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STUDY ON MAKING CITY MODEL WITH IMAGE AND LASER RANGE DATA

Masafumi NAKAGAWA*, Ryosuke SHIBASAKI**
Graduate School of Frontier Sciences,
Institute of Environmental Studies*
and
Center for Spatial Information Science**
University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo, 153-8505
Tel: (81)-3-5452-6417 Fax: (81)-3-5452-6417
E-mail: mnaka@iis.u-tokyo.ac.jp
JAPAN

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[ABSTRACT]
Photogrammetry is a current method of the data acquisition. However, as a matter of fact, a large manpower and expenditure for making detailed 3D spatial information is required especially in urban areas where various buildings exist. There are no photogrammetric systems which can automatic a process of spatial information acquisition completely. On the other hand, laser range finder has high potential of automating 3D spatial data acquisition because it can directly measure 3D coordinates of objects, though the resolution is so limited at this moment. With this background, the authors believe that it is very advantageous to integrate laser scanner data and stereo CCD images for more efficient and automated acquisition of the 3D spatial data with higher resolution. Laser scanner can measure coordinate values of an object directly, but it is rather difficult to recognize the object with only laser data, for its low resolution. On the other hand, CCD image represent detailed texture information on the object's surface and has potential of detailed 3D data generation as long as careful manual operation is applied. In this research, by using laser scanner data as an initial 3D data to determine the search range and to detect possibility of occlusions, a method to enable more reliable and detailed stereo matching method for CCD images is examined.

1. Introduction

Recently, in GIS field, vigorous demand for detailed simulations and analyses, especially, in urban areas are observed. Examples are a propagation analysis of electric wave for wireless communication, a flood analysis, an analysis of wind caused with high-rise building and landscape simulation. 3D spatial information faithful to the real world is needed for such simulations. Photogrammetry is a current method of the data acquisition. However, as a matter of fact, a large manpower and expenditure for making detailed 3D spatial information is required especially in urban areas where various buildings exist. There are no photogrammetric systems which can automatic a process of spatial information acquisition completely. On the other hand, laser range finder has high potential of automating 3D spatial data acquisition because it can directly measure 3D coordinate of objects, though the resolution is so limited at this moment.

With this background, the authors believe that it is very advantageous to integrate laser scanner data and stereo CCD images for more efficient and automated acquisition of the 3D spatial data with higher resolution. Laser scanner can measure coordinate values of an object directly, but it is rather difficult to recognize the object with only laser data, for its low resolution. On the other hand, CCD image represent detailed texture information on the object's surface and has potential of detailed 3D data generation as long as careful manual operation is applied. In this research, by using laser scanner data as an initial 3D data to determine the search range and to detect possibility of occlusions, a method to enable more reliable and detailed stereo matching method for CCD images is examined.

At the first step of a data processing flow, TLS image is corrected by projecting it to a plane called “Z plane”. Next, edges are extracted from the image, and straight lines are further identified from the edge image. Moreover, region segmentation is done to the corrected image. Then, each area in the image is labeled and grouped by using laser data. After that, the labeling is done to lines based on the unique label in the area. As a result, 3D segments with attribute information are made to calculate 3D coordinates of building parts.

2. Three Line Scanner (TLS)

Three Line Scanner (TLS) is an optical sensor for aerial survey. TLS is composed of three linear CCD arranged in parallel, and it can acquire three images of each direction (forward, nadir and backward) at the same time. Orienting it on an aircraft perpendicularly to flight direction, and scanning a ground plane, a treble stereo image of a ground object can be acquired (See Figure 1). As a result, occlusion area can be extremely reduced. Using two images of the three, it is also possible to get 3D coordinates by stereo matching.

As one of advantages of a linear CCD sensor, more pixels can be arranged in a single scene compared with an area CCD sensor. This means that a linear CCD sensor can achieve a resolution comparable with that o f an air photo, though a linear CCD sensor can acquire data only by one line at a time (The ground resolution of TLS data in this research is about 10cm). However, time of acquiring each line image is different. Since position and direction of each line when acquiring image is also different, orientation cannot be done by an existing method of photogrammetry. Moreover, the image is greatly influenced by fluctuation of an airplane position and attitude because TLS is air-borne. But setting up a stabilizer between an airplane and TLS, the fluctuation’s influences can be reduced.

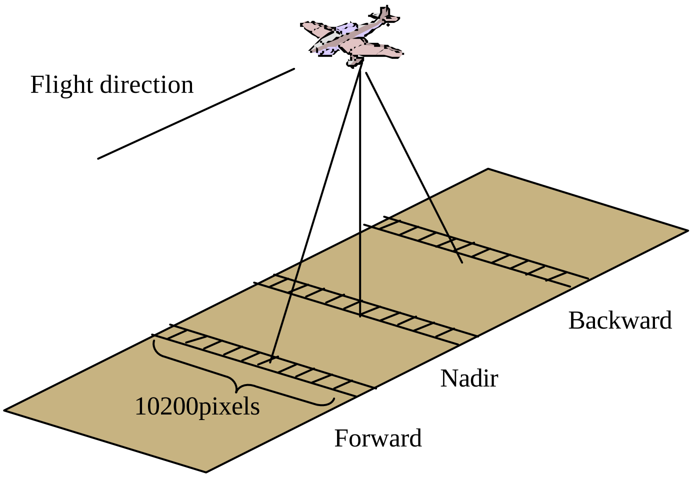

Figure 1: method of getting data with TLS

3 . Laser Scanner Data

Laser scanner is a sensor, which irradiates laser to an object and measure a distance to the object by measuring return time as the laser reflects. If the position of sensor and the angle of irradiating laser beam are known, 3D coordinates of a place where laser hits can be acquired easily. However, it is difficult to know what the object is, because laser data has only information about object's coordinates and reflection strength. To extract a building in a city area from laser data, auxiliary data is needed.

Figure 2: Data of laser scanner

An automation of measurement with laser scanner is easy too, because 3D coordinates of a measurement point can be acquired directly. But, in general, by the restriction of laser output, a ground resolution of airborne laser is two meters. It has not high resolution to make use of the laser data as 3D city data. Laser scanner data using at this time is acquired synchronizing with TLS. The place is Roppongi, Tokyo, Japan and the resolution is about 50cm. Figure.2 shows the laser scanner data.

4.Methodology of integrating laser range images and TLS image

4.1 Making an edge image

Nadir image and backward image of TLS are shown in Figure 3 and Figure 4. And, these edge images are Figure 5 and Figure 6.

As understood from Figure 3 and Figure 4, for buildings, only roofs can be seen in the nadir image. On the other hand, even walls can be seen besides roofs in the backward image (Of course, the same in a forward image). As understood from Figure 6, what building walls can be seen is meaning that it exists many similar features, like parallel lines to roof boundaries. Consequently, this makes matching nadir image and another image become difficult, because it is very likely to do a wrong matching in use only of TLS image. Therefore, to improve the reliability in matching, some kinds of devices are needed in extracting edges and segments. We think that it is at first effective to extract a richer variety of features from image, several kinds of edge detection techniques are tested. As a result, Canny method is chosen because it can extract the most edges. Figure 5 and Figure 6 are edge images by using Canny method.

Figure 3: TLS image (nadir)

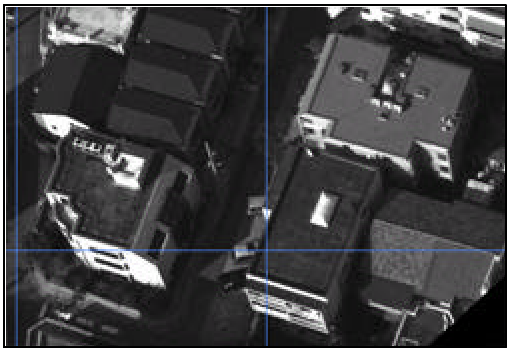

Figure 4: TLS image (backward)

Figure 5: edge image (nadir)

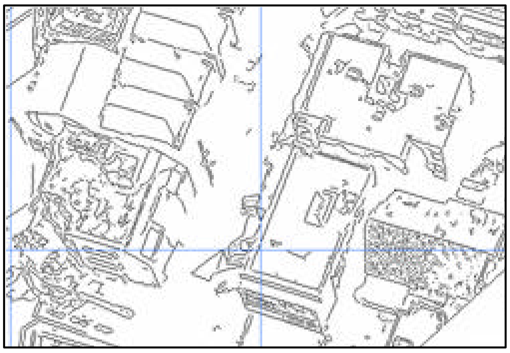

Figure 6: edge image (backward)

4.2 Using of TLS data with laser scanner data

Narrowing a search range of matching with laser data on TLS image has a lot of advantages such as improvements of matching accuracy and shortening computing time. This has been obtained as a finding. [1]

However, resolution of the laser data in this research is 50cm, it has high resolution compared with laser data used in general (resolution is 2m). Figure 7 shows an edge image of the laser data of 50cm resolution, and Figure 8 shows edge image of 2m resolution. Moreover, TLS image of this area is shown in Figure 9.

As understood from these figures, when laser data that has 2m resolution is used, it is difficult to decide a building shape from the laser edge. However, even if laser data has a low resolution, it is possible to use this data enough to detect building part from the laser data with height difference of road and building.

Figure 7: Laser edge image (50cm)

Figure 8: Laser edge image (2m)

Figure 9: TLS image (nadir)

4.3 Grouping each building

Making region segmentation of TLS image, two or more area segments appear though they belong to one building. Figure 10 shows TLS image as an original image, and Figure 11 shows region segmentation image that is done region growing for this.

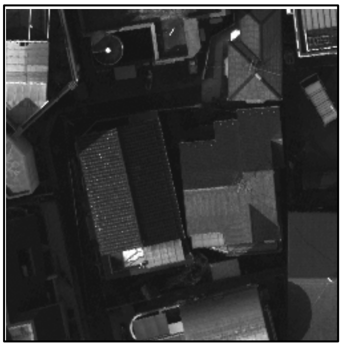

Figure 10: TLS image

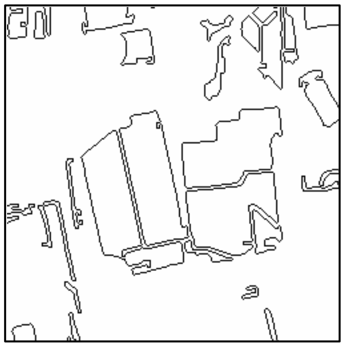

Figure 11: region segmentation

Grouping each building has more advantages than handling separately. For instance, it comes to catch a feature for a building easily. As a grouping method, first of all, building parts are detected from laser data by using height difference of road and building, unique building labels are given to the parts respectively. Next, labeled laser image and region segmentation of TLS image are overlapped. And divided areas (some roofs) of each building are grouped. The labeling is done to line segments based on each building label. As a result, it becomes possible to make 3D segment with attribute information to calculate 3D coordinates.

5. Summary

In this research, combining TLS images with laser scanner data, a more efficient method of making 3D spatial information with higher resolutions is examined.

We combined line extraction with region segmentation from TLS image, extraction of a group of buildings from laser data. Consequently, 3D segment of building can be extracted. These information can effectively support the manual development of 3D city model. Moreover, it may be possible to automate stereoscopic measurement by giving attribute information to the extracted segments. The automation of 3D city modeling with model fitting will be examined in the future.

References

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