Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

Road extraction from high-resolution commercial satellite data

Jun KUMAGAI, Huijing ZHAO, Masafumi NAKAGAWA, Ryosuke SHIBASAKI
Graduate School of Frontier Sciences, Shibasaki lab.
University of Tokyo
4-6-1 Komaba,Meguro-ku,Tokyo,153-8505
Tel:(81)-3-5452-6417 Fax(81)-3-5452-6417
E-mail:jun@iis.u-tokyo.ac.jp
JAPAN

KEY WORDS: Road extraction, high-resolution satellite data, Histogram, NDVI

ABSTRACT: It is expected that High-resolution commercial satellite data can be used for the development and the revision of map data such as car navigation map. In this research, the possibility of automatic extraction of roads is investigated based on area and road characteristics. A pattern groups of the roads were examined in search of histogram of the existent roads to see the characteristics of the roads. The part segments that match the histograms of the road pattern groups are extracted as roads from the image.

1 Introduction

High-resolution commercial satellite launches are making available imagery at resolutions close to that of aerial photographs, which can then be used in a wide variety of applications ranging from water quality monitoring to monitoring urban changes. The excellent characteristics of such data, like its high resolution (1m), real time data availability, three-dimensional measuring possibility by the stereographic observations, flexibility of data acquisition (It goes over the border, and it can take pictures of the various areas), the high sensitivity of 12bit and the availability of multi-spectrum covering up to the near infrared rays, has helped remote sensing make inroads in technological areas where satellite remote sensing was rarely considered as an option.

One of the most extensive applications for such high resolution satellite data is in the urban areas, in preparing and updating the maps. Derivation of data like the road network data can be of use in the car navigation systems. Hence, it is important to extract necessary road information from the imagery to meet such needs. So far, the extraction of the road information was mostly carried out manually by the operators. However, though considerable skill was necessary for such operations, efficiency was never very high, and it resulted in rather high costs.

In this paper, we explore the possibilities of automating the process of the extraction of the road information, that would complement the work done by manual operators and improve the results. In this research, under the main assumption that the contrast in shade value between the road and the surroundings is quite strong, the image of the aerial photograph is divided into meshes and by using the MAP (Maximum A Posteriori probability) technique and a Dynamic Programming technique for each mesh, the features of the road are extracted. Various researches done in this field include, the tracing of the starting segments of the road in the mesh with the road feature to extract the major roads automatically(Barzohar, 1996); while REF 2 carried out the research of renewing the road map of 1:50000 scale automatically by matching the existing map and the SPOT-HRV image; and a technique was developed by REF 3, that aimed at supporting the manual operations by inputting points to fit a three-dimensional road by the LSB-Snake technique.

2 Objective

In the research carried out in this paper, the authors carry out the process of automatic extraction and try to evaluate the possibility of the road being extracted in regions containing some areas and road features, by applying some techniques of the image processing technology.

3 Method

3-1 Test data

In this research, the suburb of Kawagoe City, Saitama Prefecture was chosen as the test study area. The data used for this purpose was the Band3 (RED) and Band4 (NIR) of IKONOS image, as shown in the Figure 3-1.1 and Figure 3-1.2. The metadata of this image is as follows-
Resolution is 1meter. Acquisition Date/Time: 2000-09-21 01:18
The coordinates of the four corners of the image are
Coordinate 1: Latitude: 35.92880001 degrees Longitude: 139.53209652 degrees
Coordinate 2: Latitude: 35.92886083 degrees Longitude: 139.55739965 degrees
Coordinate 3: Latitude: 35.89879840 degrees Longitude: 139.55750403 degrees
Coordinate 4: Latitude: 35.89873765 degrees Longitude: 139.53221047 degrees
The exisiting road data was used from the 1:25,000 scale maps of the study area, obtained from the Tokyo Cartographic Co. Ltd., as shown in Figure 3-1.3.

Figure3-1.1 RED image

Figure3-1.2 NIR image

Figure3-1.3 Road map

3-2 Matching

First, we select a couple of points that are common to the image and the road map at hand, and locate them on the respective data. Then road line data is converted to a surface data having a width of 2m, by using the road as its centerline, to help in masking out the road data on the imagery.

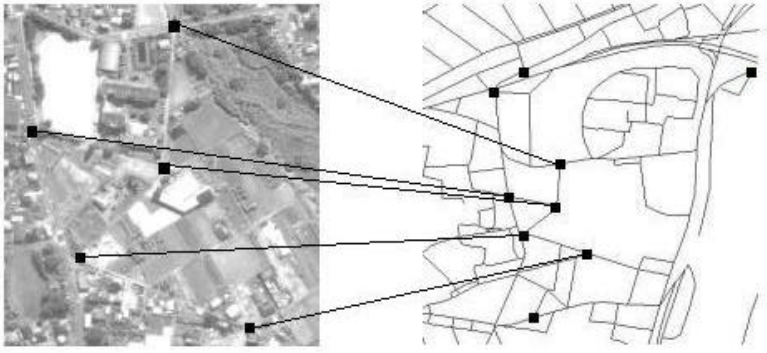

Figure3-2.1 point matching

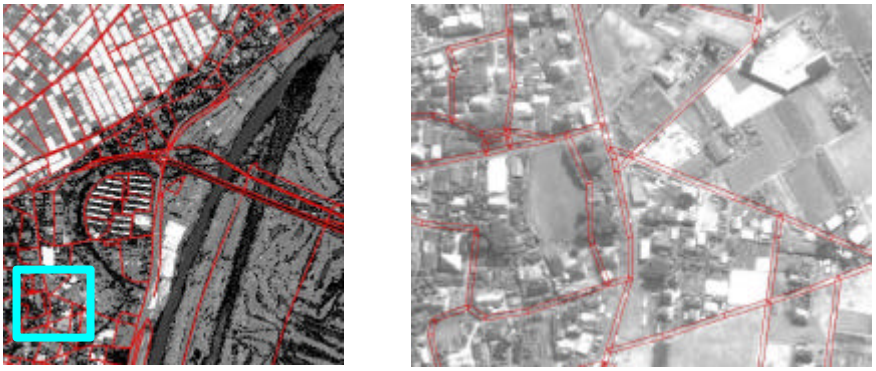

Figure3-2.2 Matching image with road data

3-3 Masking the road

Only a part of the road is masked on the image and that is extracted from it as the road, shown by white lines in Figure3-3.

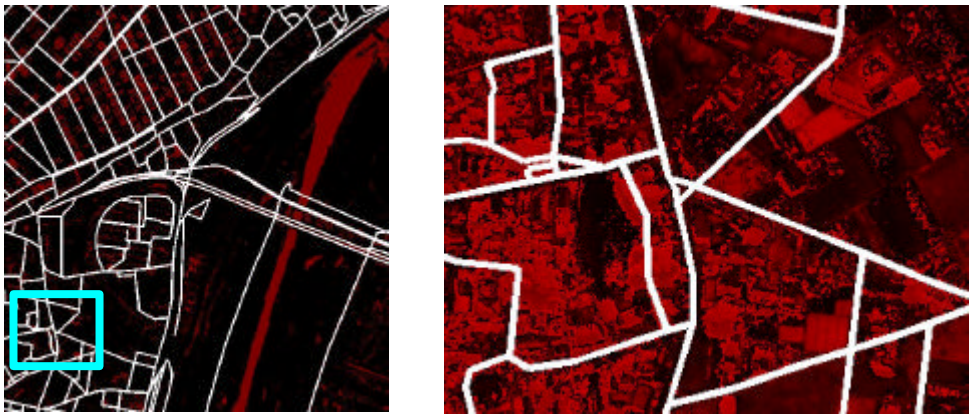

Figure3-3 Masking the road

3-4 The removal of the plant data Removal of the Vegetation information

It is quite common to find vegetation at the side of the roads, which obstruct the extraction of the continuous roadways. So, to get a pure road pattern group from the image, the vegetation data needs to be discarded from it. For this purpose, the NDVI (Normalized Difference Vegetation Index) is used. The formula for computing the NDVI is as follows:

$$NDVI = (NIR - RED) / (NIR + RED) \quad \ldots. (1)$$

NDVI is computed by using band3 (RED) and band4 (NIR) of IKONOS Multi-spectral image. The ratio of the NDVI for plants is higher in comparison with the soil, water, buildings and road. It is possible to remove vegetation data from the image by using a threshold cut-off value for the regions with rather high NDVI values. Figure3-4 is the classified image based on the NDVI values.

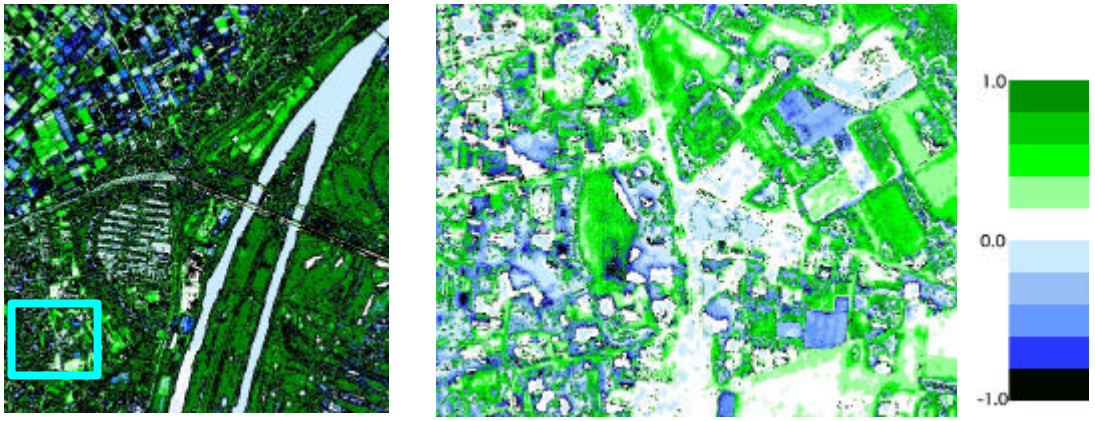

Figure3-4 NDVI image

3-5 Road pattern group preparations

After the removal of the vegetation data from the imagery and the extraction of the road pattern, the road pattern groups are made using the histograms of RED and NIR contained in the face polygon of the road.

3-6 Road extractions

The part segments that match the histograms of the road pattern groups are extracted as roads from the image.

3-7 Verification

The road data that it was extracted by using the road pattern group are compared with the existent road data. The extracted road data, using the road pattern groups, is compared with the existing road data, obtained from the 1:25,000 scale maps. It is verified to check how much of the extracted roads reflect the existing ones and whether there is a possibility for identifying new roads.

4 Results

The histograms of RED and NIR, used to extract the patterns of the extracted roads area as shown in the following figures.

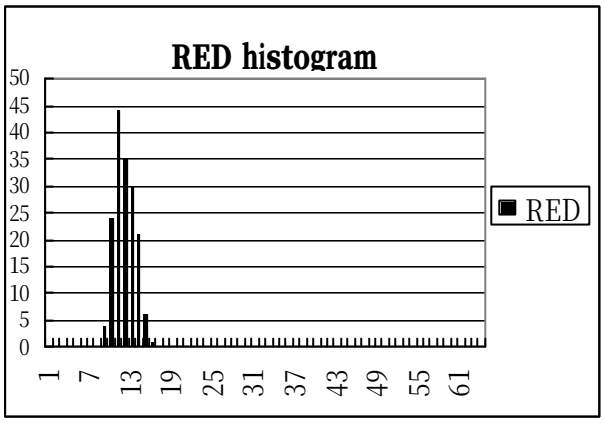

Figure 4-1 RED histogram

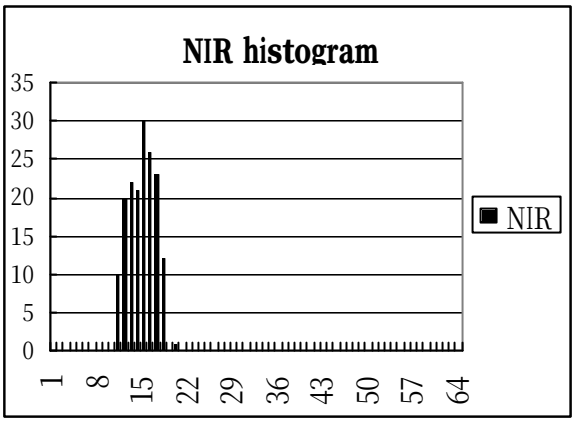

Figure 4-2 NIR histogram

5 Conclusions

By using the high-resolution satellite image data, the existing roads were extracted from the image and the unwanted vegetation information was removed from the image by using the NDVI values. As a result, pure histogram of the road could be looked at from this image. Up until the current level of research, it couldn't be verified as to how much of the existing roads and how many are the new roads can be extracted by applying these histograms. From now on, this histogram will be actually applied, a road extraction will be tried and the road extraction efficiency will be examined to improve it further.

In the current work, the road characteristics described by the histogram was looked at in the suburb of Kawagoe City. But, in order to extract road data from the high-resolution satellite imagery of various areas of the city, in addition to the suburbs, it is necessary to look at the histograms generated and characterize the road pattern groups with respect to them.

6 References

[1] M.Barzohar, D.B.Cooper, Automatic Finding of Main Roads in Aerial Images by Using Geometric-Stochastic Models and Estimation, IEEE Trans. on Pattern Analysis and Machine Intelligence, pp.707-721, vol.18, no.7, 1996.

[2] F.Cavayas, M.C.Mouchot, B.Solaiman, R.Desjardins, Map-image Matching using a Multi-Layer Perception: the case of the road network、R.Fiset, ISPRS Journal of Photogrammetry & Remote Sensing,pp.76-84,vol.53,1998.

[3] A.Gruen, H.Li,Linear, Feature Extraction with 3-D LSB-Snakes, Automatic Extraction of Man-Made Objects from Aerial and Space Image, pp.287-298,1997.