Three-dimensional Modelling Technology for City Indoor Positioning and Navigation Applications

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Abstract. For city indoor positioning and navigation applications, there are two technical problems should be solved, which are the modelling efficiency and the validity and accuracy of the spatial models. In this paper, the quick modelling technology is introduced which uses the multi-angle remote sensing based on the unmanned aerial vehicle measurement. To enhance the validity and accuracy of the spatial models, we proposed an algorithm to remove the line style and planar style foreground occlusions before reconstructing backgrounds. The three-dimensional models can only provide the spatial framework for the city indoor positioning. Furthermore, the simple indoor three-dimensional modelling technology which is based on the building design drawings. In the end, the application in the public safety emergency rescue is introduced.

Under the guidance of the concept of smart city, the future urban development proposes higher demand of city public security. A thorough indoor navigation technology is without fail the essential guarantee condition and an important technical part of the modern city safety control system. There are two key issues in the indoor positioning and navigation modeling process: fast three-dimensional modeling and spatial model accuracy problems. However, the function and the structure of modern city tends to be diverse and complex. The data sources and spatial accuracy of existing underlying database cannot meet the rapid, accurate modeling requirements. The acquisition method of city multidimensional data need to be strengthened [1].

To solve the above problem, this paper proposes a method to build a multi-angle and multi-level three-dimensional city foundation database based through the integration of data processing and rapid three-dimensional urban modeling technology. In order to improve the accuracy of the spatial model,
this paper describes an algorithm to remove the line style and planar style foreground occlusions before reconstructing backgrounds. This algorithm can realize the modeling of buildings and streetscape rapidly. The indoor modeling of the building can be realized through building design drawings and modeling software. Finally, this paper introduce an application in the public safety emergency rescue.

1. Current status and progress

1.1 The platform of spatial information retrieve

With the rapid development of computer technology, communications network technology, the improvement of the unmanned aerial vehicle (UAV) performance and continuous availability to a variety of digital, light weight, small size, and high precision detection sensors, spatial data collection technology has achieved rapid development. The traditional ways of conventional ground survey, such as astronomical geodesy, total station, GPS receivers, are not suitable for collecting spatial data. The way of collecting spatial coordinates and attributes by-point or by-sectional surface based on laser radar is out of date. Instead, space and aerial remote sensing is a feasible way of acquiring high resolution image in a large area, which can be further extracted geometric and physical characteristics to express the subtle surface features. During the research and development of sensors, only Charge-coupled Device (CCD) cameras is used at first. But now the CCD and the laser scanners can be used together to acquire planar information and three-dimensional information of the city at the same time. The user can use close-range aerial photogrammetry survey to meet the demand of high precision spatial data.

UAV remote sensing status and progress can be summarized as the following characteristics: (1) Using plane array camera to collect data. (2) The integration of low-altitude remote sensing data acquisition and post-processing. (3) The widespread use of high-precision navigation positioning and fixed point exposure technology. (4) Processing data automatically.

The characteristics of oblique photography can be summarized as following: (1) Acquiring abundant space images. (2) The capability of serving for mass levels of application. (3) The outstanding advantages in terms of three-dimensional modeling.

The integrated application of Global Positioning System (GPS) and inertial navigation system (IMU) technology promote the development of airborne, automotive and other three-dimensional data acquisition system [2]. There are many urban ground vehicle data acquisition system, such as with the current Optech Lynx laser collection vehicle, Earthmine panoramic collection vehicles, Avidech Zakhor dual laser radar scanning system and so on. These three-dimensional data acquisition system equip the CCD cameras and laser scanners simultaneously. So they can settle the problem of loss information caused by the obstruction from high buildings.

1.2 Review on city 3D modeling method

Three-dimensional modeling of surface feature is based on geometric approach originally. The model is entirely generated by geometric modeling software manually. The complex and precise object model requires experienced operators to spend a long time. At the next stage, modeling based on the image is developed. The method use a camera to capture a set of objects in the image, and then reconstruct the geometry of the object. The relatively new 3D modeling method is to obtain three-dimensional model of the surface features through various optical equipment. The method is widely used in vehicle and
airborne 3D data acquisition system. In addition, using a laser rangefinder instrument to extract the depth information of a number of probing points which cover the entire surface of the object is a hot new technology of three-dimensional modeling.

In recent years, some new 3D modeling of buildings reconstruction methods have been proposed. The trend is embodied in three aspects: (1) the integration of diverse data. (2) Introducing the theory of artificial intelligence in the process of identification matching. (3) The diversification of building model, such as parametric model, prism model, polyhedral model, CSG models and so on [3].

There are some developed reconstruction systems which include TotalCalib system developed by the Bougnoux from French INRIA, 3D surface automatic generation system developed by the Pollefeys etc. from Belgium KULeuven University and the PhotoBuilder system developed by the University of Cambridge Computer Vision Research Group.

2. Research method

2.1 Data source for modeling

![Figure 1. Brief technical roadmap](image)

This research mainly relying on the high-resolution Earth observation system as well as some close-range data acquisition devices. Based on the think of a multi-platform system integration, we build a three-dimensional data acquisition and surveillance platforms which integrate space, air, land data. And the research proposes a method to build a multi-angle and multi-level three-dimensional city
foundation database based through the integration of data processing and rapid three-dimensional urban modeling technology [4]. In the aspect of software systems development, we use the indoor and outdoor positioning integration technology for the establishment of three-dimensional virtual city scene and network application service system. On the network, we set up the integration process of urban three-dimensional information monitoring / control, the reproduction of three-dimensional scene dynamically, and intelligence service. In the same time, the system can visualize the city static and dynamic models in one scene and develop an interactive virtual urban environment to achieve dynamic intelligence, simulation and contingency plans and emergency maintenance applications.

2.2 Occlusions Remove algorithm
Removing occlusions on the foreground image will be based on abundant linear information straight of the building which can be used to split planar obstruction. The algorithm adopts edge protection template matching method to recover the block texture. Edge detection and tracking method is applied to extract the image on the blocked area for the simple linear vertical obstruction. The texture recovery can be realized by a one-dimensional mean value interpolation and bulk filling way. Experiments show that the method has good application effect.[5]

This research make full use of the structure information of three-dimensional buildings and obstructions to separate and track the blocked area on image. The texture of blocking area only correlate with its neighboring image pixel. The sequence images with overlapping degree acquired from the photogrammetric way can fully meet the requirements of image number.[6] The obstruction is classified for two types according to its shape. One obstruction type is planar images such as a large pedestrian occupied area, car parked on the street; the other is linear objects, such as the street lights, flagpoles. The linear objects showed a narrow strip area on the image. The algorithm adopted different methods for planar and linear block objects removal.

The brief introduction of occlusions remove algorithm is introduced as follows:

Divide the image by a certain size of a rectangular grid, and count the parallel lines density of the grid. If grid density is less than a given threshold, it is considered in the shelter area, otherwise, it is not blocked area. The results from above operation will contain misnomer segmentation block grids area which is generally considered containing less linear features or being covered by substantial advertising signs.

(2) Eliminate false segmentation grid
Compare the segmented block grid with the corresponding grid in the adjacent image from image sequence each grid to judge the degree of similarity to determine whether the adjacent grid is incorrect segmentation grid. If the two grid have a high degree of similarity, segmented block grid can be considered wrong, and removed the grid block. To avoid the situation that the grid area cannot block the entire block, expand a grid width along the border after removing the incorrect segmentation block grid.

(3) Template matching method based on edge preservation
With the right range blocked area, texture can be acquired from the adjacent image. This paper adopts the template matching algorithms based on edges preservation to recover the texture of the blocked area. This method references the priority edge ideas in image patching algorithm and the principle of optimal pixels local texture [7].
Obtain the rough linear edge by edge detection and tracking method. If the edge width and around texture satisfy some certain conditions, use the one-dimensional average interpolation for recovery, otherwise use the affine transform.

3. The application

Study of dynamic spatial evolution of spatial objects on fire, sudden mass emergency and other serious situation help to improve emergency response capacity. Combined with the emergency response process of emergency management department after the event, setting up the three-dimensional model of unexpected events and rules of the sport corresponding dynamic model can provide support for urban public safety in an emergency situation emergency treatment.[8]

Take the based geographic data of a city in Xinjiang as test data. Combined with the convention center, stadiums and other venues, facilities and space data related municipal infrastructure projects. In the same time, collect the real-time data of the stadiums environment in and around dynamically. Establish the large-scale 3D simulation scenarios of events venue.

Figure 2. A sketch of emergency rescue and indoor navigation

In the process of simulation, add the static 3D model such as building, road, streetlight. Add the car model and route information to make the car moving on the road. Add water pumps, fire, fire engine model to simulate the fire. The focus is on the integration of indoor and outdoor positioning information, analog of building and interior firefighters, and rescue personnel process.

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