論文の内容の要旨
(Abstract of Dissertation)

GIS を援用した画像解析による構造物被害の自動抽出システムの開発
(Development of Automated Structural Damage Estimation System Based on GIS aided Edge Detection of Digital Images)

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Regional-scale and zone-scale structural assessment in dense urban area using satellite images can only tell rough distribution of damaged area or concentration of collapse, which just gives a description of the damage. There is a requirement for structural damage identification in building-scale using objective index. In this thesis, an efficient system based on image processing is developed to quickly identify the structural damages right after a large-scale earthquake, for example in a city about 10%-30% buildings are damaged. With setting reinforced concrete buildings in a few hundred square meters as targets and analyzing displacement of buildings edges, it is available to measure the displacement with high accuracy in 30 minutes or not more than several hours.

Three key techniques have been developed in this thesis, namely, a priori analysis window preset aided by GIS, a fast sub-pixel edge detection method development and wire-frame city construction.

A priori analysis window presetting aided by GIS plays an important part in this research. Given GIS data of the observed area and the parameters of the camera (extrinsic parameters such as location, orientation and intrinsic parameters like view angle, physical size of the pixels), the scene can be constructed in virtual visualization software environment. Only several pixels difference exists between the virtual urban city scene and the real image taken by the CCD camera when doing model configuration matching. In the virtual image, the edges of the virtual buildings built on parameters in GIS can be detected, around which analysis windows can be drawn. Thereafter, edge detection can be done only inside the analysis window instead of image processing of the whole image. This GIS-aided preset window method can not only cut down the amount of computation, but also distinguish building edges from other edges like background, texture and windows.

A fast sub-pixel edge detection methodology for displacement measurement of building edge is presented. In this methodology, error function is built between the cumulative Gaussian distribution and the pixel data profile. By quantitative analysis of the pixel data across the edge

and error computation, the pixel data profile is good or not for edge detection can be judged. Subsequently, the gradient descent algorithm is applied to do the minimum searching, therefore, to identify the position of the building edge. This method shows a rapid convergence to the local optimal result, which can reduce the amount of computation.

For wire-frame construction technique, the difference from the common 3D reconstruction method is that the parameters of the camera are given. The intrinsic parameters will not change before-event and after-event and the extrinsic parameters like location and orientation can be matched due to the movement of the whole city scene. One view projection and 3D point reconstruction from two views are illustrated, based on which the methodology of 3D line reconstruction from two views is deduced. On 2D images, curve fitting can be carried out on the edge points detected in discrete way. For building edge case, line fitting method is used. From two fitted edges in two views, the coordinate of the building edge in 3D space is given. It is impossible to match points on the edges which belong to different scale images by commonly used 3D reconstruction methods, while the wire-frame city construction technique avoids this problem.

An automated structural damage estimation system based on GIS-aided edge detection of digital images is developed using C++, POV-Ray and C language. UML is adopted to descript the system. And an experiment was investigated to illustrate these techniques and the results showed that these techniques are feasible and efficient for accurately measuring displacement of the building edges.

This system of building-wise displacement measurement takes many special advantages:

1) It can extract the external buildings edges out of other complicated background;
2) It can identify the displacement of the building edge at relative high accuracy;
3) It can provide 3 dimensional displacement measurement of buildings edges before and after earthquake;
4) It can save a lot of computation cost and power energy.