

## 3D-CITY MODEL SUPPORTING FOR CCTV MONITORING SYSTEM

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**ABSTRACT:** Closed circuit television (CCTV) monitoring system is widely used in many important fields to monitor fixed objectives or special areas due to its reliable capability of visual remote surveillance and control. In tradition, the CCTV system design is a complex process including field survey, plan and selecting proposed cameras sites. The visual design method is introduced in CCTV system design and maintenance. This paper suggests that the visual design method should be introduced and advantages of spatial analysis and information query of GIS and 3D city model should be fully used to aid CCTV monitoring system in design and maintenance.

### 1. INTRODUCTION

Due to its reliable capability of visual remote surveillance and control, CCTV monitoring system is widely used in many fields. It is not only an essential element of visual surveillance for Intelligent Transportation System (ITS), but also a useful monitor tool for detecting potential criminal activities in public areas or other special areas. It is also particularly suited to the protection of government or commercial buildings. CCTV monitoring system consists of various components including a CCTV camera unit, a controller cabinet housing the control equipment and a communication system, which connects the camera to a control center. Once a CCTV camera is mounted in a field, it is expensive to relocate. Therefore, thorough consideration needs to be given in the design to ensure proper sitting and mounting. In tradition, the monitoring system design is an abstract and complicated process, which consists of not only endlessly survey and calculation but also iteratively experimentation and adjustment. Furthermore, a lot of information about the proposed monitored areas must be looked up. When all devices are installed, the system can not be run immediately until those devices have been adjusted several times to provide a reliable monitoring. All of these will lengthen the design cycle time and increase system cost.

Today, with the development of three-dimensional Geographic Information System (3D GIS), quick reconstruction methods of 3D-city model make great progress. 3D city model is an accurate and visualized description for all fixed objects (building, vegetation, traffic way and waterways, etc) and their topological relations in a city (Monika, Ranzinger and Gleixner, 1997).

OpenGL is premier environment for developing portable, interactive 2D and 3D graphics applications. The representation of a 3D city model with terrain realistic scene can be implemented easily by powerful functions of OpenGL (Xue An, Ma Ai-nai, Li Tian-hong, 2001). In OpenGL, the transformation and representation of a view port in 3D coordinate space can be gotten conveniently. All these can provide a good tool for

designers of a CCTV monitoring system to verify the condition of each camera viewing range in a 3D city model.

Spatial analysis, information management and inquiry, map and display are powerful functions of 3D GIS and 3D city model. It may be an effective means for both decreasing the design time and obtaining the better system performance by taking full advantages of them to plan the monitored areas, select cameras installing position and make maps of installing position for cameras, communication cable and other facilities. Also, all the data of locations, status and model of system facilities can be stored and managed in a database based on GIS, which can help operators use and maintain CCTV monitoring system.

### 2. RECONSTRUCTION OF 3D CITY MODEL

#### 2.1 Reconstruction of outdoor 3D scene

Both the GIS and 3D city model of the surveillance areas must be created before a CCTV monitoring system is designed. To be able to view the results from the view port of the sitting and mounting CCTV cameras, one needs the 3D city model of the proposed monitored areas and the whole cityscape.

When the outdoor objects or areas are monitored, immobile objects in the monitored area may occlude part of view. Blind spots can be formed in back of objects. Improper blind area will threat the security of the system. Geometry size of objects, distance and height between objects and camera, and the undulate terrain surface are major factors to determine the size and distribution of blind spots. For this reason, when a 3D-city model is generated, terrain must be considered in order to represent the truth scene and to calculate blind spots. It is known that a building in a city always has the same height on its bottom boundary. Hence, the Digital Elevation Model (DEM) of this area, where a reconstructed building is superposed, is modified by the height of the building's bottom boundary. In order to get or extract the shape and size of a building, vegetation and other

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fixed objects for the reconstruction of city scenes, there are several methods can be used. One method (Bailard, Dissard and et al, 1998) is developed to extract aboveground areas from aerial stereo pairs. Another (Haala and Brenner, 1999) combines multispectral image and laser altimeter data in an integrated classification for the extraction of buildings, trees and grass-covered areas. Automatic reconstruction of buildings obtained by using airborne laser data and 2D ground plan information is also an efficient idea (Brenner, 1998). Frequently, these ground plans can be obtained either in analog form by maps and plans or in digital form by 2D GIS. Of course, DEM can be acquired from airborne images like stereo images or active range data like laser range scanner. Airborne laser scanners can usually provide more accurate DEM of high and homogeneous quality.

In order to reconstruct the 3D scene of a range around monitored area, we also can apply the method (Pollefeys and Koch, 2000) that reconstructs 3D scenes from sequences of images taken with of-the-shelf consumer cameras.

## 2.2 Reconstruction of indoor 3D scene

The generation of indoor scenes is a relevant and challenging task, since there are so many objects need to be reconstructed. However, The major factors affecting indoor camera view are the building inner structure and facilities or furnishings, which should be well represented. A building inner structure can be reconstructed according to its construction map, while furnishings can be reconstructed by assembling components (Kiyoshi and Kiyokawa, 2000), which are generated in advance and stored in component base. When reconstructing the indoor scene, these components, whose sizes can be adjusted, are put on their scene position. All texture can be obtained from their surface images, taken by still video cameras.

Indoor scenes also can be reconstructed by other methods. One method (Severia, Ng, et al, 1999) is to reconstruct indoor scenes by combining spatial data acquired by a Laser Range Finder (LRF), and visual data, acquired by a video or digital camera. Another method (FrankA, 1998) is to use a single image and geometric constraints for reconstruction.

## 3. CCTV SYSTEM DESIGN

### 3.1 Planning monitored areas

To plan monitored areas is to propose all the areas that need to be monitored by CCTV cameras according to the objective of CCTV monitoring system. Since full coverage of all areas around a monitored target in an urban area would be cost-prohibitive, a plan of monitored areas must be determined strategically based on the applied objective of every CCTV monitoring system.

A system's planning solution of proposed monitored areas is different from others due to their difference objective. In an ITS, the primary objective of a CCTV monitoring system is to provide surveillance of freeway/highway segments or intersections and obtain a visual confirmation of incidents (Lee, Zachariah and Evarett, 1995). The CCTV monitoring system in a security system usually needs to provide surveillance in many different situations from parking areas and commercial districts to housing, recreational and transport facilities (Thiel, 2000). Besides providing a visual confirmation of incidents, the CCTV

monitoring system in the security system supervises all activities in surveillance areas.

At this stage, the proposed monitored areas are marked on the 3D city scene. Also, an approximate number of CCTV cameras can be acquired according to the camera viewing range. Because of its fixed resolution and angle of view, the installing position of a camera can determine its view area. Typically, the CCTV camera viewing range is half a mile (for 10 to 1 zoom). Figure 1 shows the part scene of a 3D city model. Where, the white ellipse A and the white ellipse B are two proposed monitored areas.

Figure 1. The part scene of a 3D city model



### 3.2 Selection of cameras position

Selection of CCTV cameras position is a key work in a CCTV monitoring system design. Both power supply and communication cable network designs are based on them. The process is presented as following.

#### 3.2.1 Proposing preliminary camera locations

In the 3D city scene, the best proposed camera location is selected as a preliminary camera location, which can provide the best monitoring and coverage of all the proposed areas, in terms of the CCTV camera view.

#### 3.2.2 Checking blind spots

In the monitored area, parts of camera view may be occluded due to geometric constraints, other physical structures, fixed objects or existing planting. Improper or excessive blind spots will limit the camera view and degrade the system dependability. Considering the position of the supervised objects on the 3D-city model, the height and direction of cameras can be selected and adjusted by mouse, while the blind spots can be automatically calculated and displayed by a spatial analysis algorithm (Zhou Yang, Tan Bing and Xu Qin, 2001). Then one can review all areas supervised by monitoring system.

If the proposed preliminary camera location needs to be adjusted in order to eliminate or minimize blind spots, the camera at the new location can still provide a similar viewing range.

### 3.2.3 Checking safety and repellence

All the underground and aerial existing facilities, such as irrigation facilities, high or low-risk utilities, drainage and existing planting, which will be impacted by construction activities for installing a camera, are displayed on the 3D scene where cameras are located around. It may be possible to move the camera location slightly to avoid impacting existing facilities, and still provides a better viewing range. At this step, the preliminary cameras locations are picked.

### 3.2.4 Checking available power source

Once the preliminary cameras locations have been picked, a check for available power source (utility company power pole, electrical service cabinet or underground vault) must be done by displaying all information of power sources around every preliminary camera location in the 3D scene. If the available power is too far to provide power, one should then consider moving the proposed cameras to another location that provides a similar viewing range. So, the process of selecting camera location from the sentence (3.2.1) to the sentence (3.3.4) needs to be done again.

### 3.2.5 Determining final cameras position

This phase is the video survey, which is a more detailed survey of all the proposed cameras viewing range at the various locations. The main purpose of the final site review is to verify cameras viewing range, select the best correct mounting height, and eliminate blind spots and significant overlaps of viewing range via displaying the 3D scene of each camera's viewing range. Finally, the best scheme for all camera positions can be acquired by the interactive way. Figure 2 shows the camera A, monitoring the area in the ellipse A shown in Figure 1. Similarly, Figure 3 shows the camera B, monitoring the area in the ellipse B shown in Figure 1.

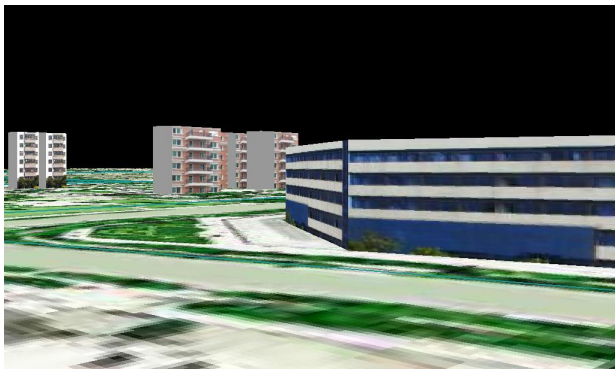


Figure2. The 3D scene of the A camera's viewing range



Figure 3. The 3D scene of the B camera's viewing range

### 3.3 Power supply and communication network

Because final camera positions are determined after checking available power source, the power supply solution can be obtained easily. On the other hand, according to final cameras positions, the installing plan of communication cable network from every camera to control center or controller cabinet can be made out in the same way as cameras positions are done. Then, the cable's length can be acquired by GIS network analysis function. Both number and installed position of the signal amplifiers can be calculated in terms of the cable's length and attenuation rate and amplifier's actual magnification (Gu Youshi, Qi Shijian, et al, 1995). In a word, the construction plan can be easily made out by the interactive way.

## 4. AIDING IN OPERATION AND MAINTENANCE

When the CCTV monitoring system is running, the 3D city model and CCTV cameras location map can be used to indicate the position corresponding to every image from cameras. At the same time, operator can watch a specified area or object conveniently on the 3D city model or 3D city scene when all of them are integrated with the control system of the CCTV monitoring system.

Both the cameras location map and the network map of power supply and communication cable may provide great help to find fault position. The model data about all the system's facilities can be used as referenced information for their replacing and repairing.

## 5. CONCLUSIONS

GIS and 3D city model can conveniently provide a lot of abundant and accurate and visual background information for CCTV monitoring system design. The visual design method may reduce cycle time and labour load of design, together with cost for a large CCTV monitoring system.

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