A Study on 3D Reconstruction of Urban Area

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Abstract – This paper proposes a reconstruction method for the shape and color information of 3-dimensional buildings. The proposed method is range scanning by laser range finder and image coordinates' color information mapping to laser coordinate by a fixed CCD camera on laser range finder. And we make a 'Far-View' using high-resolution satellite image. The 'Far-View' is created that the height of building using DEM after contours of building extraction. The user select a region of 'Far View' and then, appear detailed 3D-reconstruction of building The outcomes apply to city plan, 3D-environment game and movie background etc.

Key Word – laser range finder, 3D-reconstruction, contours of building

I. Introdution

The reconstruction method includes two processes: Ground 3D reconstruction process and 'Far-View' create process. Ground 3D reconstruction process is done based on the flow by figure 1 and is explained in detail in part II.

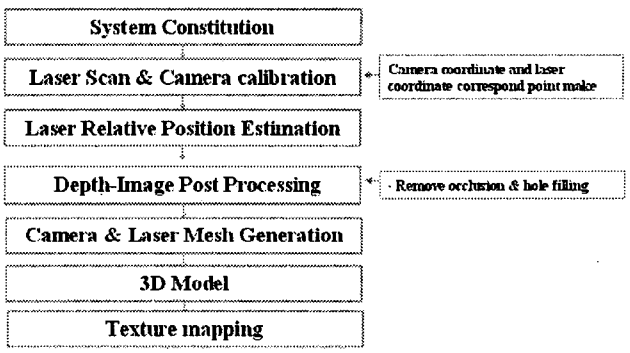


Figure 1. Ground 3-D reconstruction process

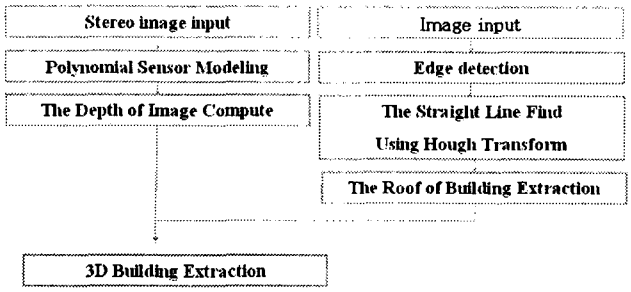


Figure 2. 'Far-View' process

Figure2. shows the flow of building 'Far-View', which is explained more in detail in part III.

II. Ground 3-D Reconstruction Process

The used equipments were composed of two laser range finder and a CCD Camera. The Laser range finder(SICK) is 2-D scanner. And laser range finder can measure 0-180 degree. The one is horizontal scanner, the other is vertical scanner. Horizontal scanner acquires the horizon data of object or surroundings. These horizon data of each scan can be known an instantaneous position. Compare with each an instantaneous scan to know a relative position by a method of histogram matching[1][2]. And we estimate extrinsic calibration of a CCD Camera and Laser range finder by calibration board(checkerboard). The extrinsic calibration parameters are the position and orientation of sensor relative to some fiducial coordinate system.

$$X_c = K[R/T]X_w$$
$$X_w = [R_l/T_l]X_l \qquad (1)$$
$$X_c = [KRR_l]X_l + [KRT_l + T]$$

*** Xc : camera, Xs : Laser, Xw : world coordinates**

Figure 3. show extrinsic calibration. And (1) are equation of extrinsic calibration.

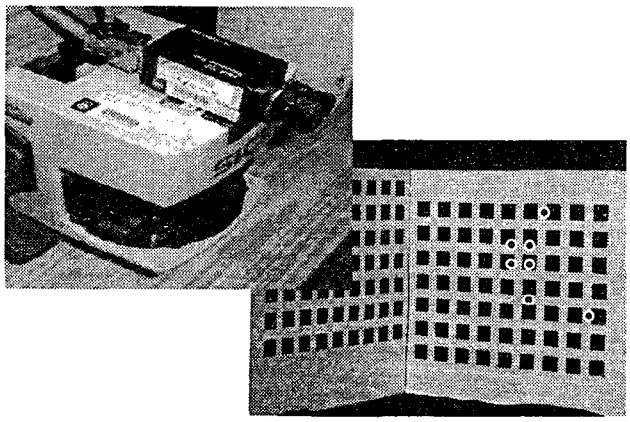


Figure 3. Extrinsic calibration of Laser range finder and CCD Camera

And then we can be mapping color information from images to reconstruction coordinates.

III. Far-View

For correct edge extraction in high-resolution satellite image, noise is removed prior to edge extraction. Based on diffusion equation from anisotropic diffusion theory[3], pixels with small variation in intensity values are smoothed and pixels with big variation are reversely sharpened through preprocessing of noise removal. Figure 5. shows the result of preprocessing explained above. For the edge image[4], then, the hough transform[5] for line extraction and perceptual grouping method[6] are applied and finally the result indicates the candidate regions for buildings.

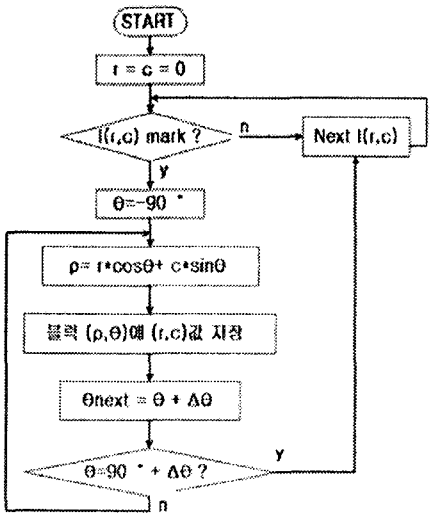


Figure 4. Processing of hough line detection

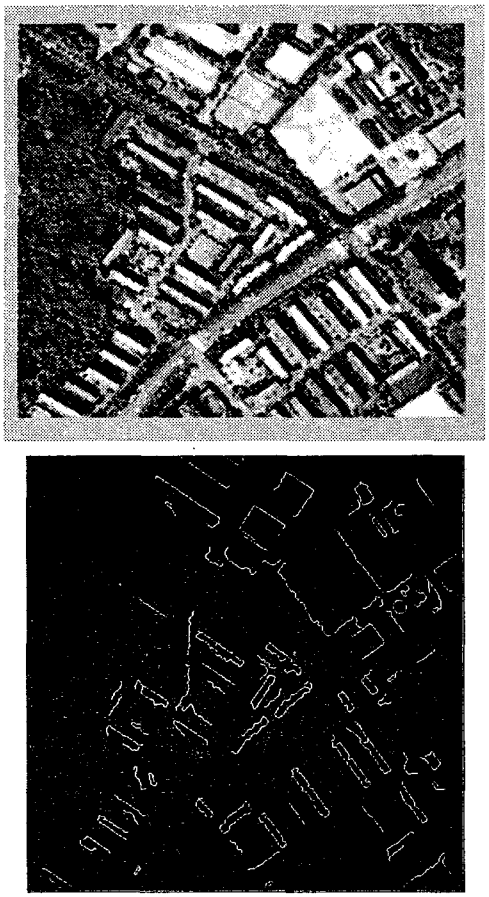


Figure 5. contour of building extraction

a) original satellite image b) edge image c) hough transform d) perceptual grouping method

And it creates coefficients of PSM(Polynomial Sensor Model)[7] using GCP(Ground Control Point)s.

DEM is produced with normalized correlation method after stereo matching. The DEM obtained above are compared to those of the candidates for building and the building is finally reconstructed.

IV. Result

1) Ground 3-D Reconstruction

First, these experiment were done at indoor. And then, outdoor experiment were done in urban area. An object of outdoor experiment were buildings. Others(tree, pedestrian, car etc.) remove by classification method(k-means algorithm).

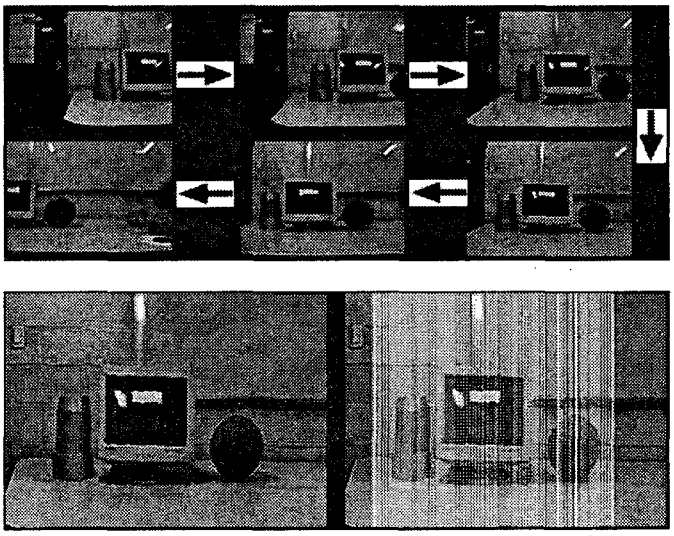
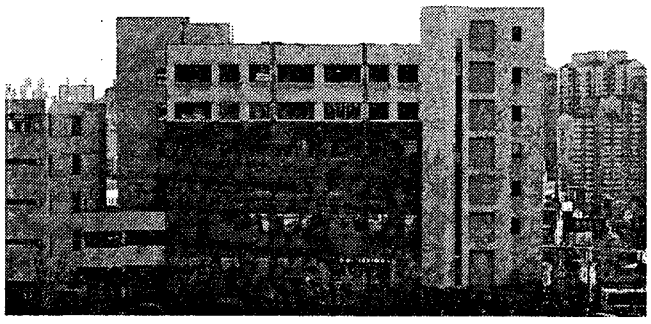


Figure 6. Indoor experiment result a) sequence images b) Panorama image c) 3D reconstruction of object



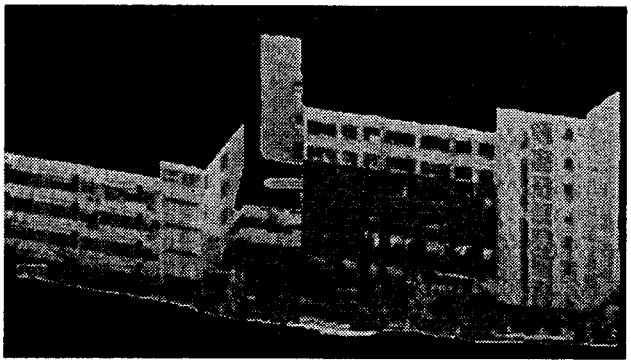


Figure 7. outdoor experiment a) original image b) 3D reconstruction of building

2) Far view

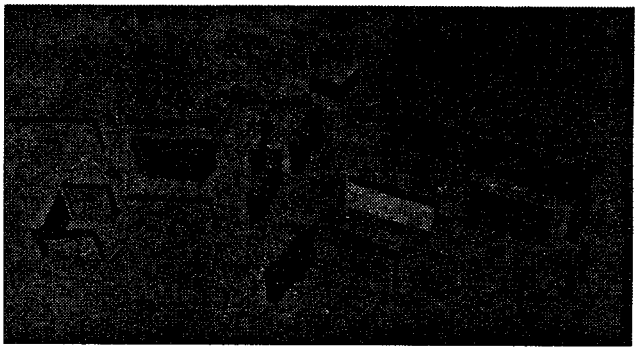


Figure 8. DEM and Far view

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