ZI-EDAS: A Fast Elevation Data Acquisition System

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ABSTRACT

A PC-based fast elevation data acquisition system called ZI-EDAS is developed to digitize contours on topographic maps into vector form and then generate DEM.The hardware consists of an AST386 computer with TVGA display, a mouse and a HP ScanJet Scanner. The contours on scanned map are digitized interactively arc by arc. The cursor is located on the nearest contour automatically and then the contour is traced at once. The heights of the contours are determined by increasing or decreasing one interval by pressing different mouse keys.Experiments show that the input time using ZI-EDAS can be reduced to about 10%-20% of that using a conventional digitizer. A fast DEM generation method is presented by using variable-direction 1-D interpolation. The precedure is much faster than that of 2-D interpolation by about 10 times.

[KEYWORDS]

automatic digitizing, line tracing, raster-vector conversion, scanner input system, DEM generation.

1. INTRODUCTION

Digitizers are used as graphical input device in geographic information systems because of their low hardware cost and operational simplicity. However, manual digitization for topographic maps is considerably strenuous and time-consuming due to the large number of manual operations involved in tracing. The scanner digitization systems have been developed in recent years (Satoshi Suzuki, et al., 1990) in order to reduce the labor intensity and input time. Since no automatic methods can extract contours and their height values on topographic maps, an efficient semi-automatic interactive method is developed by ZISM to digitize contours into vector form. The dense vector data of contours can be used to generate DEM by using variable-direction 1-D interpolation which is much faster than that of 2-D interpolation.

This paper presents a truelly efficient elevation data acquisition system called ZI-EDAS, which digitizes contours on topographic maps into vector form and then generates DEM. The main features of ZI-EDAS are described as following.

2. HARDWARE COMPONENTS

The hardware consists of a PC-computer with a TVGA display, a mouse and a scanner. Equipment specifications are shown in Table 1.

Table 1. Equipment Specifications

Main processor	Intel 80386
Main memory	4 MB
Magnetic disk	110 MB
Optical disk	600 MB
CRT display	1024 X 768 dot
scanner	HP ScanJet Plus
mouse	microsoft mouse

3. PROCESS OF ZI-EDAS

The system process consists of eight stages : scanning and preprocessing, curve detection , vectorization, vector editting, orientation and clipping, adjoining and combination, multi-direction sorting, DEM generation. The operation procedure is shown in Fig. 1.

The topographic map is scanned into computer block by block whose size is the scanning size of the scanner.The control points in each block are measured for orientation. Each block is divided into subblocks which can be fully displayed on the screen viewport. The curve detection operators are used to detect contours (which are difficult to be extracted by binarization due to the heterogeneous distribution of grey scales) from the scanned image. There are eighteen cases of curve when a 5 X 5 window is considered. The contours on scanned image are digitized interactively arc by arc. The cursor is automatically located on the nearest contour and then the contour is traced at once. The heights of the contours are determined by increasing or decreasing one interval by pressing different keys of the mouse.

The feature lines, which are used for DEM interpolation latter, are also digitized by the mouse. The incomplete contours can be linked and combined into complete contours automatically by using step-by-step node matching technique. The theoretical values of the intersections of the grids which can be used as control points are computed according to the map number. The vector data from each image block are transformed into user coordinate system through eight-parameter orientation or four-parameter planimetric block adjustment. A very fast polygon clipping method is applied to the dense vector data. After adjoining and combining all the vector data blocks, a unified complete vector contour data set is established. The dense contour data can be compressed by 5 - 10 times by line approximation algorithm.

Based on the dense contour data and feature line data, a fast DEM generation method is presented by using variable-direction 1-D interpolation. First, all the data are sorted according to the different direction and the specified DEM interval. Then, the slope for each direction is computed at each grid point. The direction which has greatest slope will be the direction for 1-D interpolation. The dead areas for interpolation are marked with special signs. This procedure is in accordance with the train of thought by which specialists estimate the heights from topographic map. Therefore, it not only has fast interpolation speed, but also possesses high reliability.

4. EXPERIMENTS

ZI-EDAS was developed to process topographic maps and generate DEMs. Experiments on different maps (scale from 1:10,000 to 1:250,000) show that the input time using ZI-EDAS can be reduced to about 10% - 20% of that using a conventional digitizer, and the variable-direction 1-D interpolation is much faster than that of 2-D interpolation by about 10 times.

Fig. 2 is a scanned map image block. Fig. 3 is the original vector data traced by ZI-EDAS. Fig. 4 is the vector data after automatic editting. Fig. 5 is the contours and partial feature lines used for DEM generation. Fig. 6 is the 3-D perspective view of the area using the DEM generated by ZI-EDAS.

5. CONCLUSION

This paper has presented a PC-based fast elevation data acquisition system ZI-EDAS. The software is writen in an object-oriented language Borland C++ (originally Turbo C++). It consists of about 10,000 lines of code. ZI-EDAS has multi-windows, menu drive and user-friendly interactive interface. The integrated run-time environment offers great flexibility to the user.

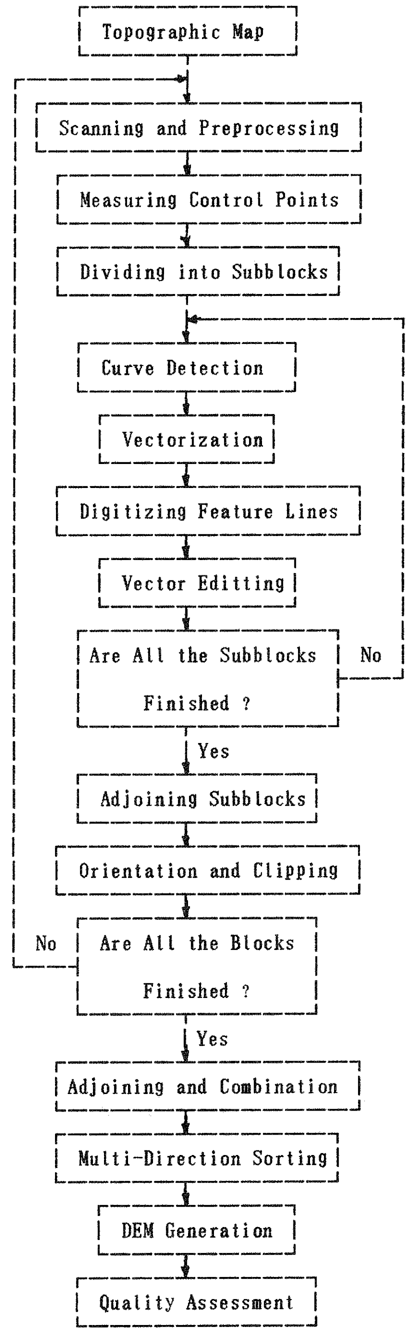

Fig. 1 Operation Procedure of ZI-EDAS

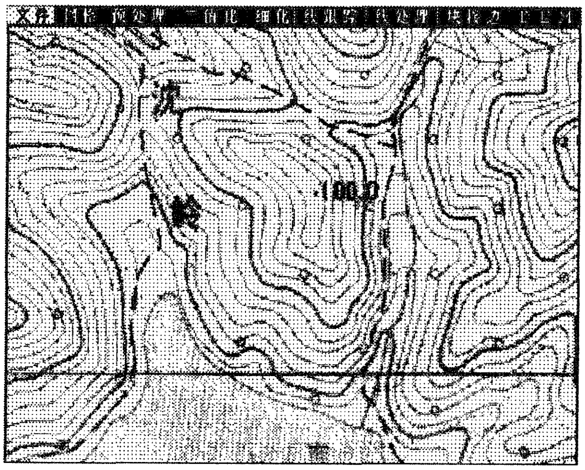

Fig. 2 A Scanned map image block.

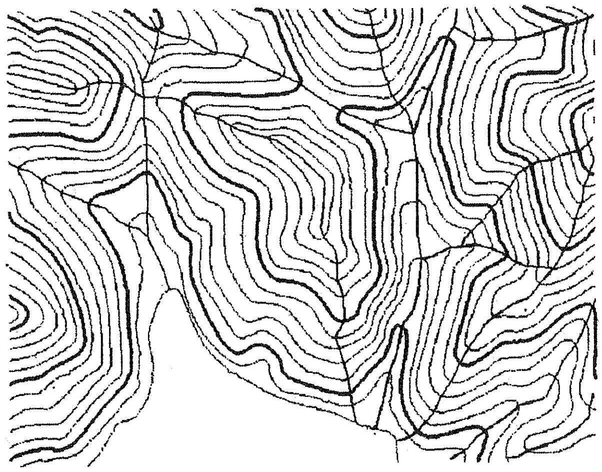

Fig. 5 Contours and partial feature lines.

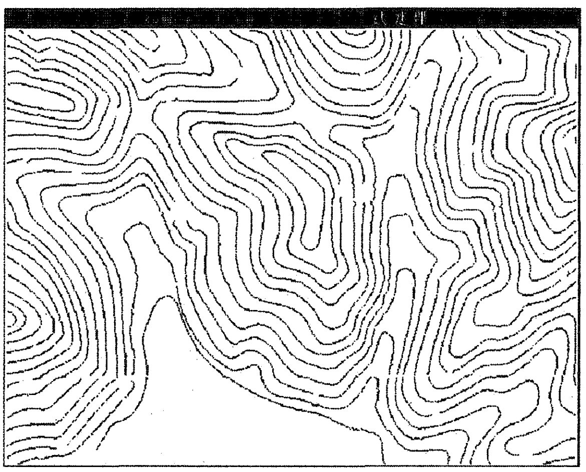

Fig. 3 Vector data traced by ZI-EDAS.

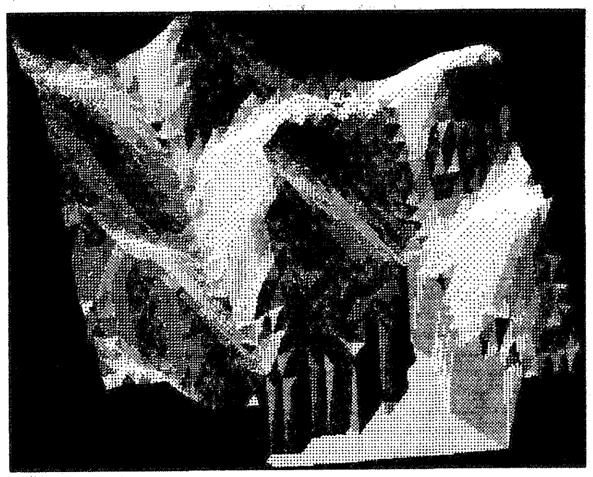

Fig. 6 3-D perspective view.

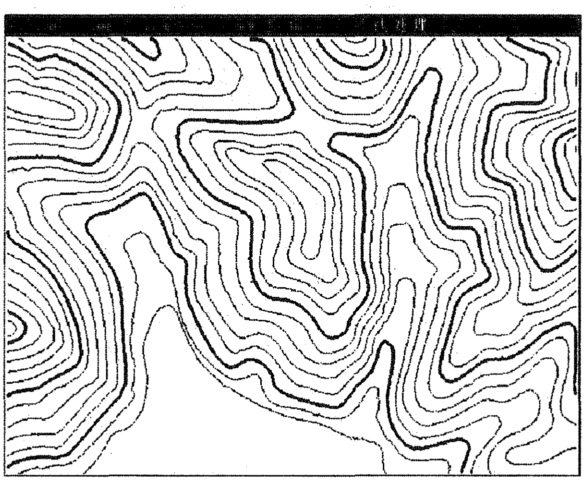

Fig. 4 Vector data after automatic editting.

Although our work only concerns contours on topographic maps, the basic methodology could be expanded to cover other geographic information on various kinds of maps. We believe that the scanner input system, which has powerful potential of obtaining geographic information, will supersede the conventional digitizers in geographic information systems in the near future.

REFERENCES

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