CONSTRUCT 3D CITY MODEL BY MULTI-SENSOR DATA

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ABSTRACT:

This Paper describes a hybrid system on 3D city modeling, data management and visualization component for 3D GIS infrastructure. The framework obtained high efficiency, without compromising the detail and accuracy of the result .The method utilize multi source data – digital camera and laser scanner to provide data redundancy required by automation. Classification and segmentation can be processed by combined multispectral information which is provided by color aerial image and geometric information from a laser scanned point cloud. Laser Point provide heuristic clue and digital camera provide detailed texture and linear segment by multi-view feature matching. Finally we discuss the data structure used for storage ,efficient access , transmission ,and visualization of 3D data.

1. INTRODUCTION

The reconstruction of houses and other objects in 3D is currently a very active research area and an issue of high importance for telecommunications planning, disaster management, and urban planning.

Manual 3D processing of aerial images is time consuming and requires the expertise of highly qualified persons.

Fully automatic systems working with aerial images are not considered for practical use (Brenner, 2001), although tremendous progress has been made. Commercial utility collect 3D models rely almost exclusively on manual data acquisition. So an efficient and at least semi-automatic procedure to reconstruct virtual city models is a valuable research topic.

Photogrammetry is a current method for GIS data acquisition .On the other hand, laser scanner (LIDAR) has high potential of automating 3D modelling because it directly measure 3D coordinates of objects. It is a advantageous to integrate laser scanner data and digital camera for generating the city model.

2. PREVIOUS WORK

Significant progress has been made in recent years in the goal of extraction city models by means of automatic or semi-automatic ways.

Masafumi (Masafumi) combined TLS images with laser scanner data to making 3D spatial information with higher resolution in a efficient method.

In the ETH's project AMOBE (Henricsson etc, 96) , they use the strategy of interaction of 2-D and 3-D procedures at all levels of Processing ,such as Digital Surface Models and 3-D edges, should be drive as soon as possible.

Scholze use a probabilistic approach to roof extraction and reconstruction (S.Scholze) The 3D line segments are grouped into planes by means of a Bayesian model selection procedure. Gruen and Wang provide a semi-automated methodology and a commercial Implementation (Grun, 1998). Given the primary data as point clouds measured on analytical Plotters or digital stations ,a generic topology generator fit the planar structures. Maas use of invariant moments applied to laser scanning data for the Determination of roof parameters of simple building types (Maas, 99). Using only first and second order invariant moment, a number of basic parameters of a building (position , orientation ,length ,width , height ,roof type and roof steepness) can be determined as closed solutions.

3. OUR WORKING FRAMEWORK

In our procedure, multi-sensor and multi-view data were provided to increase the efficiency of modeling process. There are three steps in the generation of 3-D building models: (1)data acquisition and aerial triangulation, (2) feature extraction and multi-view model measurement, and (3) model reconstruction.

3.1 Multi Flight Lines Image

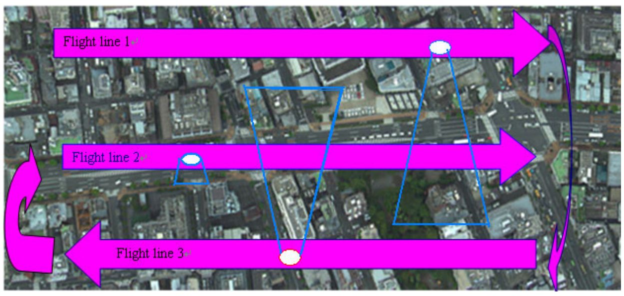

Figure 1. Three Flying Routes

In principle, two overlapping view are sufficient for surface reconstruction. Nevertheless, for generation of complete and accurate model of dense urban areas more views may be required because of the occlusion. Thus we utilization of high-resolution, multiple-overlap images.

There are totally three image sequences, one with optical axes looking downward to get the images for roofs and roads, other two sequences with oblique view-angles of about 45 degree to acquire the texture of walls of buildings. The image in the first sequence is nearly level and the others in the sequences with oblique photography are oblique. Three flying routes are shown in Figure 1.

Because image pixels outside the near-nadir area cannot be accurately correlated with the laser points, traditional film cameras are impractical for the collection of imagery for this application. Medium format digital camera system is ideal for this treatment of LIDAR data. The longer focal length and smaller field of view virtually matches the swath width of the laser system allowing the proper alignment of laser data and pixels.

3.2 Laser Scanner

Airborne laser-scanning has become a viable technique for the surveying data during the past few years. As an active technique, it delivers reliable height data without requirements to surface reflectance variations. The inherent 3-D nature of laser-scanning data saves time consuming and reduce potentially erroneous matching techniques and yields a high potential for real time application if laser ranger data can be fused with GPS/INS data onboard in aircraft.

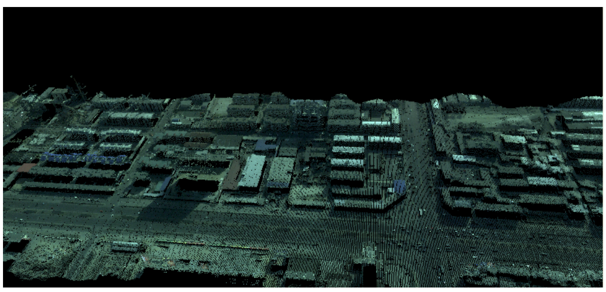

Figure 2. LIDAR point cloud with RGB, perspective view

3.3 Registration Between LIDAR And Images

Traditional aerial photographs overlapped about 60 percent in a strip. While image sequences taken with digital camera has the advantages of high overlapping and redundancy of corresponding features, which has a well potential for automatic 3D reconstruction.

Automatic aerial triangulation technique can be adopted to acquire initial values of camera parameters. linear features were used for pose estimation. Many conjugate lines are automatically generated by extraction of linear primitives from images and laser data. The exterior orientation parameters of the images are calculated based on the theory and the arithmetic of the line photogrammetry , in which the conjugate lines are used as the observation values. The coplanar condition was used as error equation to resolve the external orientation parameter of digital image.

3.4 Preprocess in Multi-Spectrum

The precise calibration and alignment of these two subsystems make it possible for the software to integrated LIDAR and Color / CIR digital camera systems.

Multispectral pixels to be photogrammetrically associated with individual X,Y,Z values. The imagery is not overlapped to the surface, rather each laser return is mathematically projected through collinearity equations onto its proper position on the taking into consideration the camera model. each surface point possesses an accurate spectral signature assigned to its location, allowing accurate classification of features using conventional remote sensing techniques.

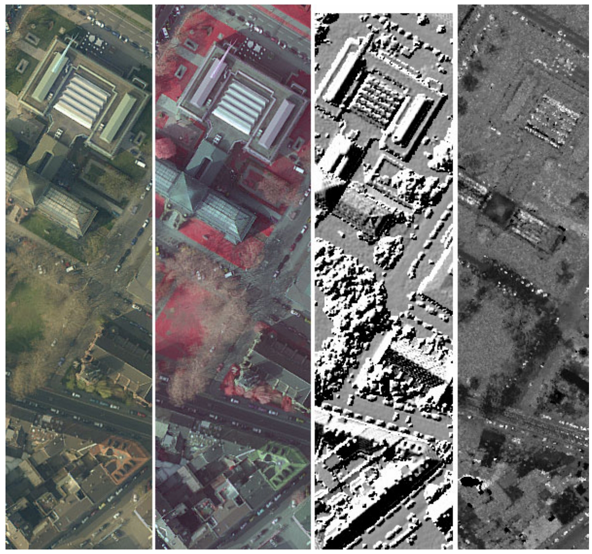

Figure 3. Multi spectrum of integration system: Color , CIR, Elevation and Intensity (Data provided by TopoSys)

In the segmentation, we compute an approximation of the topographic surface by mathematical morphological filtering .To reduce noise caused by small objects such as antennae or chimneys on roofs ,the median filter was used . To Separate the building from other blobs ,such as trees , classification can be processed by combined multispectral information.

3.5 Multi-View Feature Matching

Linear features were extracted in the digital camera image . We are interested in 3D straight lines because they are prominent in most man-made environments, and usually correspond to objects of interest in images, such as buildings and road segments.3D position could be calculate by intersection of homogeneous lines .We utilization of three views to compromise between complexity and quality of the results.
Trifocal constraint are imposed to get exactly right match result.

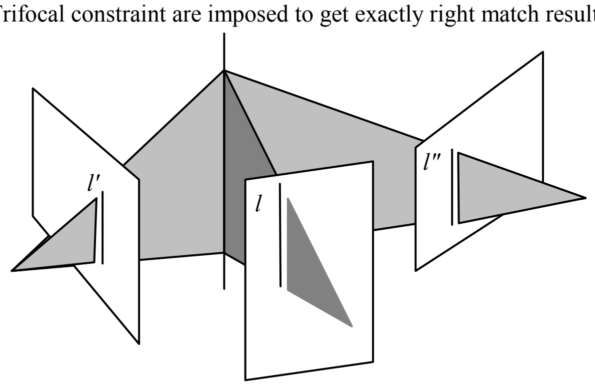

Figure 4. Trifocal geometry.

3.6 Model Construction

The initial knowledge database is established by the information extracted from existing geographic data .Colour cues, expressed in the form of colour region attributes, are also used to support stereo matching and improve the performance of 2D and 3D grouping when combined with geometric cues. Since neither 2D nor 3D procedures alone are sufficient to solve the problem of build extraction, we propose to extract the build model with the mutual interaction of 2D and 3D procedures.

The scene is represented as a constrained hierarchical model of parametric polyheral primitives .Each primitive has a small set of parameters which serve to define its size and shape. The relation between a primitive and its parent is most generally represented as a rotation matrix and a translation vector .Our reconstruction algorithm works by minimizing an objective function F that sums the disparity between the projected edges of model and the edges marked in the images .We minimize F using a variant of Levenberg Marquardt method ,which involves calculating the gradient and with respect to the parameters of the camera and the model. A reliable initial estimate be given to avoid of converging to a local minima.

Figure 5. Decomposition of 2D ground plane

If 2D Vector map of the buildings were provided , our approach can use the ground plan to infer on how the building can be subdivided into primitives. The decomposition of complex building is based on the assumption that a high percentage of building can be modelled using a small number of building primitives like flat boxes ,polyhedron with saddleback and hipped roofs ,and other geometric primitives like cylinders and cones .Each 2D primitives ,resulting from ground plan decomposition ,is the footprint of a corresponding 3D primitive. The location ,orientation, and size of the 2D primitive apply as well to the 3D primitive .The individually reconstructed primitives are overlapping 3D solids ,which are merged to a boundary representation.

Following a combined top-down and bottom-up strategy a coarse given 3D model will be iteratively refined until the desired degree of detail is achieved .The result is that accurate architectual models can be recovered robustly from ariel and ground images with a minimal number of user-supplied interaction.

3.7 Data Management

The data management component provide a framwork to organize, manager ,store ,retrieve and interactively, photo-realistically visualize the data for quality control and preservation of the relationships among various data sources and data formats ,such as GIS data ,aerial and terrestrial images ,and descriptive information about objects.
A main requirement in the data structure is the ability to access subsets of the data.This is accomplished by using an hierachical data structure , LOD-R-tree, because it is simple and efficient. Due to the straightforward mapping of the R-tree-structure onto object-oriented and even relational database designs can be used with little effort. The LOD-R-tree hierachical is designed to reflect a geometrical subdivision of the scene and can therefore easily be used for spatial queries .This both facilitate identifying a building given a particular location and retrieving all data within some region at different levels of detail.

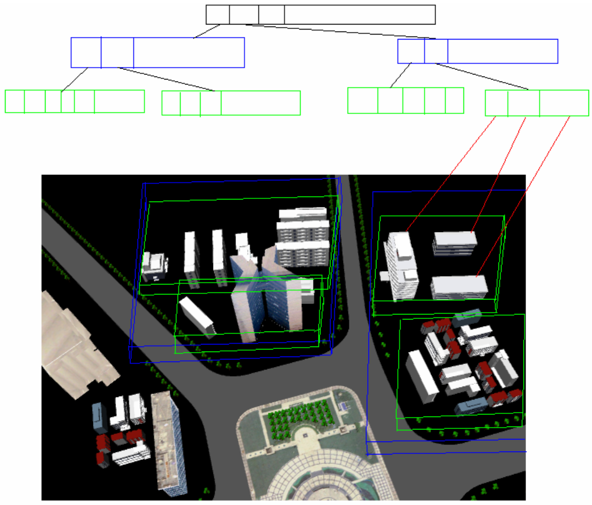

Figure 6. LOD-R-tree

In order to render the scene in a acceptable rate ,We reduce the complexity of the 3D model by using technique of Level of details , occlusion culling ,and image based rendering .Our approach trades off space for frame rate by using images to replace distant geometry. The preprocess algorithm automatically chooses a subset of the model to display as an image so as to render no more than a specified number of geometric primitives. At an image from a grid point near the current viewpoint. The geometry behind the projection plane of the image is culled while the remaining geometry is rendered normally. The approach could abtain a photo-realism render result and avoid exceed the capacity of high-end computer graphics hardware.

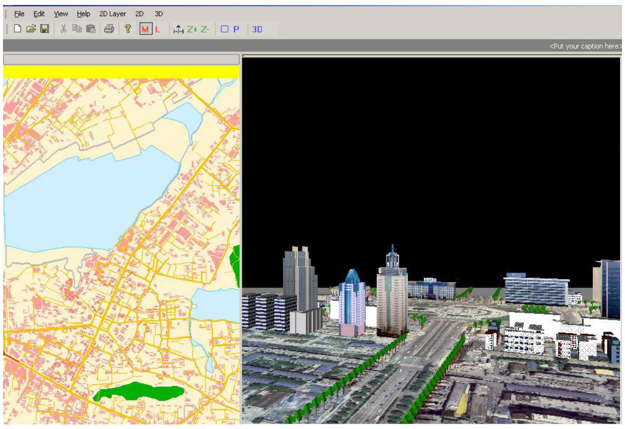

Figure 7. 3D GIS system

4. CONCLUSION

This paper describes an algorithm framework for 3D reconstruction in urban area with laser scanned data (LIDAR) and image sequence. With the framework presented in this paper we can construct 3D urban models in a more efficient and reliable way.

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