Urban Building Edge Detection Utilizing GIS

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1. Introduction

Regional scale or zone scale damage estimation using satellite image can not satisfy the demands in building-wise scale. Catching damage information of the buildings immediately from some cheap image tools like camera or video is required when a large scales of earthquake occurs, especially in dense urban area. The authors proposed GIS aided edge detection of digital images method to build a structural damage estimation system [1]. The key issue is application of GIS to preset a window for image analysis to find the edge of building. Doing edge detection of images, building edge can not be distinguished from other edges such as windows, shadows, and texture. While if approximate building edge can be located by virtue of GIS, presetting an analysis window to find the exact building edge becomes viable as shown in Fig.1. Additionally, computation cost can be reduced substantially.

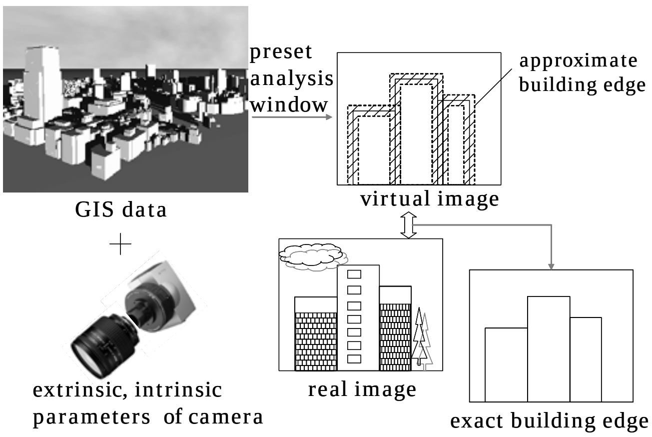

Fig.1 Preset analysis window aided by GIS

2. Methodology

Common 3D reconstruction methods need matching carefully and sufficiently a set of image correspondences to allow the fundamental matrix to be computed uniquely, then the scene may be reconstructed up. While in our system, the intrinsic and extrinsic parameters of the cameras, such as location, orientation, aspect ratio, view angle, screen distance and the vector point upwards in the camera coordinate system are given. With the aid of those useful known information, it is possible to reconstruct a scene for any points as shown in Fig.2. Equation 1-4 show the two steps for realizing 3D reconstruction from two 2D views, viewing transformation and perspective projection.

A point M $(X, Y, Z)^T$ is represented in homogeneous coordinates as $(X, Y, Z, 1)^T$.

$$M_{RC} = \begin{bmatrix} R & t \\ 0^T & 1 \end{bmatrix} \tag{1}$$

Here matrix M_{RC} composed by rotation R and transformation t relates the world coordinate system to the camera coordinate system.

$$[X_C, Y_C, Z_C, 1]^T = M_{RC}[X_R, Y_R, Z_R, 1]^T \tag{2}$$

$[X_C, Y_C, Z_C, 1]^T$ and $[X_R, Y_R, Z_R, 1]^T$ stands for the point coordinate in the camera coordinate system and the real world coordinate system separately in homogeneous way.

$$\frac{X_p}{X_C} = \frac{D}{Z_C} \tag{3}$$

$$\frac{Y_p}{Y_C} = \frac{D}{Z_C} \tag{4}$$

Here X_p and Y_p are point pixel position of in image, D is the screen distance.

Other parameters in the Fig.2 are illustrated as bellows, cameras location (C_{xi}, C_{yi}, C_{zi}), orientation n_i ,other two axis of camera u_i, v_i ,the vector point upwards in the camera coordinate system u_{p_i}, the inferior $i = 1,2$ stands for camera number.

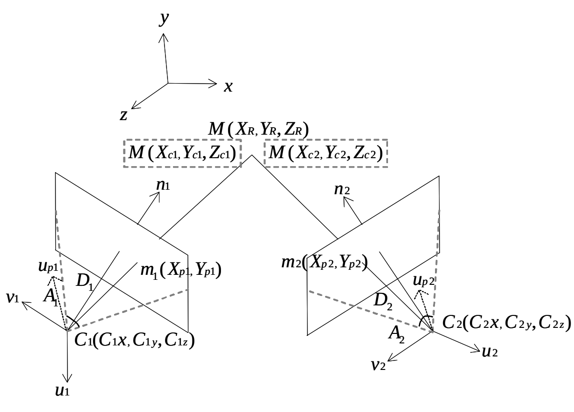

Fig.2 3D reconstruction from 2 views

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GIS contains several layers of knowledge, including vertex coordinate information of each building; which can be visualized insome visual software like POV-Ray, OpenGL. With given intrinsic and extrinsic parameters of the camera in the visual system with GIS in, images from two views are exactly simulated. If the 3D vertex coordinate on the end of edge can be detected using the proposed reconstruction method, edge in the virtual image can be obtained through connecting the corresponding vertexes, then follows the analysis window by define some boundary to the visual edge location. Once analysis window determined, exact building edge becomes easy and available to be detected inside the presetting window in the real image.

3. Experimental

We choose agriculture campus of Tokyo University as our observation area. The same cooled CCD camera with 24mm lens locates at (-31260.3851, 44.6, -6628.8534) and (-31264.2251, 44.6, -6628.2782) pointing to some parts of a building which have some overlapping parts to take images as shown in Fig.3. The image resolution is 772×580 .

POV-Ray is utilized as visualization software with setting view angle 15.08^0 and the vector point upwards in the camera coordinate system (0, 1, 0). Importing GIS of the observation area and giving the location and orientation of camera, the corresponding virtual images are generated as shown in Fig.4.

Fig.3 Real images

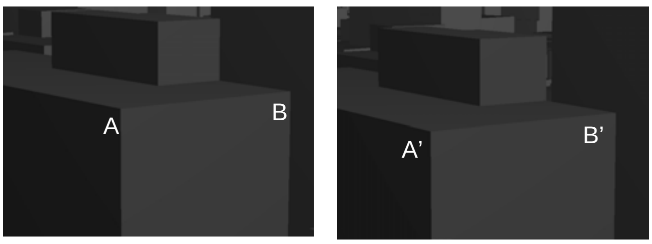

Fig.4 Virtual images

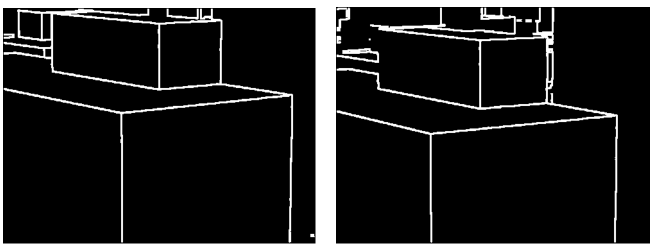

Fig.5 Analysis window

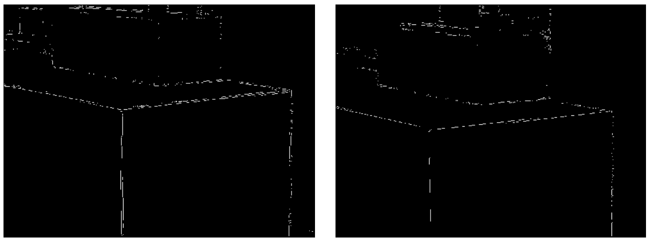

Fig.6 Building edge

For example, the 3D coordinate of A ($A^{'}$) and B ($B^{'}$) can be found as (-31242.33, 36.83, -6676.86) and (-31231.87, 36.83, -6678.77) by proposed reconstruction method. Connecting A and B presents one of the edges of the building. From approximate edge location, around which the domain include exact building edges are defined to be analysis window as the white parts shown in Fig.5. Image processing on the real image considering the wire frame, detection of building edge becomes not too difficult as shown in Fig.6.

4. Conclusions

This paper proposes presetting of an analysis window including the building edge supported by GIS to promise the fulfillment of edge detection. In this method, with the known location and orientation, resolution, view angle, screen distance and the vector point upwards in the camera coordinate system of the camera, the 3D reconstruction problem becomes easy to solve. The method can distinguish building edge from abundance of additional edges such as windows, shadow and drastically reduces amount of computation. Thereby, it meets the demand for the quickness in evaluating urban earthquake disaster.

References

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