Experimental Approach for Urban Structure Identification Using Remotely Sensed Imagery

Mitsunori YOSHIMURA
Remote Sensing Technology Center of Japan
(RESTEC)
7-15-17, Roppongi, Minato-ku, Tokyo 106
Japan

Taichi OSHIMA
Faculty of Engineering, Hosei University
3-7-2, Kajino-cho, Koganei-shi, Tokyo 184
Japan

Junichi OSHIMA
College of Industrial Technology, Nihon University
1-2-1, Izumi-cho, Narashino-shi, Chiba 275
Japan

Commission III

Abstract

The multispectral classification is the most common method for the feature detection from remotely sensed imagery. The results of its extraction method is provided as an area with relative location. For the detection of absolute location, this multispectral classification approach is not suitable. However, the absolute location of ground target is important for the urban structure monitoring.

From the mentioned background, this paper describes on the relationship between ground resolution and capability of target identification and is the algorithm for an urban structure identification applying the binary image processing method.

Key Words: Feature Detection, Absolute Location, Target Identification, Urban Structure

1. Introduction

On the remotely sensed imagery, many ground objects such as river, forest and houses are existing complexly. And it is difficult to discriminate automatically each of them by some simple statistical approach based on the spectral features. Because ground target should be decided automatically by many informations for itself such as its color and contrast between the target and its neighboring other ground targets.

Recent trend of spaceborne sensor development is two directions. One is subdividing spectral bands and other is high resolution.

Therefore, this paper focused to the application of high resolution imagery and the capability of target discrimination/ identification based on the ground resolution was discussed and an actual urban structure identification was performed for high resolution black and white imagery. This paper is composed of following three parts; (1) Simulation of ground resolution, (2) Target Identification by Image Interpretation, (3) Detection of urban structure by applying the binary image processing method.

2. Multispectral Classification and Target Identification

Multispectral classification technique is well known as one of the feature extraction methods from multispectral image data. At the process of multispectral classification, every category of interest must be carefully selected and defined on the imagery. In this case, it is important to realize for an analyst that there is fundamental difference between "landuse" and "landcover". Landcover class must be identified and labeled by an analyst. The urban area on remotely sensed imagery means likely residential housing area and not pure residential area. Landsat TM imagery might be able to identify a few pure pixels such as asphalt roads by point-wise multispectral classification. However, this asphalt roads is not the asphalt roads exactly but asphalt construction. For instance, concrete construction can be identified by multispectral classification, but concrete roads and concrete building can not be separated by this approach.

The target identification is not point-wise multispectral classification based on the spectral feature but one of analytical pattern recognition methods. Therefore, simple structure items, such as roads and large artificial constructions, might be able to be extracted by this approach. In this study, road network detection based on this concept was carried out.

3. Simulation of Ground Resolution

In order to investigate the capability of target discrimination (roads, large construction) based on the ground resolution, six different resolution black and white imageries were simulated using digital aerial color ortho photograph with 1m resolution.

3.1 Used Data and Study Area

The used digital aerial ortho photograph was derived by participating for the campaign of digital image information (experimental), conducted by geographical survey institute. Fig.1 shows the used digital ortho aerial photograph. The specification of this aerial photograph is as follows;

(1) Observation Date Oct.9,'88 - Nov.1,'88
(2) Camera System Wild RC-10A
    Focal Length 152.21mm
    Image Size 23cm X 23cm
(3) Altitude 1,500m
(4) Scale 1/10,000

Fig.1 Digital aerial Photograph of Study Area

The coverage of this study area is from northern edge of Kohoku region to Kanagawa region , Yokohama city, total 4km x 3km area. In this area, Daisan-keihin national toll road with 6 leans, Tokaido-shinkansen (bullet train) are existing.

3.2 Simulation of Ground Resolution

Fig.2 shows the procedure how to produce these simulated imageries by an application of HSI transformation.

At first step, RGB-HSI transformation was performed for an original aerial photograph in order to extract three color attributes H,S,I. Three attributes are basic color features. H means hue, S is saturation and I is intensity. Intensity is also the black and white component of color composite imagery and should be given the most effective information for an interpretation of urban structure. According to mentioned reasons, Intensity was used for the simulation of the ground resolution.

At second step, simulated imageries were generated by averaging operation. The ground resolution was decided by the window size of this operation. 2x2 window size could generate 2m resolution imagery. 4x4 window size is 4m, 6x6 is 6m and so on.

Digital Aerial Color Photograph (with 1m resolution,Red,Green,Blue)
RGB-HSI Transformation (Red,Green,Blue -> Hue,Saturation, Intensity
Extraction of Intensity from Three Color Attributes
Averaging Operation for Intensity (Operation Size:2x2,4x4, ,10x10)
Simulation Imagery Products (with 2,4,6,8,10m Resolution)

Fig.2 The Procedure for Resolution simulation

Fig.3 shows the four different kinds of imageries for the comparison of ground resolution. Upper left is 2m resolution imagery, upper right is 4m, lower left is 6m, lower right is 8m resolution respectively.

Fig.3 Imageries for Resolution Comparison

4. Ground Resolution and Target Identification

4.1 Basic Concept of Target Identification

In the case of discriminating some target on the remotely sensed imagery by human eyes, many kinds of informations about its target, such as its own color, contrast with neighboring targets, are used in the same time. Golf course is a typical ground target, and it is possible to be easily discriminated by its unique shape and colors.

However, it is difficult to identify each ground target by applying point-wise multispectral classification instead of human eyes. Only for large artificial constructions, such as large buildings and roads, it might be able to identify automatically by the applying the binary image processing in response to its shape, contrast and texture.

4.2 Target Identification by Image Interpretation

The mechanism for an image interpretation on digital imagery is explained in this paragraph. Fig.4 shows the location of an actual artificial construction on the grid cell.The solid line corresponds to the grid cell on the earth surface and one square is a unit of image data (i.e. one pixel). The dotted line also corresponds to an actual artificial construction ,such as a building.

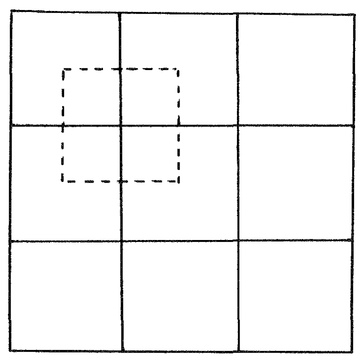

Fig.4 Location of an Actual Artificial Construction on Grid Cell

An actual artificial construction (dotted square) is located on the center of four pixels (square). In every four pixel (square), this construction is occupied a quarter (i.e. 25%) of one pixel. In this case, the construction with the same size as one pixel might not to be able to identify as one target by the above reasons. Therefore minimum target size for identifying as one target is required three or four times larger pixel size than one pixel.

In this study, 2,4,8m resolution imageries were chosen for image interpretation. In its interpretation, the capability for the identification of road network and large artificial constructions was investigated. Following results were obtained through the image interpretation for three kinds of imageries.

On 2m resolution imagery, road surface was complicated because of existing vehicles, medium strips and center lines. Therefore this resolution imagery must be provided more detailed informations than road network.

On 4m resolution imagery, most of vehicles were disappeared. This imagery had sufficient image quality for automated target identification by applying the binary image processing.

On 8m resolution imagery, the disconnectivity of roads were appeared at some curve points. However it had lowest image quality for target identification.

The large artificial constructions were easily discriminated for every resolution imagery.

4.3 Target Identification by Applying Image Processing

The basic concept of target identification by applying the binary image processing was based on the mechanism of image interpretation. In this process, road network as the most simple structure was adapted for its identification. And road network is most important for an urban structure detection. Fig.5 shows the procedure for extraction of road network by applying the binary image processing.

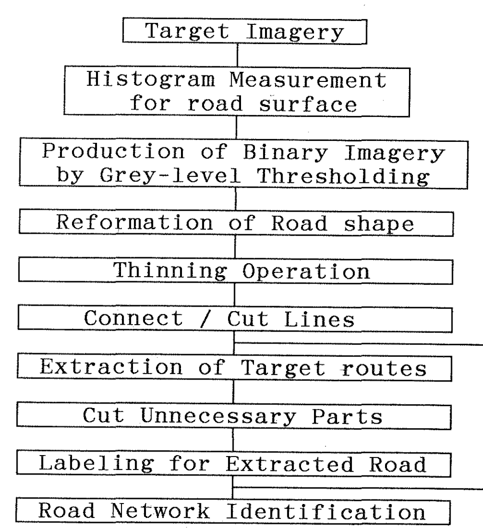

Fig.5 The procedure for Road Network Extraction

On 8m resolution imagery, main roads were possible to be dealt with line problem, consist of few pixels width.

The separation of road surface and others was performed by grey-level thresholding. The data, consists of road surface, was distributed in the range from 68 to 90.

Some parts of detected roads were cut by noises, such as holes and points with small area. In this study, the noise reduction was done before thinning operation and other operation, such as cutting and connecting, was performed by the same method as the contour line detection after thinning. Thinning operation was effective for its width shrinking and detect the center of road.

Target road was extracted by line following operation. This operation could cut line and erase independent points by considering eight components of connectivity for some pixel.

Each extracted road was stored by labeling.

On 2m resolution imagery, main roads were not possible to extract by a line detection approach because of its dozens of pixels width.

In this paper, the results of this road network identification for 8m resolution imagery were concluded . And they are shown in Fig.6 to Fig.8. Fig.6 is the binary imagery by grey-level thresholding of this study area. Black portion corresponds to road area including some different targets and white is other target. Fig.7 is extracted main road network. On this imagery, some noises are existing. Fig.8 is the final result of road network detection. This imagery was generated by cut some unnecessary lines for extracted main road network imagery.

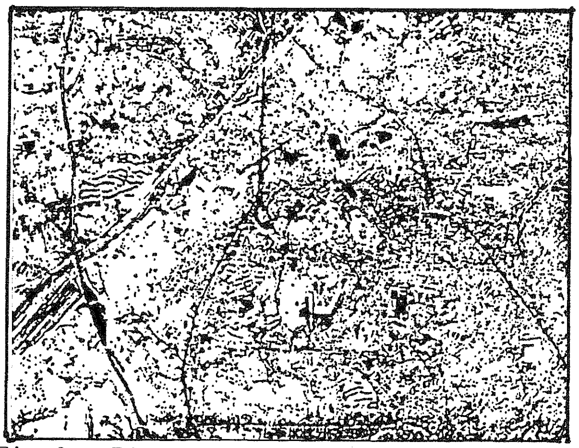

Fig.6 Binary Imagery of This Study Area

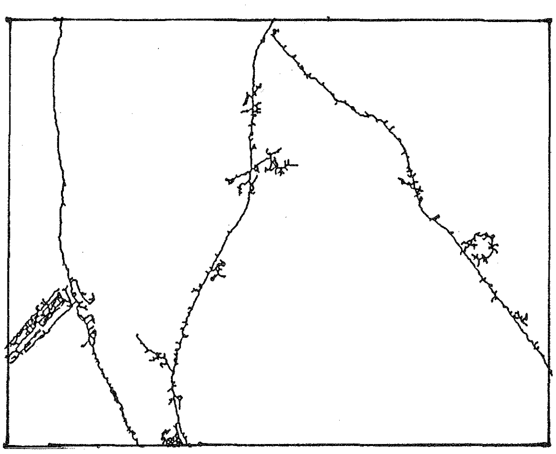

Fig.7 Extracted main road network including Some Noises

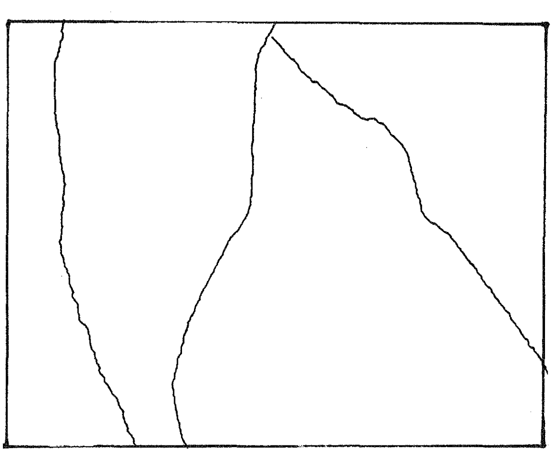

Fig.8 Final Result of Road Network detection

5. Conclusion

In this study, the capability of road network detection as an urban structure identification was discussed from the points of ground resolution and image processing. From the results of actual analysis, proposed approach was confirmed to be effective for the road network detection. And this approach is also effective for map updating. However ground resolution of digital imagery by the present satellite remote sensing is not suitable for this urban structure identification. As the future direction of this study, our authors' research group is trying to develop the computer assisted image interpretation system by applying this approach for other ground targets, such as large artificial construction (buildings) and vegetation area.