EXTRACTION OF BRIDGE POSITONS FROM IKONOS IMAGES FOR ACCURACY COLTROL OF BRIDGE DATABASE

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ABSTRACT

A bridge database which has rough coordinates of bridges, was established and shared in a local government for the purpose of their maintenance. When bridges in the database overlaid with commonly used river and road data, they were not exist on near the intersections of roads and rivers. In previous studies, some bridges of bridge database were adjusted by using GIS data of rivers and road, and 23 bridges existed on a test area. It was possible to adjust the bridge database, but only 8 bridges were adjusted because of limitation of GIS in accuracy domain. In this study, only remote sensing data were used for the accuracy adjustment of the bridge database of the test area. River streams data and edge of bridges were needed to adjust the positional accuracy of the bridge database. River streams were extracted from ASTER images. And the edges of bridges were extracted from IKONOS images. The outsides of rivers on the edged IKONOS images were masked by the river data from ASTER images. Then the accurate bridge positions were obtained from the edge of bridges. 17 of 23 bridge's positional accuracy were adjusted.

1. INTRODUCTION

A bridge database has rough positional accuracy, was established and shared by a local government in Japan for the purpose of maintenance. But when the database overlay with commonly used river and road data, bridges in the database were not exist near the intersection of road and river. To use the bridge database in an official work, the accuracy adjustment of it was needed. Up to now, to adjust the accuracy of the database, two GIS data that were based on 1 to 2,500 scale and 1 to 25,000 scale maps, were used. Their roads and rivers were intersected, then the coordinate of the intersections combined with the attribute data of the bridge database. They showed limitations in accuracy adjustments (figure1): they contained much digitizing errors and incomplete objects. And not all GIS data could be available for all interest areas. In contrast with GIS data, remote sensing data have less error, are available for all interest areas. It is easy to obtain up-to-date remote sensing data. Because of the advantages, only remote sensing data were used in this study for the accuracy adjustment of the bridge database. A reliable river data was obtained from ASTER images that have 15 spectral bands, and bridges on the test area were extracted by edging the IKONOS images. Then the outsides of rivers on the edged IKONOS images were masked to consider edges of bridges on river.

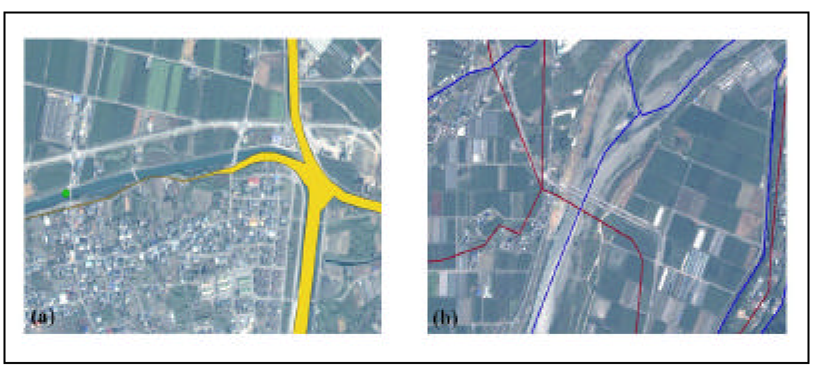

Figure 1. GIS data show errors on an IKONOS image. (a) A river data based on 1 to 2,500 scale maps. (b) A river and road data based on 1 to 25,000 scale maps.

2. TEST AREA AND DATA USED

Test areas were Tosayamada and Nankoku in Kochi Prefecture, Japan. It contained rural and urban area. 23 bridges on rivers existed on the test area, and most of their width were more than 15m. To extract positions of bridges, a river data and a high-resolution image which has enough resolution for generating clear shape of bridges, were necessary. In this study, ASTER and IKONOS images were used in order to obtain accurate bridge positions. ASTER images consist of 4 visible infrared bands (VNIR), 6 short wave infrared bands (SWIR) and 5 thermal infrared bands (TIR). The resolution of VNIR is 15m, SWIR is 30m and TIR is 90m. IKONOS images consisted of 4 spectral bands including infrared band. Its resolution is 1m. It was rectified with high accurate control points which were obtained from GPS surveying. Extracted edges of bridges, and rivers from the data, were used for accuracy adjustment of the bridge database.

3. METHODES

To extract bridge positions, edges of bridges, and river data were used. River streams on the test area were extracted from ASTER with a classification method. And edges of bridges extracted from IKONOS images. Then the outsides of rivers were masked by the river data from ASTER. On the masked data, noises were eliminated and clear linear edge were extracted by performing Hough transform. The center points of linear edges were calculated. Then the coordinate of center points combined with the attribute data of the bridge database.

3.1Extracton of Edge of Bridges on The IKONOS Images

Although linear line-detecting template worked well in bridge detection, it was not used for the edge detection of bridges because it generated much noises which prevent authors from performing Hough transform (Figure 2). Instead of the line-detecting template, Prewitt filter was used.

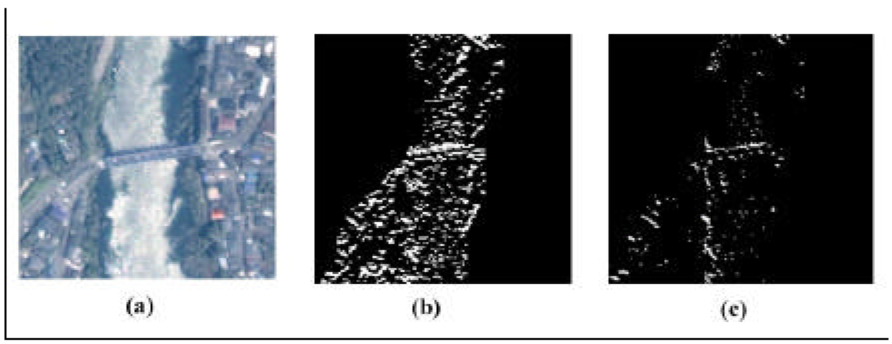

Figure 2. (a) Original image. (b) After applying Line detecting template. (c) After applying Prewitt filter.

3.2 Extracting river streams from ASTER images

In our previous study, the result of classification of IKONOS images was not so efficient for extracting bridges on the IKONOS images because 4 channels were not enough for the extraction of rivers, and too many fuzzy classes were generated on rivers (Jong Hyeok JEONG, Masataka TAKAGI, 2002, ISPRS). To extract river streams, a decision tree classifier was used. Only 4 interested categories were classified: water (river and sea), vegetation, river, bare soil and urban. The average of pixel values of each band on each category was investigated. Then the characteristic of each category was investigated. River streams were extracted according to a decision tree (Figure 3). Figure 4 shows extracted river and sea.

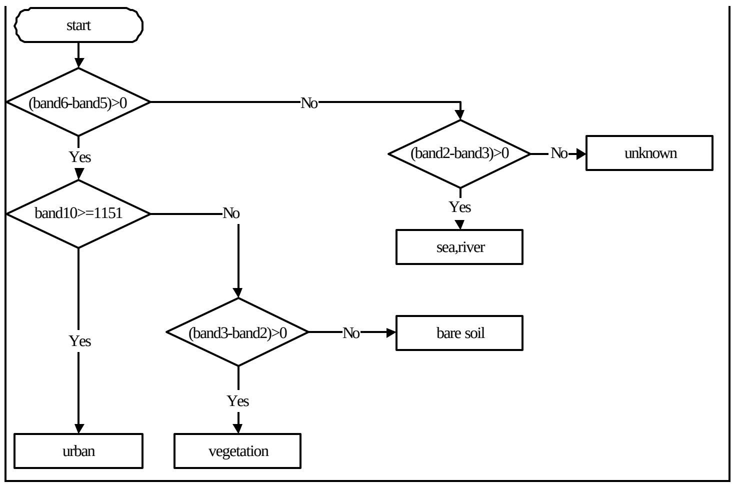

Figure 3. A decision tree for the extraction of river streams.

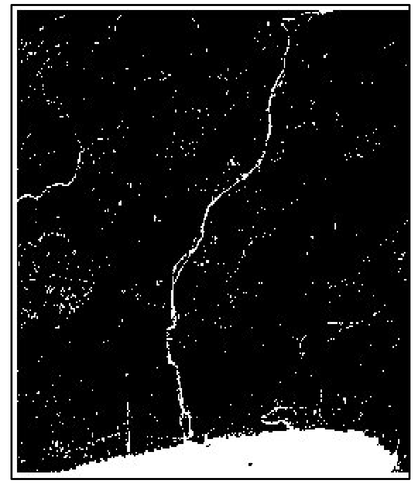

Figure 4. Extracted river and sea.

3.3 Connecting broken river streams

Some disconnected lines of river streams were generated. To connect the broken line, a simple method was used. Yun Zhang (2000.8) developed a continuous extraction algorithm of multispectrally classified urban rivers, and obtained reliable result. But some of extracted river streams in urban areas were too fuzzy to be connected in this study. Although some river streams whose width were more than 15m, they were disconnected because of accumulated soil, sands, stones and gravels on river streams. Some parts of river streams were not disconnected too much, could be connected with a modified Zhang's algorithm: firstly, the center of a 7×7-pixels template window was located on the end of a disconnected river (Figure 5-a). Then the gradient of the river in the template was calculated. A searching zone to find connecting pixel was lead according to the gradient. When there was a connecting pixel in the searching zone (Figure 5-b), the end of river connected to the connecting pixel (Figure 5-c.). After that, the template moved to the end of connected pixels (Figure 5-d). If there was no connecting pixel, a neighbor pixel of center pixel was added according to the gradient until it found connecting pixel (Figure 6-c). Figure 7 and Figure 8 show how to decide the searching zone in the template. Figure 9 shows a result of connecting a river.

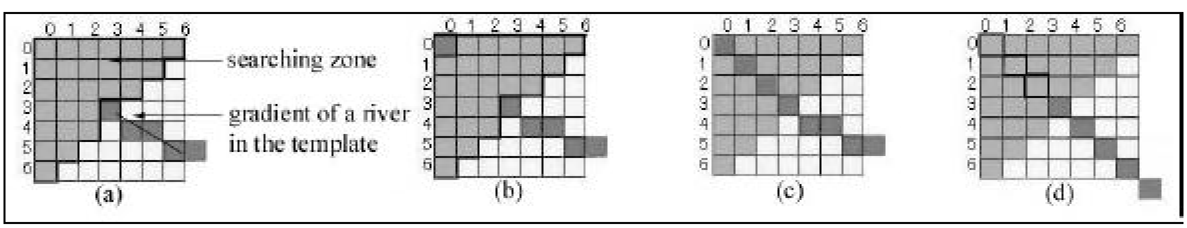

Figure 5. (b) Exist a connecting pixel in the searching zone (c) Connecting (d) Template move to the end of connected line.

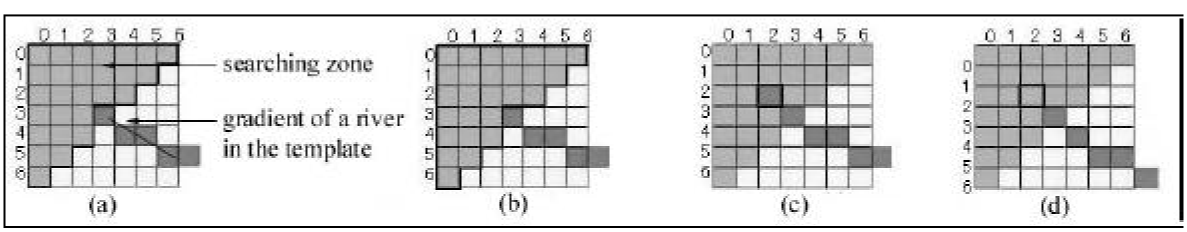

Figure 6. (b) No pixels in the searching zone. (c) Extending (d) Template move to the end of extended pixel.

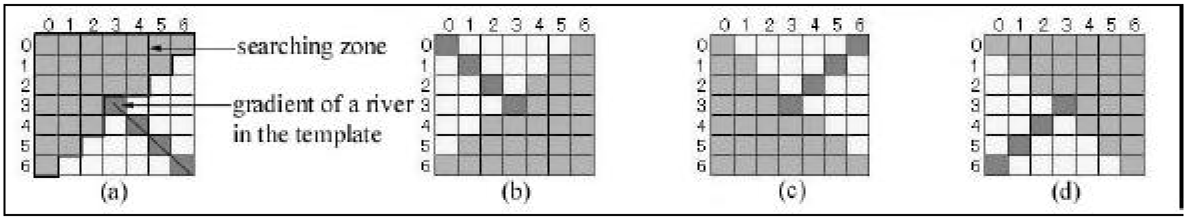

Figure 7. (a) The searching zone, when gradient>0 and x coordinate of center pixel < x coordinate of boundary pixel. (b) Gradient > 0 and x coordinate of center pixel > x coordinate of boundary pixel. (c) Gradient<0 and x coordinate of center pixel < x coordinate of boundary pixel. (d) Gradient<0 and x coordinate of center pixel > x coordinate of boundary pixel.

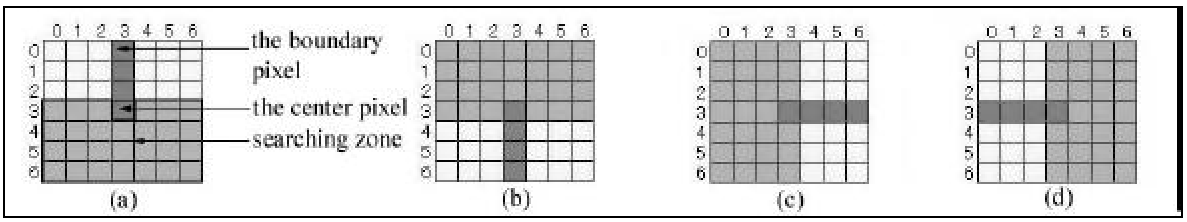

Figure 8. (a) Gradient = 0 or infinite, and y coordinate of center pixel < y coordinate of boundary pixel. (b) Gradient = 0 or infinite, and y coordinate of center pixel > y coordinate of boundary pixel. (c) Gradient = 0 or infinite, and x coordinate of center pixel < x coordinate of boundary pixel. (d) Gradient = 0 or infinite, and y coordinate of center pixel < y coordinate of boundary pixel.

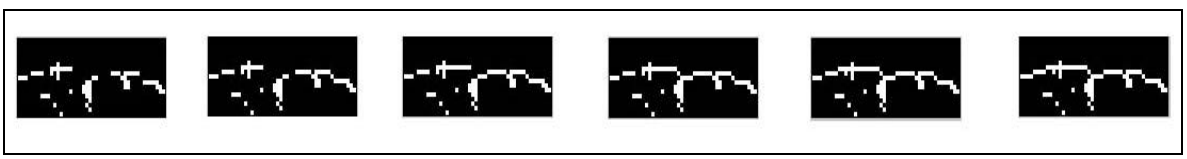

Figure 9. Connecting a river stream

3.4 Hough transform

After extracting river streams from ASTER images, the outsides of rivers were eliminated by the river streams to consider edges only on river streams. To complete some disconnected linear edges, Hough transform could be applied. Hough transform was performed on segmented areas because it was difficult to find a range of thresholds for whole test area. Equation1 is the algorithm of Hough transform. When Hough transform performed, the river streams were referred to decide the region of drawing a line (Figure 10.). Figure 11 shows a result of Hough transform. In Figure11-c, most of noises which were generated during edging IKONOS images, were eliminated after applying Hough transform.

$$r = x\cos q + y\sin q$$

r :The distance from a line to the origin

q :The angle between the line and the abscissa

x : x coordinate

y : y coordinate

Equation 1. Hough transform

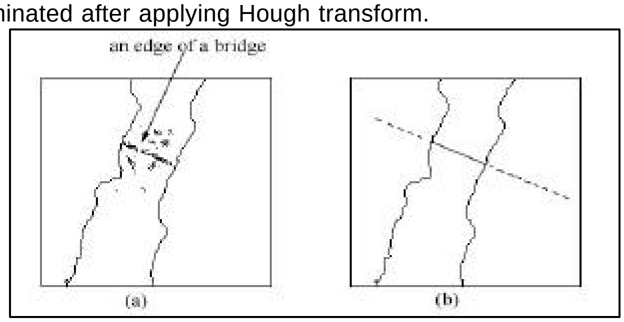

Figure10. Drawing criteria

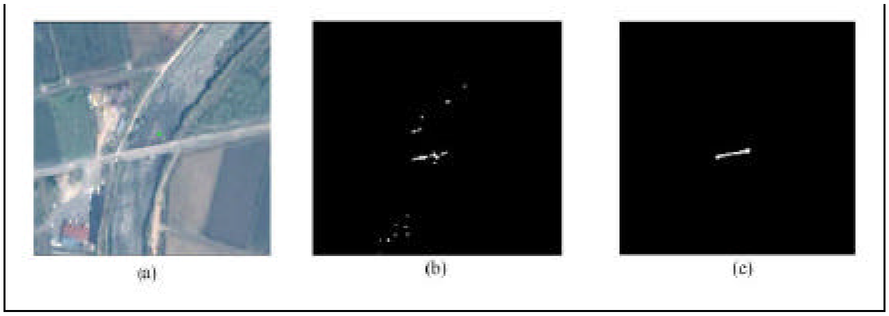

Figure 11. (a) Original image. (b) After masking IKONOS image. (c) After Hough transform

3.5 Extracting bridge positions and Accuracy adjustment

The centers of extracted lines were assumed the accurate position of bridges. Therefore, centers of extracted edged lines, were calculated. Then the attribute data of the bridge database were combined with the coordinates of the center of extracted lines.

3.6 Assessment of Accuracy adjustment

Actually it was impossible to find the positions of surveying of bridges, so it was impossible to assess the result of accuracy adjustment. But the bridge database has the name of bridges and the length of bridges. That information was used for the accuracy adjustment. Also it was possible to evaluate the result of adjustment by overlaying the result with the IKONOS images because the images have enough resolution for recognition of bridge shape.

4. RESULTS

From the result of accuracy adjustment, 17 points of bridge database were obtained high accurate coordinate. 6 points of bridge database could not be adjusted because some river streams in urban area, there were no water flows, so river streams which have no water stream, were classified to an urban area or bear soil area (Figure 12).

In the previous study (Jong Hyeok JEONG, Masataka TAKAGI, 2002, JSPRS), only 8 bridges were adjusted with a GIS data based on 1:2500 scale maps. But 17 bridges were adjusted with remote sensing data in this study. Remote sensing data provide more reliable river data compare with use of the GIS data.

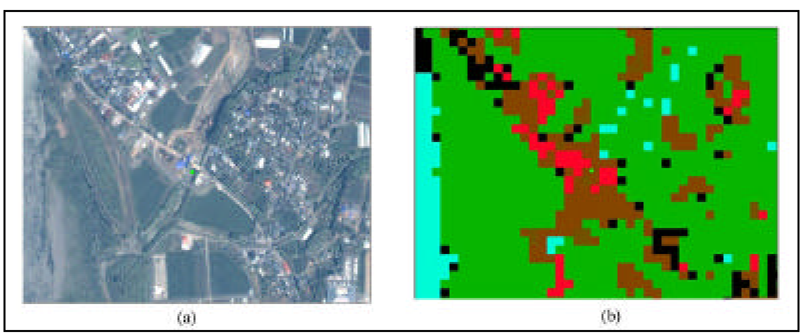

Figure 12. (a) A bridge is on a river stream which has no water flows.
(b) The area was classified to bare soil category (brown).

5. CONCLUSION

A practical procedure of accuracy adjustment of bridge database was introduced in this study. In updating a spatial data, using remote sensing data may provide or generate more certain result rather than using GIS data. Using remote sensing data can be a certain solution to obtain reliable result in accuracy adjustment of GIS data. If it is possible to extract not only water-stream but also stream channel of rivers, the accuracy of the bridge database may be adjusted completely.

6.FUTHER STUDY

In this study, the limitations of accuracy adjustment of the bridge database using classification methods appeared: some bridges on river streams which have no water flow, could not be adjusted. To cover the problem, modified SNAKE algorithms, optimized template matching techniques will be useful for extracting those kinds of river streams. Also defining the difference between water-stream and river-stream with remote sensing data will be important parts of this study.

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