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PROCEDURE FOR COMPUTER-GRAPHIC PROCESSING OF MAPPED LINEAR DATA

by

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INTRODUCTION

Mapping and comparative analysis of linear features, whether of areas as large as a State or as small as a sample thin section, can be achieved by using digital processing techniques. Lineament plots, cell-by-cell histograms of lineament length and frequency plotted against 10^{o} increments of azimuth, and rose diagrams of lineament distribution within cell areas may be derived from the digital processing procedures described below. Geologists having minimum backgrounds in computer procedures wishing to use these computer processing capabilities might find application for the simplified do-it-yourself instructions given herein. After 2 or 3 days of training and supervision, available from the system supervisors in the U.S. Geological Survey (USGS), "hands-on" operation of the machines can be achieved. The FORTRAN IV programs would also be adaptable to other systems in use outside of the USGS, and most commercially available digitizers can be used for input of data.

The described procedures use the Interactive Graphic Design System* (I.G.D.S., M & S Computing, Inc., 1979), and the Multics (Honeywell Information Systems, Inc., 1975) computer system of the USGS. Figure 1 is an example of histograms produced for a single cell seen on figure 2. Figure 2 is a rose diagram plot of karst lineaments mapped in central Kentucky. Figure

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*Use of trade names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

3 is a sample of a Multics terminal session.

Acknowledgements. The described procedures were adapted from data processing programs written by M. H. Podwysocki, U.S.G.S., and P. D. Lowman, Jr., Goddard Space Flight Center (Podwysocki and Lowman, 1974). Equipment and assistance were supplied by other members of the USGS in Reston, Va.

PROCEDURES

For purposes of identifying operator-entered text, teletype input has been capitalized and flagged with an arrow in this report. In practice, input is not capitalized. Equipment and operational nomenclature and system replies are shown in quotes.

I.G.D.S. Operations

A. Digitize Mapped Lineaments

1. On the M & S digitizer command menu and teletype console, allocate "design file" and copy desired base-map information into the file. This step will require assistance from equipment supervisor.
2. Orient and scale map by precise placement of a suitable number of 7 1/2-minute quadrangle corner "cells" (four or more) using Universal Transverse Mercator coordinates from the U.S. Department of the Army (1959) tables or other appropriate coordinate system. The machine coordinates are orthogonal, but errors caused by lack of convergence of meridians of longitude are negligible.
3. Select "active level" separate from that used for any other input data (such as base-map information).
4. Digitize beginning (south) and end (north) points of rectilinear features using "place line" command. Press "data" button on the digitizing "cursor" at the end of each line and then press a "reset" button. (Equipment supervisor should verify that lines are "M & S Type 3 lines", i.e., two-point vector line segments.)
5. Continue process to completion of the "design file."

B. Transfer Data From Disc to Tape

1. Hang magnetic tape on tape-drive unit with "write ring" in place.

2. On console, install "VCOUT" program in system.

--> INS DP1:(200,1)VCOUT command.

3. Set tape drive to "MT1" (knurled wheel set at 2).

4. Run "VCOUT" program. -->VCOUT command. Invoke all "levels" desired for graphic plot (base-map information as well as lineament data). Terminate with second -->EOF (end of file) asked for by program.

C. Transfer Data from "VCOUT" Tape to "PLOT" Tape

1. Hang "VCOUT" tape (without "write ring") and blank "PLOT" tape (with "ring") on tape-drive units.

2. Assign input unit ("VCOUT") as "MT0" (setting 1) and output unit as "MT1" (setting 2).

3. Install "PLOT" program in system

--> INS DP0:(10,1)PLOT command.

4. Run program.

--> PLOT command. As asked for, enter scaling parameters: Desired map dimension (maximum Y) in inches, and minimum and maximum XY coordinates (meters or other digitized dimensions). Files may be combined and attributes assigned if applicable; as used herein they are not. The program processes data and transfers it to "PLOT" tape in a form suitable for input to a "Gerber plotter."

5. Submit "PLOT" tape for Gerber plot. Machine drafts map at desired scale for film using "photo head" or on mylar or paper using variously colored pens.

D. Prepare Data for MULTICS and CALCOMP input

1. Follow steps outlined in section B to prepare a separate "VCOUT" tape containing only that level on which the lineament data have been entered.
2. Follow steps outlined in section C, except install and run DP1:(5,1)CARD2 program which prepares data for MULTICS and CALCOMP processing.
3. Using "CARD2" tape labelled REH101 as input, proceed to MULTICS operation outlined below.

MULTICS OPERATIONS

A. Run Transform Program

1. On terminal, create or edit pre-existing "TRFM.CONTROL" card: Enter "QEDX editor" of system

--> QX command, then R-->TRFM.CONTROL command (reads card), then -->1,$P (prints card)

Edit title by substitution

--> S/old text/new text/

Note: Though use of upper- and lower-case text is permissible at this stage, only upper-case type should be used throughout program; otherwise printout will be unintelligible when plotted on CALCOMP machine.

Write modified version and exit from "QEDX editor"

--> W (Write)

--> Q (Quit) commands

2. Deliver input ("CARD2" above) tape labelled REH101 and blank output tape labelled REH100 (CALCOMP plot tape) to operator.

3. Send message to system operator

--> SM SYS OP PLEASE LOCATE TAPE REH101.

Operator will locate tape and reply

4. Invoke unload command

--> EC UNLOAD_TAPE

Program proceeds with various messages to terminal ending with "ur all" then "ready message".

5. Check that new file is present as temporary file named TEST_DATA

--> LS TEST_DATA command.

6. Delete old file labelled FILE08

--> DL FILE08 command

7. Rename file labelled TEST_DATA -- FILE 08

--> RN TEST_DATA FILE08 command

8. Delete zeros at end of FILE08

--> QX (enter editor),-->R FILE08 (reads file),-->$P (prints last line)

This line will consist of zeros.

--> D (delete command)

--> $P (prints new last line)

If this line contains zeros, -->D command.

Continue process until last line contains data.

After deletions are complete, issue -->= command to obtain line number of last line.

Note: Record this line number as it is to be entered during next phase of the operation.

Write modified file and exit from editor

--> W (Write)

--> Q (Quit)

9. Invoke "new process" to destroy user's current process and create a new one.

--> NEW_PROC command

10. Attach files to program

--> IO ATTACH FILE41 VFILE_TRFM.CONTROL command (Note space after FILE41_).

"ready message"

11. Run Transform program

--> TRFM command

Wait for program to be completed.

System will send "close files" query

--> YES command

B. Run Azmap.2 Program

1. Edit "AZMAP.CONTROL" card

--> QX (enter editor),-->R AZMAP.CONTROL (reads file),-->1,$P (prints contents),-->1P (prints first line to be edited)

Contents of first line and required changes:

Cell size - xinc yinc (change numbers)--Use:xmax - xmin/no. cells

Coordinates - xmin ymin (replace) ymax - ymin/no. cells

- xmax ymax (replace)

Note: Coordinates should be chosen for an area slightly larger than that occupied by file. Subtract a few meters from xmin and ymin, add a few to xmax and ymax.

No change to next two figures

Change required for next figure will already have been made

(xinc yinc above)

except insert number of records (recorded earlier) as last

four digits of figure

No change to last figure in line

--> +1P (Prints next line for editing)

Edit title (-->S/old/new/) by substitution.-->W (Write),--> Q (Exit

from editor)

2. Edit AZMAP.PRINT (As above)

Only text needs to be edited in this step.

3. Invoke "new process" command.

--> NEW_PROC command

--> IO ATTACH FILE05 VFILE_AZMAP.CONTROL

"ready message"

--> IO ATTACH FILE97 VFILE_AZMAP.PRINT

"ready message"

4. Run program

--> AZMAP.2 command

Wait, then close file when prompted

5. Print out histograms of data

--> DPRINT AZMAP.PRINT command

Note: The experienced operator may wish to use QX and

a "global delete" to purge all data lines containing

"zero" data as the print summary will also contain

data for "null cells" (gridded cells containing

no data). Use of a "global delete" will eliminate large volumes of printout for projects that have irregularly spaced grids.

6. Print out input file for next phase

--> DPRINT AZMAP.PUNCH command

7. Pick up printouts at Computer Center mailbox

"AZMAP.PRINT" histograms are ready for comparative analysis with other parameters.

"AZMAP.PUNCH" printout is to be searched for largest vector (needed for next phase)

C. Run Rose Program

1. Edit"ROSE.CONTROL" card

--> QX (enter editor),-->R ROSE.CONTROL (reads existing file),-->1,$P (prints contents),

First line unchanged

Second line contents and required changes:

xmin., ymin., xmax., ymax., (substitute new figures)

azmax (fifth figure, substitute largest vector found in search of "AZMAP.PUNCH" printout)

scale (sixth figure, substitute if desired)

Third line (edit title)

--> W (Write),-->Q (Exit from editor)

2. Send message

--> SM SYS OP PLEASE LOCATE TAPE REH100

Operator sends "tape here" message

3. Invoke "new process" command

--> NEW_PROC command

--> IO ATTACH FILE05 VFILE_ ROSE.CONTROL

"ready message"

--> IO ATTACH FILE06 VFILE_ ROSE.PRINT

"ready message"

4. Run "ROSE" program.

--> ROSE command

Note: Instructions printed out at beginning of this run are to be ignored as these procedures are now automated by "ROSE.CONTROL" card. Close file when prompted and pick up tapes. Deliver REH100 for CALCOMP plot.

REFERENCES CITED

Honeywell Information Systems, Inc., 1975, Multics programmers' manual, commands and active functions: HIS AG-92.

M & S Computing, Inc., 1979, Interactive Graphic Design System operating manual: M & S Computing, Inc., Report No. 77-006, Revision B, 175 p.

Podwysocki, M. H., and Lowman, P. D., Jr., 1974, Fortran IV programs for summarization and analysis of fracture trace and lineament patterns: Goddard Space Flight Center document X-644-74-3, 43 p.

U. S. Department of the Army, 1959, Universal Transverse Mercator grid tables for latitudes 0 deg. - 80 deg., Clarke 1866 spheroid (meters) coordinates for 7-1/2-minute intersections: U. S. Department of the Army Technical Manual TM 5-241-11, 162 p.

KYSTRUC, CENTRAL KENTUCKY, KARST LINEAMENT ANALYSIS, D.F.B. BLACK, BEEG

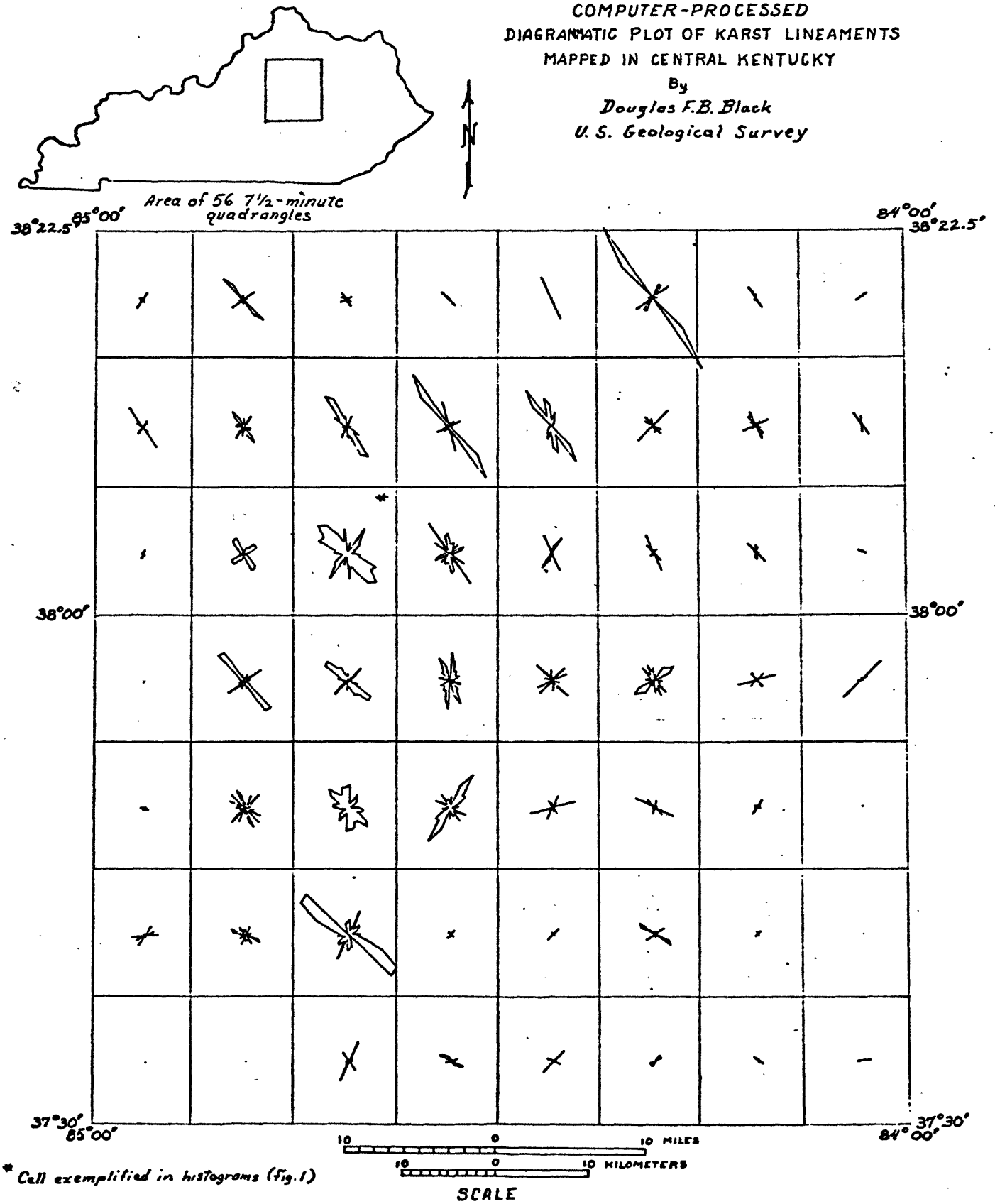
EACH GRID CELL IS 10988 M. (10988.0 meters) BY 13746 M. (13746.0 meters)

PROGRAM USES SUBROUTINE MID; CONSIDERS WHOLE VECTOR AS BEING WITHIN CELL IF ITS MIDPOINT FALLS IN THE CELL

GRID CELL NUMBER: ROW 5, COLUMN 3 (696684 <X< 707672; 4206999 <Y< 4220745)

AZIMUTHS	CLASS LENGTH (IN meters)		NUMERICAL FREQUENCY	
270.0-280.0	2718.00	>xx	3	>***
280.0-290.0	2496.00	>xx	5	>*****
290.0-300.0	6696.00	>xxxxxx	7	>*******
300.0-310.0	6037.00	>xxxxxx	6	>******
310.0-320.0	8624.00	>xxxxxxxx	6	>******
320.0-330.0	7542.00	>xxxxxxx	8	>********
330.0-340.0	4515.00	>xxxx	5	>*****
340.0-350.0	2667.00	>xx	4	>****
350.0-360.0	5345.00	>xxxxx	8	>********
0.0- 10.0	604.00	>	2	>**
10.0- 20.0	2462.00	>xx	3	>***
20.0- 30.0	722.00	>	1	>*
30.0- 40.0	6529.00	>xxxxxx	11	>**********
40.0- 50.0	3757.00	>xxx	5	>*****
50.0- 60.0	3074.00	>xxx	6	>******
60.0- 70.0	1765.00	>x	2	>**
70.0- 80.0	1233.00	>x	3	>***
80.0- 90.0	957.00	>	3	>***
TOTALS	67743.00	EACH X = 1000.00 meters	88	EACH * = 1 UNITS

Figure 1


COMPUTER-PROCESSED
DIAGRAMMATIC PLOT OF KARST LINEAMENTS
MAPPED IN CENTRAL KENTUCKY
By
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U.S. Geological Survey
Area of 56 7½-minute quadrangles
N
85°00'
84°00'
38°22.5'
38°00'
37°30'
10 0 10 MILES
10 0 10 KILOMETERS
SCALE
* Cell exemplified in histograms (Fig. 1)

Figure 2

Figure 3. Sample segment of Multics terminal session illustrating some of the described procedures. Arrows flag teletype input.

```
-->new_proc
-->io attach file41 vfile_ trfm.control
   go 1200.4
   go 1200.8
-->io attach file42 vfile_ trfm.print
   go 1201.2

-->trfm

   STOP

   fortran_io_:  Close files? -->yes
   go 1202.1

-->qx
__>r azmap.control
-->1,$p
   1186213561 5774724052741 779121433753410.  1.0-11111000.  1 meters 09011862135611082 0.0
   KYSTRUC,CENTRAL KENTUCKY,KARST LINEAMENT ANALYSIS, D.F.B. BLACK, BEEG
   (2i6,2f10.2,8f10.2/10f10.2)                                          2
-->1p
   1186213561 5774724052741 779121433753410.  1.0-11111000.  1 meters 09011862135611082 0.0

-->s/1186213561/8790597225/
-->s/5774724052741/6747084152015/
-->s/7791214337534/7652354251480/p

   8790597225 6747084152015 765235425148010.  1.0-11111000.  1 meters 09087905972251082 0.0
-->w
-->q
   go 1226.7
-->new_proc
-->io attach file05 vfile_ azmap.control
   go 1228.5
   go 1228.9
-->io attach file97 vvfile_ azmap.punch
   io call: Segment not found. vvfile_$vvfile_attach
   go 1229.8
-->io attach file97 vfile_ azmap.punch
   go 1230.4
-->io attach file06 vfile_ azmap.print
   go 1230.9

-->azmap.2

   STOP

   fortran_io_: Close files?-->yes
   go 1231.8

-->dprint azmap.print
   1 request signalled, 0 already in printer queue 3
   go 1236.8
-->dprint azmap.punch
   1 request signalled, 1 already in printer queue 3
   go 1237.2
-->logout
   DBlack BEEG logged out 12/07/79  1237.5 est Fri
```