3D building Reconstruction from Google Earth Satellite Images

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Abstract

The system is aimed to develop the 3D building model of urban area with low resolution satellite images from Google earth that provides to create the three dimensional geographic information systems (GIS). In this paper, an efficient building extraction algorithm is introduced based on color segmentation and morphological method. The approach is based on the affine projection to compute the corresponding between two satellite images. To reconstruct the 3D model, the depth map is created by the modified factorization algorithm with singular value decomposition (SVD) is used to project the image point. The objective of the system is to reconstruct the 3D model of building in urban area with low resolution satellite images using efficient digital image processing method.

1. Introduction

Nowadays, three dimensional city representation models are widely used in urban planning, traffic control, disaster management, architecture, environmental planning, telecommunication, and tourism work. The 3D urban models make it easier for people to understand the spatial properties of urban objects. The 3D visualization model of building, object and scene are very useful to understand simply the situation of urban area. Some famous building and places already have been represented by 3D model view in Google earth, any GIS and other GIS application software and so on. The reconstruction of work by using satellite image is harder than the reconstruction of the images taken by camera.

This paper present the new 3D urban reconstruction for low resolution satellite images in which efficient morphology building extraction method and modified factorization method has been used. In this process, image acquisition process is done by grabbing the satellite images from Google earth. The input satellite images are preprocessed such as image resizing, noise filtering to enhance the images. The next step is to extract the building features that are used to create the fundamental measurement matrix, which are inputs to the singular value decomposition method to calculate the 3D point. The morphological method is useful for extracting image components with more complex operation. The entire measurement matrix is made by gathering the measurement matrix of the feature points of each of the object through the more than two images. The SVD can robustly recover shape and motion form the image under orthographic and affine projection. It computes a reconstruction up to an unknown projective when nothing is known about the camera calibration parameters or the scene.

2. Related Work

Many reports have been already reported for 3D reconstruction of object, scene and building in Urban. Most of the research in 3D reconstruction has focused on high resolution images. Myint Myint Sein et.al. performed 3D control point are reconstructed from the multiple images taken by a high resolution camera Nikon D1. The first step determines the control point of B-Spline curve on the object and the second step computes the 3D control point of curves from the 2D points based on the factor decomposition [1]. M.Han and T,Kanade used bilinear factorization algorithm for the scene reconstruction from the multiple uncalibrated view[3]. The factorization method can recover the shape of the object. A.Habib et.al. presented a framework for automatic 3D building generation by integrating data-driven and model-driven method with the input images of light detection and radiation (LiDAR) and aerial images[4]. The quality of images is very high resolution image such as stereo images, aerial images and commercial satellite images. Triggs proposed a method for the recovery of shape and motion from multi un-calibrated perspective images of 3D points and lines[5]. The fundamental matrix is estimated from the image data. Then, the single measurement matrix can be created by gathering the point projections and their correspondence depth. Xiaojing Huang et.al. presented a semi-automated method for height measurement and 3D object reconstruction from single imge by combining building top, base and shadow information[8].

3. The Proposed 3D Urban Reconstruction

The system is mainly developed for 3D urban reconstruction of low resolution satellite images. The sixth processing steps are included in this system. These are acquisition of satellite images from Google earth, preprocessing for image enhancement, feature extraction of building, computing depth by factorization method, computing the 3D features based on the affine projection, and 3D building reconstruction.

The Figure1 show the input satellite images for my system experiment which are used two or more images to reconstruct 3D urban modeling.

Figure1. Multiple views of input satellite images

3.1 2D Building Feature Extraction

The first step of the system is an acquiring the image. In the preprocessing step, image resizing, grayscale converting, noise filtering are performed. All images are resized to a uniform size. The original image is needed to resize for reducing the memory space and the computational time. Figure2 depicts the resizing of the input image. Next, the noise filtering and color image processing is performed to improve the image that increases the chances for the success of the other processes. The input image is complex background scene.

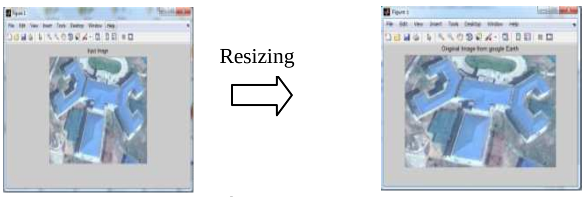

Figure2. Resizing of image

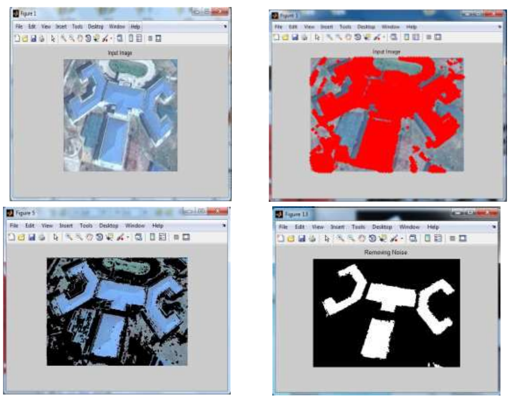

Figure3. Noise filtering process

The feature extraction of building from remote sensing imagery by using manual method is time-consuming process. The system develops automated methods of feature extraction. To retrieve the building features of low resolution satellite images, the colour segmentation process is first developed. The building feature points are extracted based on red value threshold. The background elimination is performed. The extracted features are not directly applied to model the three dimensional building. To generate the certain building features, the morphological operation has been developed. The morphological method is useful for extracting image components with more complex operation.

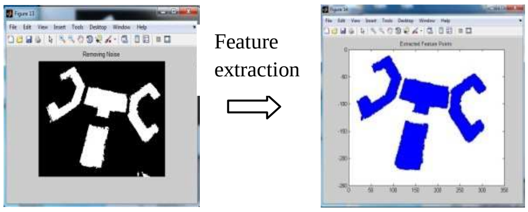

Figure5. Building feature extraction form input image

3.2 Factorization algorithm and 3D affine transformations

An essential component of factorization algorithm is the mathematical procedure of singular value decomposition (SVD). Tomasi and Kanade introduced the factorization algorithm for an affine reconstruction using a measurement matrix [2]. The algorithm assumes that the image points to be measured are present in all image view. The SVD is a simple effective technique for reconstructing the 3D structure of object space by using two images from un-calibrated camera. 3D affine transformations have been widely used in computer vision. Affine transformation include translation, scaling, similarity transformation, reflection, rotation, shear mapping, and compositions. If X and Y are affine spaces, then every affine transformation $f: X \rightarrow Y$ is of the form matrix, $x \rightarrow Mx + b$ where M is a linear transformation on X and b is a vector in Y. 3D affine transformation is denoted by

$$\begin{bmatrix} X' \\ Y' \\ Z' \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & t_X \\ a_{21} & a_{22} & a_{23} & t_Y \\ a_{31} & a_{32} & a_{33} & t_Z \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

The 3D affine structure from images obtained from affine view. The 3D feature depth map is obtained by using the singular value decomposition under affine projection approach. The extracted features from the image are transformed the fundamental matrix which decompose the three matrix using the factorization method of SVD. SVD can be performed on real (m, n) matrix. A matrix A with m rows and n columns with rank r and $r \le n \le m$, Then the A can be factorized into three matrices: $A=USV^T$. In this paper modified factorization (SVD) has been proposed to generate the depth map of the object. To reconstruct the 3D shape of each object, it is necessary to obtain the group of feature points relative to the object separately. Each building on an object is considered as an individual object and the shape of the object. The entire measurement matrix is made by gathering the measurement matrix of the feature points of each object through the more than two images. The 3D cloud points are obtained from an image based on the modified SVD with affine relations. Next, surface reconstruction for 3D building reconstruction using Delaunay triangulation method and wire frame drawing. The triangle is build using the three nodal points which are projected from a planar surface in the 3D scene and the surface reconstruction is achieved by using Delaunay triangulation method and wireframe.

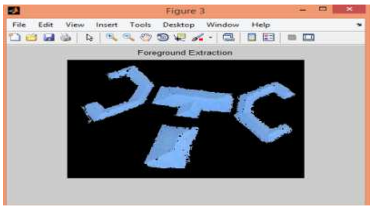

Figure6. Extracted Foreground Image

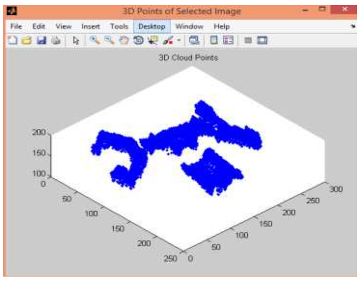

Figure7. Calculated 3D cloud point of the object

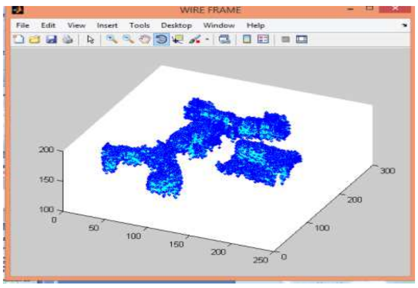

Figure8. Triangle drawing for the object

4. Result and Discussion

The developed system was tested with Ministry of Science and Technology, NaypyiTaw satellite images grabbed from Google Earth. In the selected study area, contains rectangle building shapes, grasses, and ground. In this paper, a new approach for 3D urban reconstruction of the low resolution satellite images is proposed. Some specific conditions such as high resolution images, LiDAR or radar image and intrinsic and extrinsic camera parameters are not necessary for this system. The 3D surface data is computed by the depth information from the images. The depth is computed by factorization method of SVD. The SVD is a robust mathematical function to employ when reconstructing the affine structure. This method can robustly recover shape and motion from the image under orthographic and affine projection. In this system, the input image is low resolution image so it is difficult to acquire the depth of the building. The 3D feature point and shapes of the building are recovered from the images of an object by multiple objects. It is necessary to obtain the group of feature points relative to the object separately to reconstruct the 3D shape of each object. Each building on an object is considered as an individual object and the shape of the object. Using this information, the dense depth map for the extracted building object is created in the next stage. Once the depth data is obtained, the 3D positions of the object are computed from the relation of the camera viewing angles and the centre coordinate of image. The entire measurement matrix is made by gathering the measurement matrix of the feature points of each object trough the more than two images. In the final stage, 3D building result is described to prove the how does work of the proposed method.

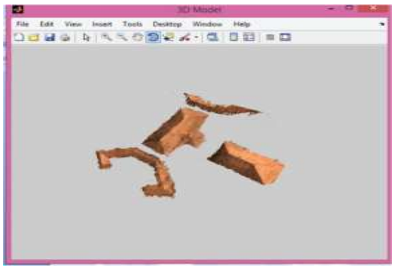

Figure9. 3D surface reconstruction model of Urban object

5. Conclusion

3D urban reconstruction system is developed to provide the visualization in the geographic information system. The reconstruction of 3D building model can be achieved using more than two low resolution images without knowing the camera calibration. The efficient building features are extracted using colour segmentation and Morphological processing. A multiple objects reconstruction system is generated for the low quality satellite images of buildings in urban area. In future, the system aims to generate the 3D urban views for geographic information system and to construct the complete 3D urban modelling.

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