STUDY RELATED TO THE VECTOR MAP OUTPUT OF IMAGE DATA
- ORGANIC COMBINATION OF RASTER DATA AND VECTOR DATA -

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Abstract

The raster data such as the land cover classification by LANDSAT data are said to be very effective for grasping phenomena having two-dimensional extension, and for overlaying and analysing multi-dimensional information. The output however stays in most cases within the limit of color image by means of display, photograph and color printer, and lacks the practicability offered by vector map. Particularly in Japan where the vector map is used generally and practically, it becomes necessary for the practical use of image information to change it to boundary data and output it as paper map by using pen plotter and others. This report deals with our study to freely conduct mutual conversion between the image data and vector data, to establish the vector map system which can output the classification map by using pen plotter, and to analyze vegitation areas by utilizing this system.

1. Introduction

A few decades have passed since remote sensing techniques using satellite data and air-borne MSS data was put to practice, and these techniques have been applied in a variety of fields. Traditional analysis, such as land cover classification, plant vitality analysis and water surface temperature analysis, which has been made based on only single image processing is extending its application to more comprehensive analysis in recent years based on overlay of multi-dimensional information including geographical information.

Image-type data are extremely effective to understand phenomena which change with time and space or to overlay multi-dimensional information simultaneously, and provide an easy way to classify evaluate very precise information, which can not be treated with vector-type data, and to update information. However, since many output media of image data stress analog type color expression such as display, photo and color print, they are inferior to vector-type map in practice because of their difficulties in writing down information and storing and lower precision. In particular in Japan where most governmental organizations adopt vector type map, it is very difficult to use analog type color image output in practice.

In addition, as no effective method to connect vector type data with image type data has been available, these two types of data are separated and consequently the shortcomings of these two types of data can not be compensated or systematic processing of these two can not be done. Free conversion and mutual communication between these two types of data allow us to take advantage of the merits of the both and cover their disadvantages. Furthermore, application of these two types of data for different purposes can result in an extension of their applicability.

In the light of this situation, we have developed a new system which provides free conversion between image data and vector data and processing of vector map output resulting from the image processing and vector data. This paper reports mainly abstraction of boundary lines of vector data and preparation of final output maps by the use of a pen plotter and others.

2. Algorithm and Method of Line Drawing Output of Image Data

2.1 A flow of Image Data up to Map Output

When one wants to express image data (for example, land use map) as a line drawing map, the image data have to be recognized as polygon for each region (category) such as paddy field and city. This allows output of the image data as a single paper map or overwriting on an existing map.

Fig. 1 shows a system flow of the developed system. In the first step, two neighboring pixels with a same value are merged to abstract boundary lines among pixels with different values. After the boundary lines are abstracted, they are decomposed to line data from node to node. The steps up to this point form the center of our development of this time. Next, the line data are converted to chain data with right and left region values, and then the chain data are further converted to polygon data. Finally, the polygon data thus prepared are put out on a XY plotter which provides designation of scale for output of accurate map data. In addition to these functions, functions including smoothing (approximation to a linear line) of boundary lines required for map expression of image data and blocking for mass image data processing were provided.

2.2 Algoriths of Individual Processing

(1) Abstraction of a border line

Fig. 2 illustrates the concept of the border line tracing method.

1) Raster data are scanned from the left side to obtain a pixel with no mark of completion of tracing. A mark of tracing completion is put on the boundary point of this pixel and this points is used as a trace starting point (Xo) to memorize its coordinates.

2) Eight pixels centering around Xi are examined counterclockwise starting from the trace starting point. A pixel which is encountered first and has the same value is used as the next boundary point Xi + 1, of which direction is then memorized. The study starting point is determined according to the direction of Xi + 1 (see Fig. 3).

3) The procedure 2) is repeated until Xi = Xo to obtain neighbouring boundary points one after another.

4) Finally, the outside of the boundary pixels are abstracted as a boundary line to prepare line data.

(2) Construction of vector data

The abstracted boundary line (line data) are decomposed from node to node to convert to chain data with right and left region values (Fig. 4(1)). Next, the chain file is used to construct polygon which recognizes individual closed regions (Fig. 4(2)).

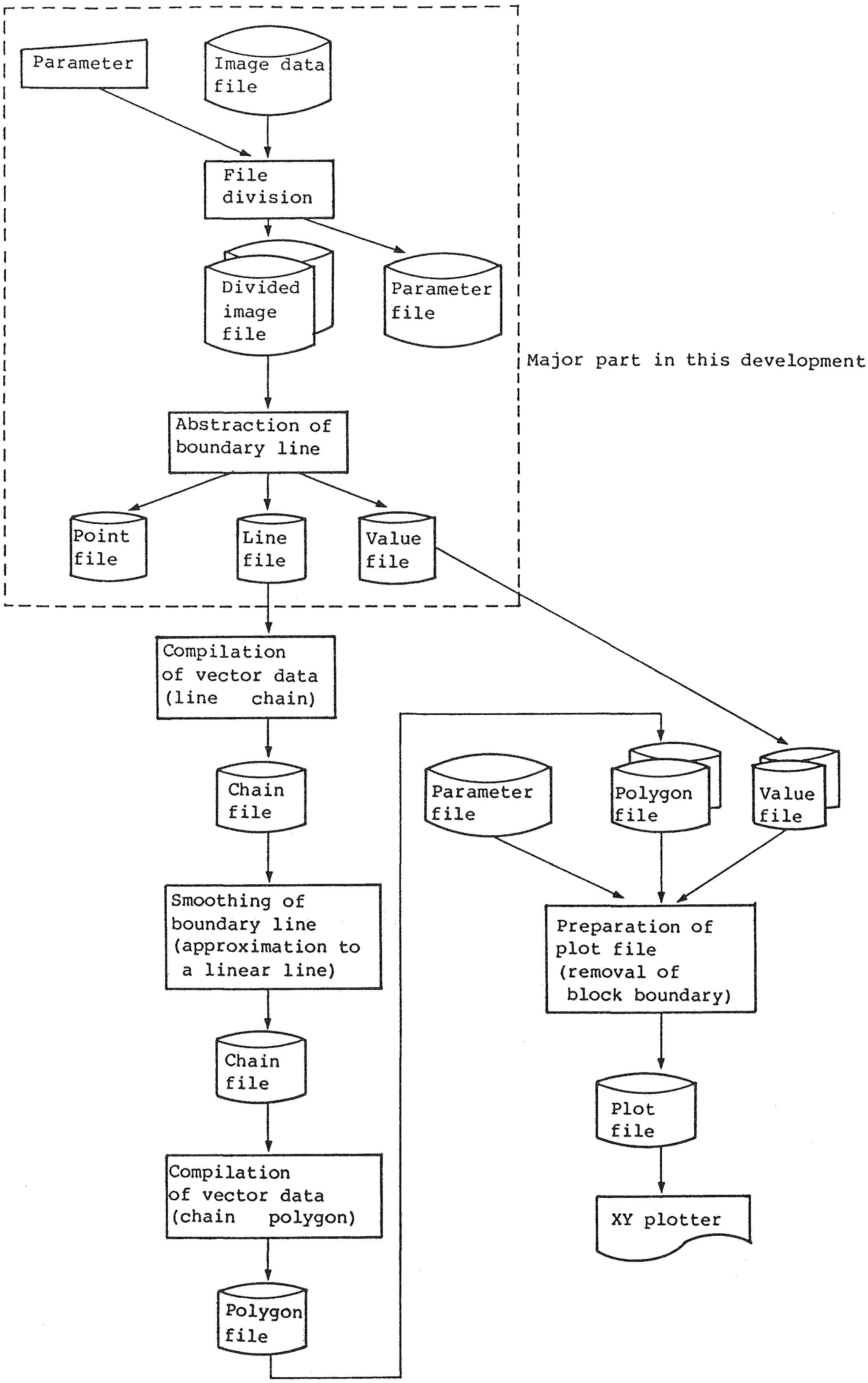

Fig. 1 System flowchart

These processings utilize a vector data compiling system.

(3) Processing for map expression improvement

Up to this point, pixels of raster data are treated as square to abstract a boundary line. For this reason, jaggy is expressed in the final polygon as it is. Output of this polygon on a map raises some problems in map expression. Better expression requires approximation of this boundary line to a linear line.

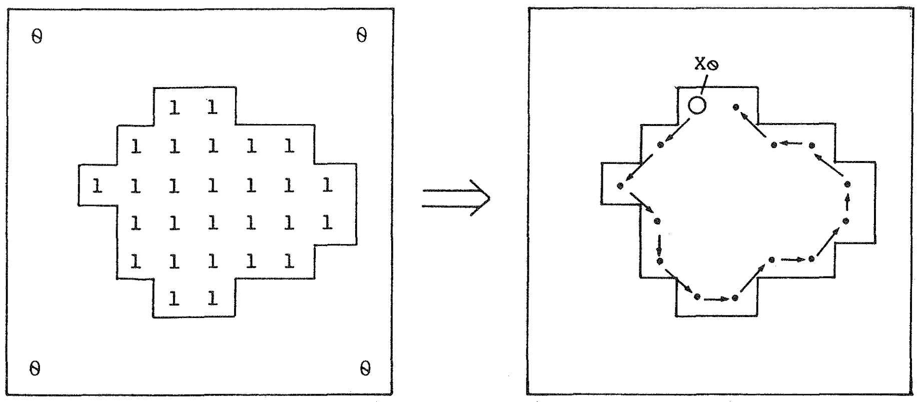

Fig. 2 Concept of boundary line tracing

d	c	b
e	Xi	a
f	g	h

When Xi - 1 is at the position of a, the starting point is b.
b ... h
c ... a

Fig. 3 Order of boundary line tracing

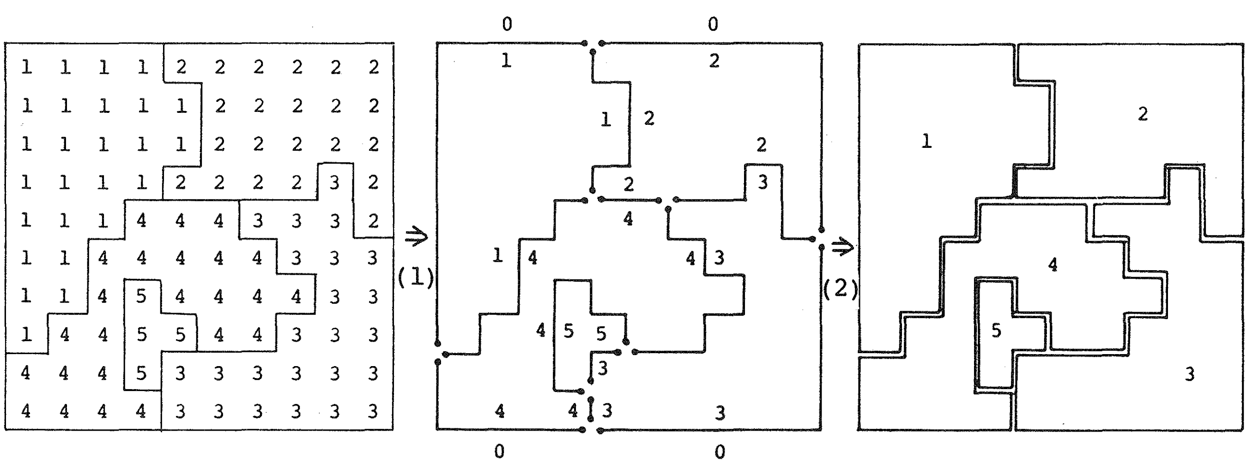

Fig. 4 Concept of compilation of vector data

The method for this linear approximation is as follows:

1) A linear line from node to node is assumed (linear line a-f).

2) Distances between the linear line and each points are obtained and the point with the maximum distance among them is determined (point e).

3) If this point exceeds tolerance value, then the line is divided into two segments at this point (linear lines as and e-f).

4) For the divided segments, the process of 3) is repeated (linear line b-e).

5) The division completes, when the distance from each point against all segments becomes less than the tolerance value.

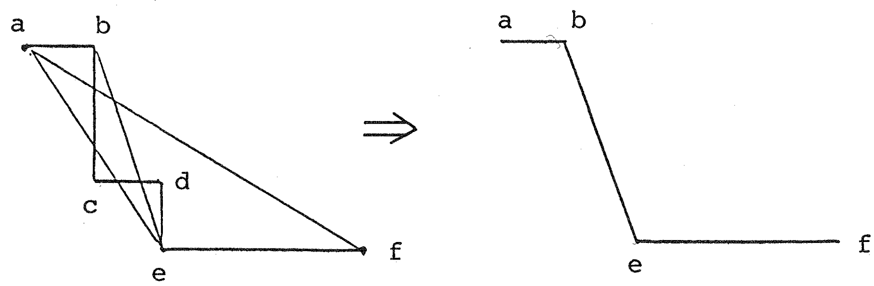

Fig. 5 Linear line approximation technique

(4) Blocking for mass data blocking

When mass image data have to be processed, the limitations of processing time and process system requires to divide an image to several blocks. One of problems in this process is output of polygons on a boundary for the division on a plotter.

If these divided blocks are expressed individually on the plotter, a polygon on a block boundary is recognized as two. Therefore, polygons which are continuous with the neighboring block are not written as a segment on the block boundary for processing (Fig. 6).

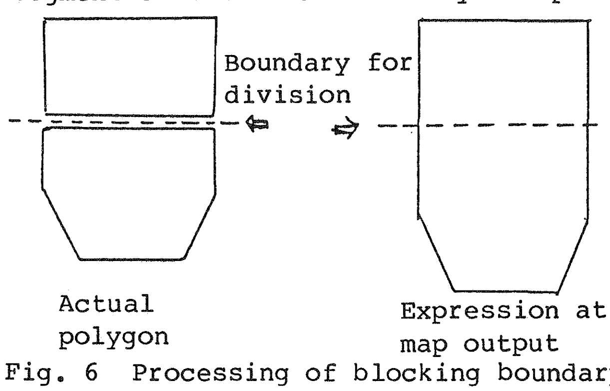

Fig. 6 Processing of blocking boundary

(5) Scaling

When the output is made on a XY plotter, it is necessary to provide a mean to allow any map scale. For this reason, the system was so designed that the size of a pixel of an input image was input in advance and the scale was maintained even in the course of vector procesing.

3. Processing Capacity of the System

3.1 An Amount of Input Data

The present system can process at once approximately the size of image with 512 x 512 pixels, but in actuality this processing capacity varies greatly according to the contents of an image. The actual limit is around 2000 - 3000 lines after boundary lines have been abstracted. However, in the present system mass image data are divided and then processed, which does not impose restriction on the size of image data in practice.

3.2 Processing Time and an Amount of Prepared Data

In order to confirm the processing capacity of the system, a bench mark test was conducted for various types of images. Table 1 shows a list of results from the bench mark test. The size of each image is 200 x 200, with two kinds of pixel category, and a VAX-11/730 is used for CPU. As this processing was made concurrently with other processings, the obtained values are not necessarily accurate, but they suggest a tendency that the more complex the original image is and more the number of polygons in the prepared vector data, the longer the required time is. The entire processing of this kind of image needs at longest approximately 45 minutes.

Table 1 List of results from processing time bench mark test

Type of data	Processing time				Amount of data	
	Boundary abstraction	Line chain	Chain polygon	Plotter file	Number of chain	Number of polygon
Land cover classification	14 min.	12 min.	4 min.	4 min.	333	274
Vegetation map image	17 min.	15 min.	3 min.	3 min.	216	189
Overlay image of the above two	18 min.	15 min.	7 min.	5 min.	349	309
Administrative boundary image	2 min.	2 min.	5 min.	3 min.	54	20

4. A Case Study of the Analysis

In this section, results of urban green analysis in Sapporo City, Hokkaido JAPAN, are explained. This analysis was made to updata existing information of green distribution in the city by using newest LANDSAT TM data to abstract its annual variation and preparation of the newest green distribution map.

4.1 Study Area

The study area covers the central part of Sapporo City, Hokkaido, including Kita Ward and Chuo Ward. Fig. 7 illustrates the study area for the analysis. In the biggest city in Hokkaido, Sapporo, urbanization has progressed in the central part, resulting in almost no primeval forest. On the other hand, urban planting has been actively promoted and man-made green areas such as large scale parks distribute widely.

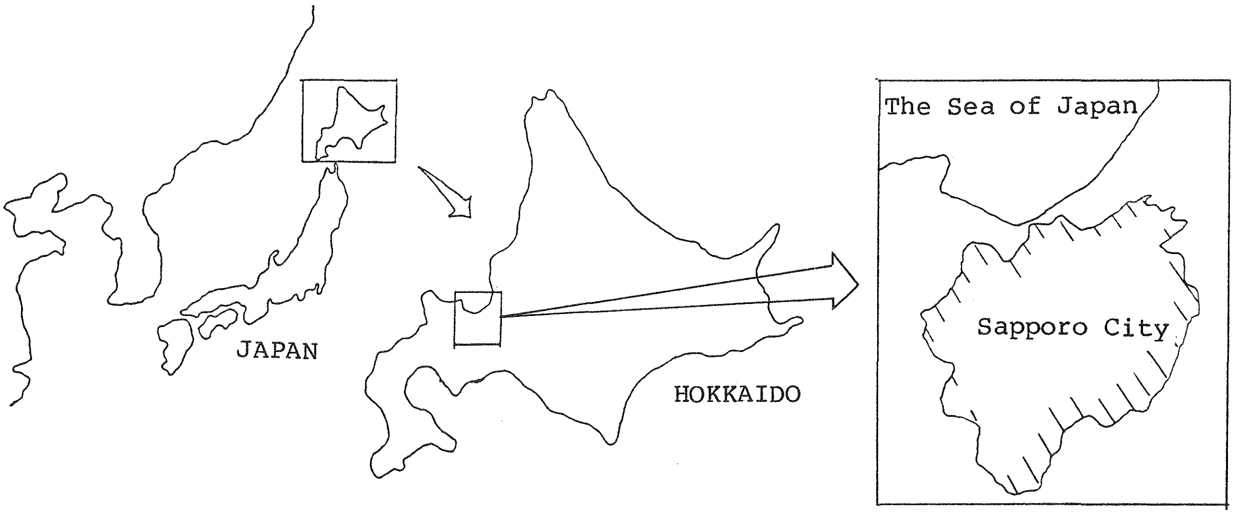

Fig. 7 Area to be analyzed

4.2 Method of Analysis

A flowchart of the analysis is shown in Fig. 8. As shown in this figure, mutual conversion between image data and vector data was fully used in this study for processing in which the functions of raster overlay and vector overlay were fully utilized.

(1) Processing of an existing green cover distribution map to an image.

The green cover distribution map surveyed in 1981 was processed to vector data by the use of a digitizer to store in the system. Then, green cover distribution image data were prepared by conducting the vector raster conversion processing.

(2) Land cover classification using LANDSAT TM data

LANDSAT TM data observed in September 1985 were used to know a recent green cover distribution. After the TM data were subjected to rectification in the pitch of 25 m x 25 m, principal component analysis was made to reduce the amount of the data. Green cover classification items were set to classify land covers with the maximum-likelihood method, and then these classification items were integrated to prepare a green area distribution image.

(3) Preparation of a newest green area distribution image

The prepared past green area distribution image and the new green area distribution image based on TM data were overlayed to prepare a newest green area distribution image. The overlay was so made to updata that the past green area distribution image was the first consideration and the green area distribution image from TM image was treated as dependent data.

(4) Output of the present green area distribution map

The newest green area distribution image obtained by the raster overlay was subjected to the raster vector conversion to prepare a plotter output file by compiling the vector data. A pen plotter was used to get a present greeen area distribution map as the final output.

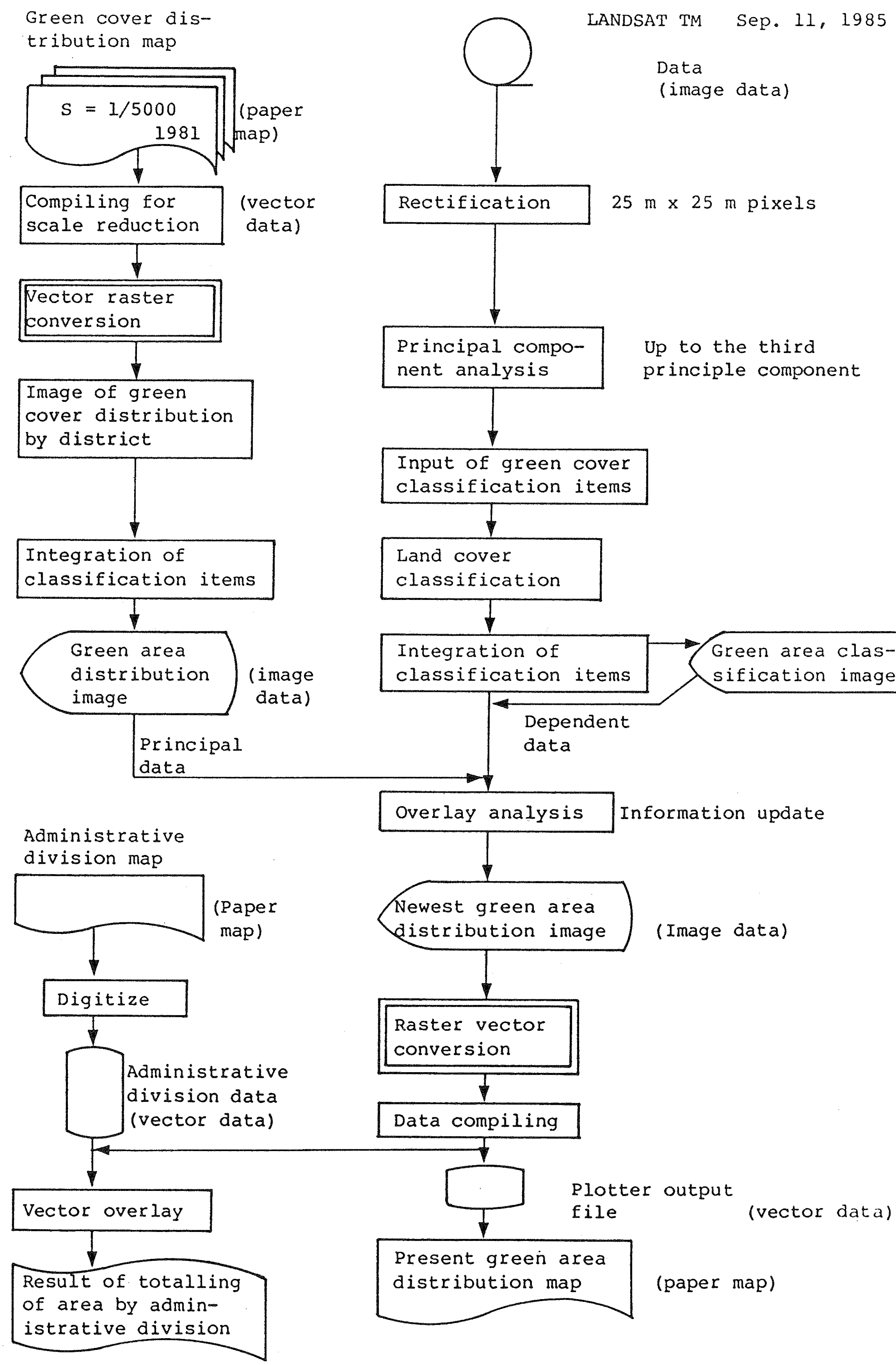

Fig. 8 A flowchart of the analysis

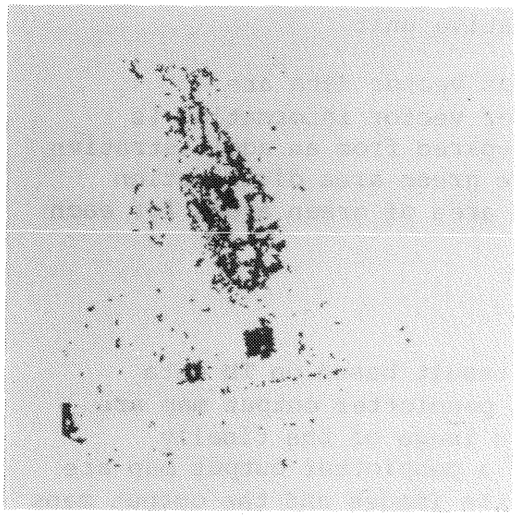

Photo 1 Land cover classification
by TM data

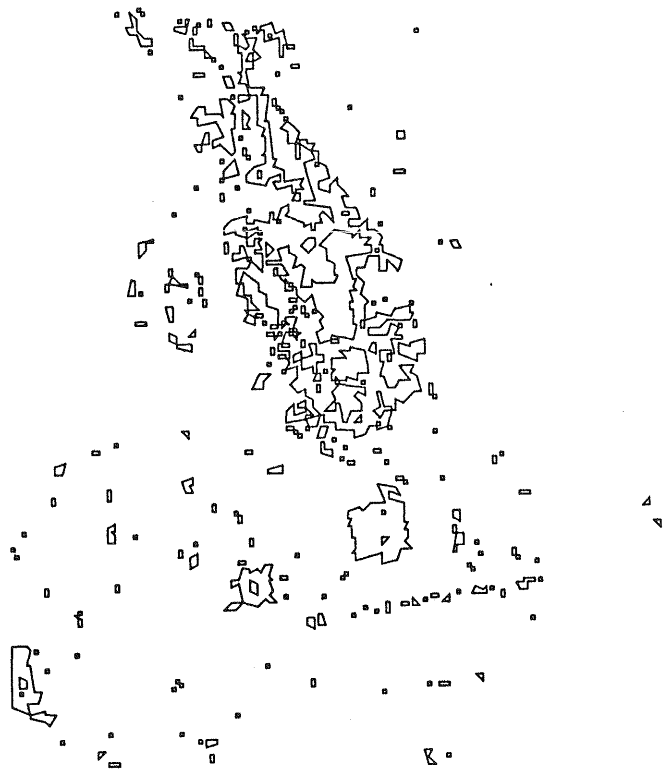

Fig. 9 Map output of Photo 1

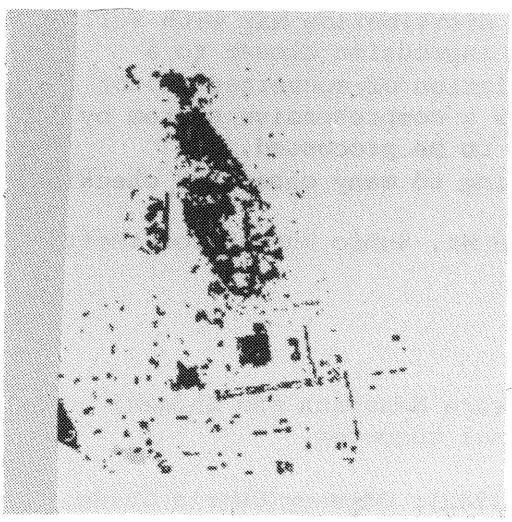

Photo 2 Green area distribution
by overlay

Fig. 10 Map output of Photo 2

(5) Totalization of area for each administrative unit

Since the present green area distribution vector data are structurized, overlay analysis with other vector information is possible. Ward boundary vector data prepared from an administrative division map using the digitizer and the green area distribution vector data were overlayed to total the area of green areas for each administrative unit.

4.3 Analytical Result

An image from the green area classification result based on TM data obtained in the course of the analysis and a penplotter output map are shown in Photo 1 and Fig. 9. In addition, an image of the finally obtained present green area distribution and a penplotter output map are shown in Photo 2 and Fig. 10. The range of the images and the output maps are 200 x 200 pixels (5 km x 5 km). This analysis divided only green areas from non-green areas, and so no examples are prepared on the basis of attributes. The expression in the linear drawings is slightly vague, but this analysis gave accurate vector data of green area distribution. thus, the function of raster vector conversion has been satisfactorily established.

5. Afterword

This study intended to construct accurate and structuralized vector data from image data with special reference to the development of a system for this purpose. Application of this system to green area analysis in Sapporo City allowed versatile analysis based on mutual utilization of image data and vector data, which was traditionally impossible, and provided preparation of a present green area distribution map with full automatic processing. Future issues include expression closer to a conventional mannualy colored map by interpolation of converted vector data and rounding treatment, establishment as a comprehensive system by arranging properly the flow among each items to be processed, and establishment as a practical system by applying to many cases for checking.

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