

AUTOMATED GENERATION OF DTM FROM EXISTING TOPOGRAPHIC MAP

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ABSTRACT

An automated system has been developed for the generation or interpolation of grid data(DTM) from rasterized contour data. The conventional method based on "raster-vector conversion" requires a lot of data input and computing time.

The system developed here, is based on line by line, automated trace of sectional height of rasterized contour. A neighboring dot on a line is either up, down, or flat, in relation to the information on the current line section .

This new system reduces remarkably the time required to generate a dense DTM.

INTRODUCTION

The various uses of DTM include (1) Determination of contour line, (2) Generation of profiles, (3) Determining intervisibility of points, (4) Generation of perspective views, (5) Terrain simulation, etc.

DTM data may be acquired from existing maps, from photogrammetric stereomodels, from ground surveys, or from other systems such as altimeters carried in aircraft and spacecraft.

The present technique of acquiring DTM data from existing map are

(I) Manual following of contour lines using a digitizing tablet. But this is actually a very tedious and boring operation with a high probability of error, and either duplicating or omitting information.

(II) Mechanical following of contour lines using a scanning device. This approach requires a fair amount of computing time to connect together the individual segments of lines and manual works to assign the proper elevations. In Japan, two methods have been used; (1) Contour Following method for raster output data, and (2) Vectorization method for vector output data. But both of them still require a lot of manual works.

Method (1) requires 4-5 days in average to recognize all of rasterized contour lines of a topographic map of 1:25,000 scale, while method (2) requires 2 weeks in average for vectorization of the rasterized contour lines.

The system developed here is based on Relief Change Detection Method (RCD) which reduces the computing time as well as manual works required for assigning the proper elevation to each contour line automatically. The final goal of this study is to enable "one day" processing for a sheet of existing topographic map.

OUTLINE OF SYSTEM

The system is consisted of the following procedures. (Fig.1)

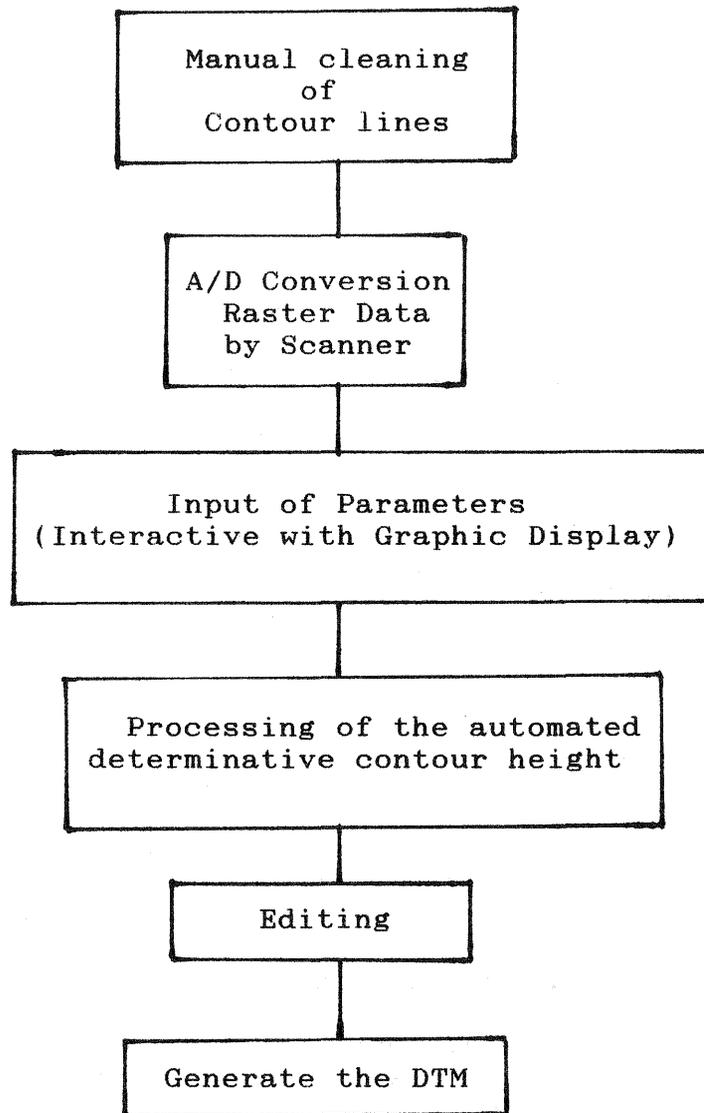


Fig.1 Program Flow chart of the automated system

Manual cleaning of contour lines :- This is a process for cleaning of connected contour lines and all symbols because this system dose not allow for a input image that still contain connected contour lines, symbols and supplementary contour lines.

A/D Conversion :- This involves the scanning of cleaned existing topographic map for the generation of raster image data.

Input of Parameters :- The following parameters are required to be input for the system :

- (a) Size of image
- (b) Position of the relative relief change on the first starting horizontal line.
- (c) First left contour height on this horizontal line.

- (d) Position of the relative relief change on another vertical line (the position of the vertical line is to be chosen by the user).
- (e) First top contour height on this vertical line.
- (f) Contour interval.

Editing :- More relief change information are usually requested by the system if there are some contour height which the system cannot identify . In such cases, the system will show the position of unidentifiable height-contour line on the Graphic Display and request the user to input the requested information interactively and the user can use editing function for checking the height of contour lines.

PROCESSING FOR THE AUTOMATED DETERMINATIVE CONTOUR HEIGHT

The subsystem involves the following principles. (Fig.2)

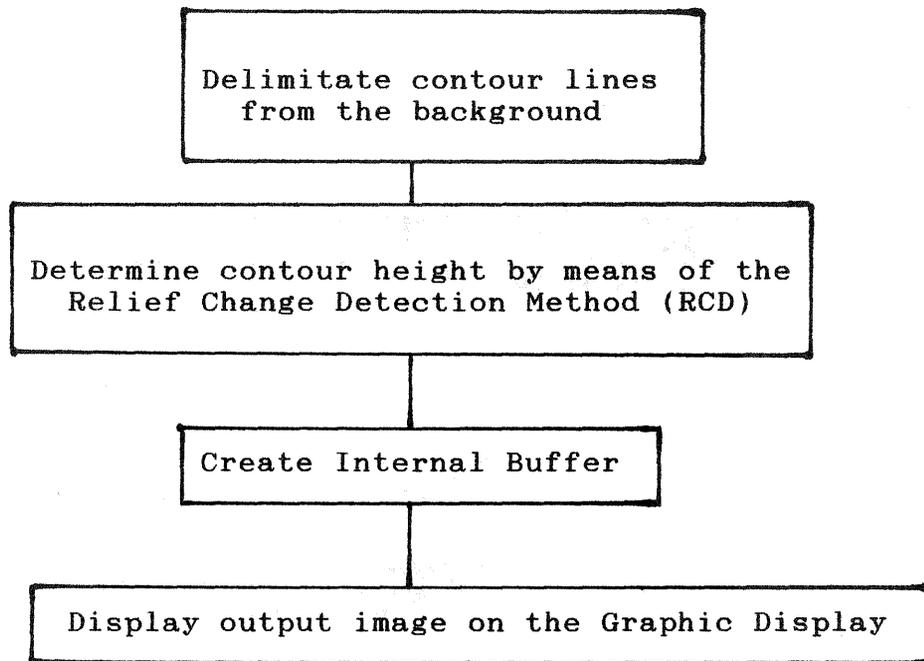


Fig.2 Flow Chart of processing part

The algorithm called by the authors "Relief Change Detection Method"(RCD), is a method for tracing of sectional height of rasterized contour, line by line scan.

A neighboring segment on a scan line is either up, down, or flat in relation to the current height determined from the former segment, as shown in Fig. 3

The Relief Change Detection method provides the three additional functions as listed in table 1 in order to determine the height of contour lines accurately. For example "Merging" function will give the same value for two contour lines having the same height.

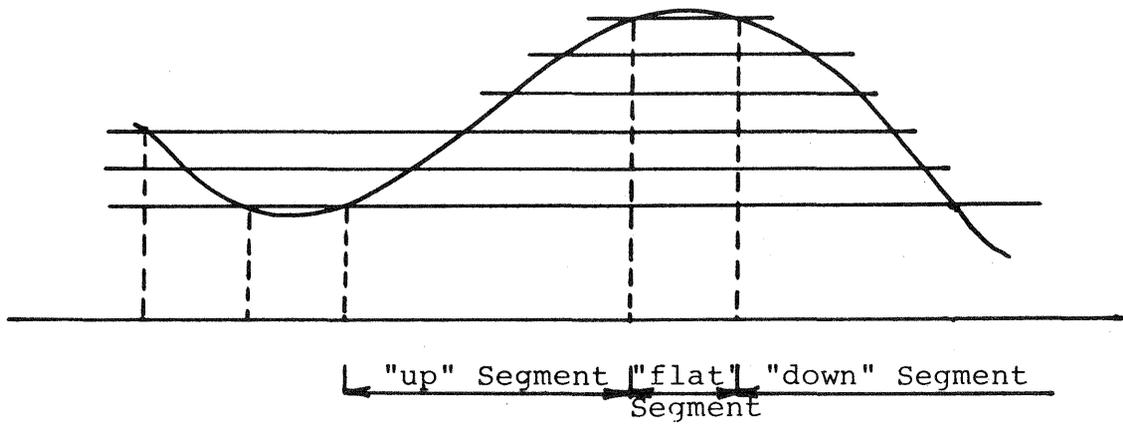


Fig 3. Relief Change Detection Method

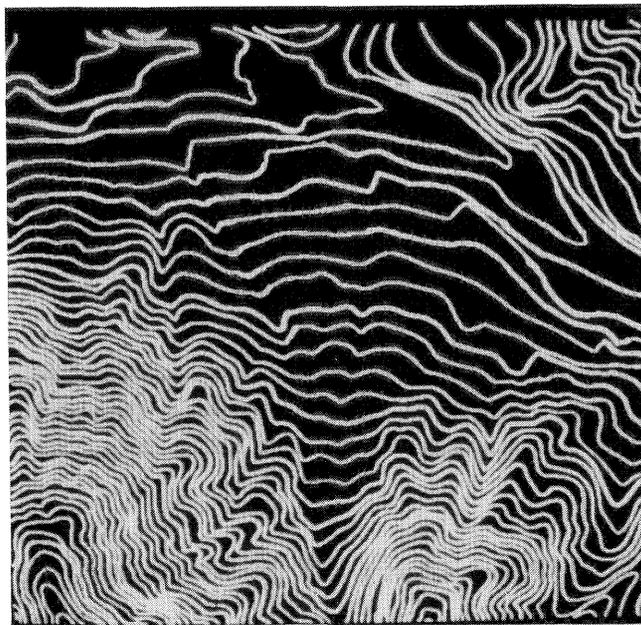


Fig 4. Input data for Case Study 1

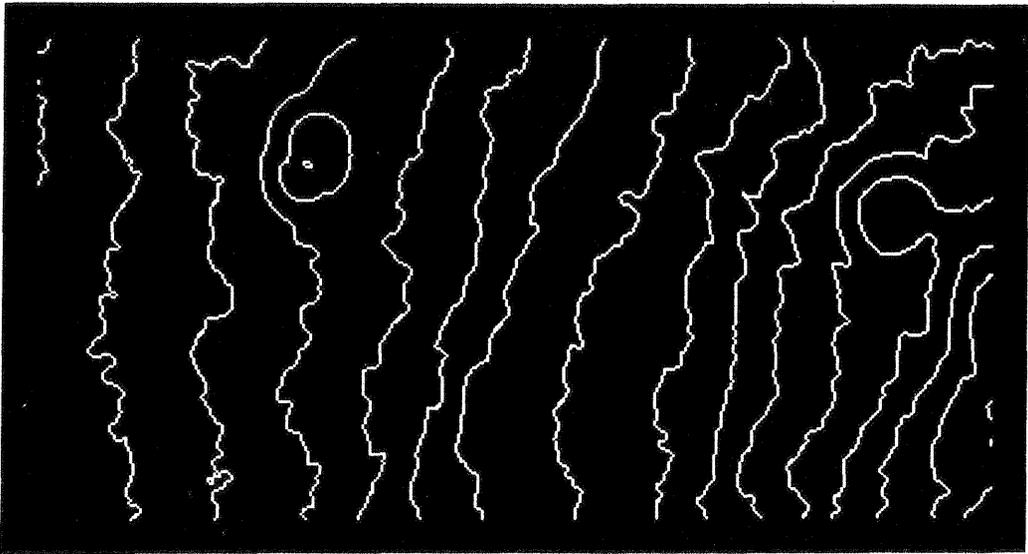


Fig 5. Input data for flat area

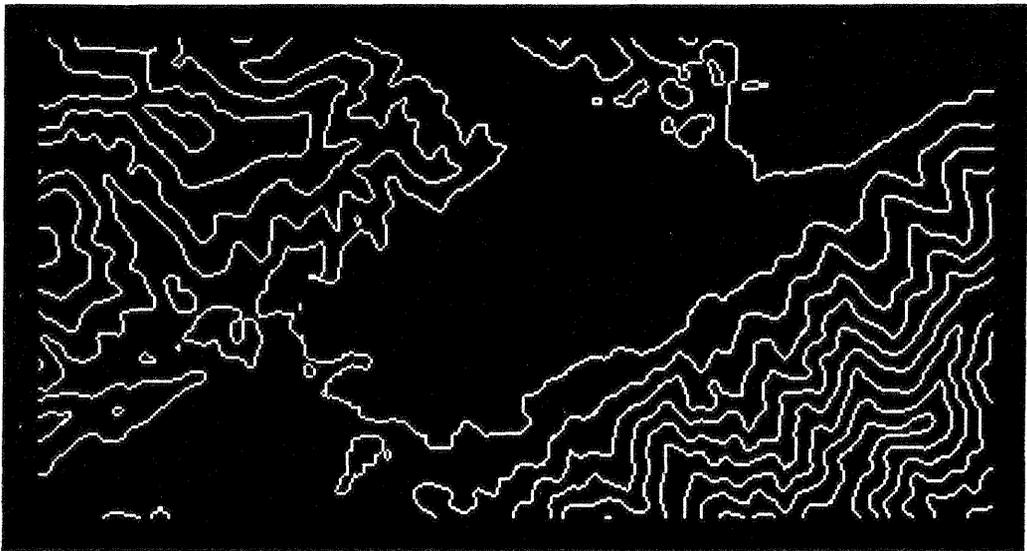


Fig 6. Input data for general slope area

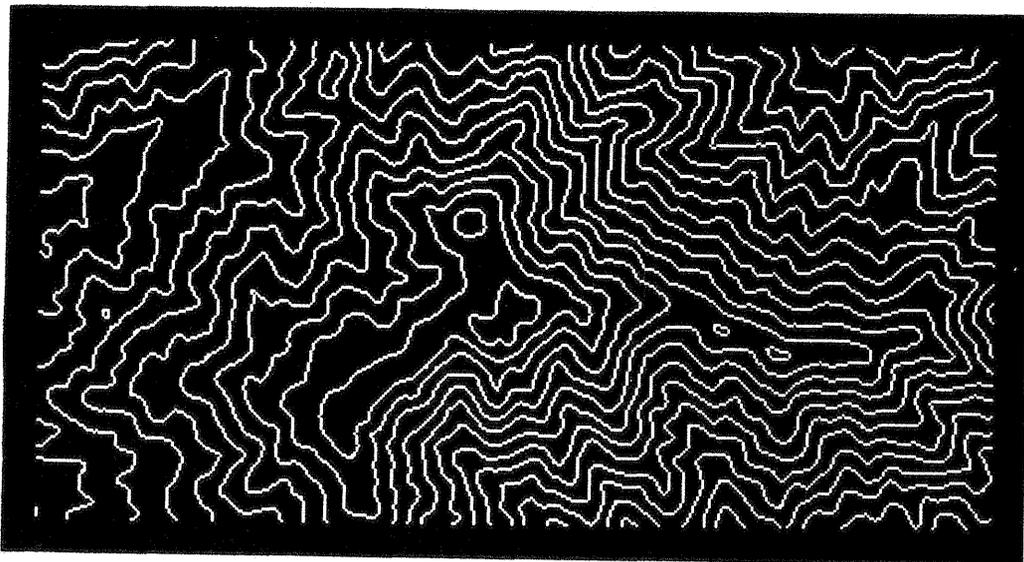


Fig 7. Input data for steep slope area

Table 1. Additional Functions

Added Function	Purpose
1. Merging	To identify contour lines having the same height.
2. Processing for uncontinuous contour lines	
- New Starting Detection	To detect new starting contour lines which starts inside the image.
-Ending Detection	To detect ending contour lines which ends inside the image.
-Joining	To identify those non-continuous contour lines having the same height.
3. Editing	
-Detection of Undetermined Height	To detect those contour lines that do not have enough information of relief change.
-Updating	To update contour height which edited.

The above system has been operated on the FACOM M 170 F computer with 32 MBytes main memory, in the time sharing environment, and is interface with the NEXUS 6400 image processing system. All of the CPU times were observed from this main frame system.

CASE STUDIES

The following case studies have been carried out to access the RCD functions as well as to compare RCD with the conventional method of Contour Following Method. Fig. 4 shows the contour lines for the case study 1, which size is 512*480 pixels with 86 contour lines. Fig. 5,6,7 show the contour lines for the case study 2, which size is 401*201 pixels with 23, 45, and 51 contour lines respectively.

1. Improvement of Accuracy

The performances of the additional functions shown in Table 1 were compared with respect to the accuracy and CPU time. The accuracy was evaluated in term of ratio of number of complete contour lines to the total number of contour lines. The CPU time is expressed as indicator to the CPU time required for RCD without additional functions.

RCD with additional function	Accuracy %	CPU time sec
None	75	20
Function 1	75	7
Function 1 and 2	79	8
Function 1,2 and 3	100	9

2. Comparison of time with Contour Following Method (CF)

Status	Test Area	RCD				CF		
		Manual input min	CPU time min	Edit time min	Total processing time min	Manual input min	CPU time min	Total processing time min
Contour Recognition	Flat	1.5	0.1	2.9	4.7	2.1	0.1	2.4
	General slope	2.7	0.1	2.8	5.8	7.5	0.2	7.9
	Steep slope	3.8	0.1	3.4	7.5	11.0	0.3	11.5

CONCLUSIONS

As compared with the conventional Contour Following (CF) method, Relief Change Detection (RCD) method developed by the authors showed better results, except flat area, in reducing the manual works as well as CPU time. RCD method increases the total processing time rather gradually in accordance with steepness of the terrain than CF method. Therefore, the steeper the terrain is, the more the difference of the total processing time is. From the result of case studies, the manual works and editing time dominated the total processing time. In this case, RCD method would be much convenient to the users.

It is expected that RCD method can provide more by-products such as computations of gradients, easy access to interpolation of grid data (DEM), and 3D representation of contour lines than the conventional method of Contour Following method, because RCD is based on the sequential processing, that is, line by line scan instead of random access.

REFERENCES

- 1) Yoshiaki Shirai, " Three-Dimensional Computer Vision ", Springer-Verlag, 1987, pp 86 - 89.
- 2) Frederick J. Doyle, "Digital Terrain Model : An Overview", Photogrammetric Engineering and Remote Sensing, Vol. 44, No 12, Dec. 1978, pp 1481-1485.