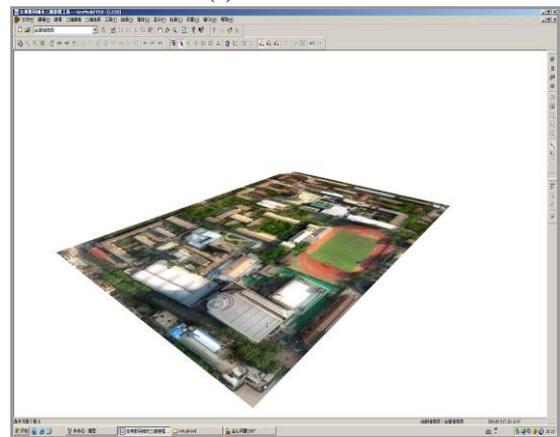
Since we cannot meet the conditions of quantity and precision for the particularity of Chinese traditional wooden structure yet,

we chose a site about 350m by 500m in our campus for testing. Testing objects are the buildings located in the site. (Figure 8.) Leica ScanStation2 laser scanner, which with 4mm survey precision, 300m rang finding, 360°×270°visual field and 50,000 points/second of data sampling rate, is used for point cloud scanning.

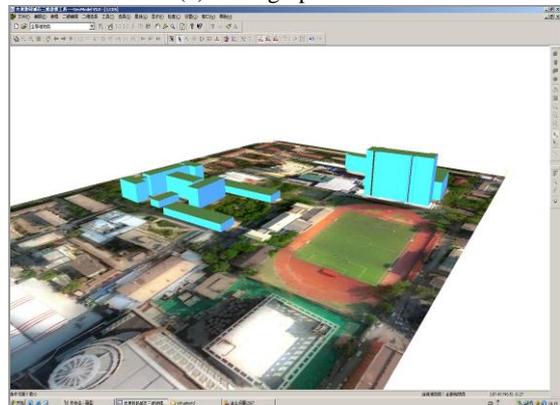
AutoCAD2006 and Adobe Photoshop 7.0 are used for graph processing. 3DMax 8.0 and Cyclone 5.8 are used for data converting and modeling. At last, CCGIS 5.1 is used for VR scene reconstruction.



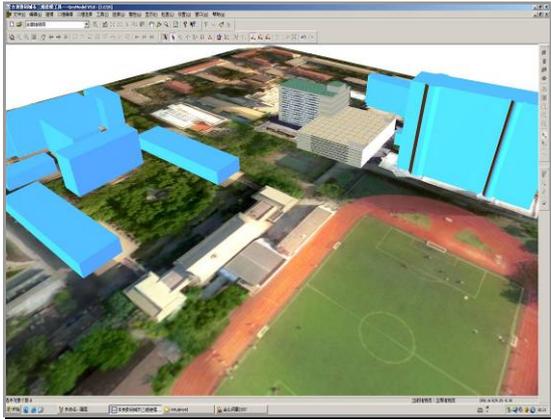
(a) DTM loaded



(b) Orthograph loaded



(c) Simplified solid models loaded



(d) Detailed solid model from point cloud loaded  
Figure 8. Combinative representing test

### 3.6 Storing

All the data of one scene are stored in one workspace, but disjoined in different file folders or databases according to their layers including DTM, digital orthographs, vector files and 3D solid models. If in database, not data but only the path information of data is stored in the workspace, and the data is still separate in different databases. There are DTM database, vector database and image database in all. Only the 3D solid models are stored in files not database, because they are stored in a tree structure according to the topological relation among them.

## 4. CONCLUSIONS

It is proved that compared with total detailed model representation, the combined representation of the scene reconstruction is more cost-efficient and faster both in storing and visualizing after the data collaboration. With the assistant of TLS, it is also convenient to build a virtual reality for heritage documenting, deformation monitoring and planning for reconstruction.

There're advantages as follow:

- (1) It reduces the workload of artificial modeling;
- (2) It makes detailed model of construction from point cloud data can be used for survey directly and with high precision;
- (3) It makes TLS focusing on core object, and keep workload balance between the outdoor and the indoor, which is helpful to the synchronization of surveying and processing;
- (4) It decreases the data and optimizes the models of non-core objects, and expedites the representation of VR scenes.

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