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PRESENTED PAPER

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GENERATION OF SYMBOLS IN COMPUTER-AIDED MAP PRODUCTION

ABSTRACT

The purpose is to devise a way to generate symbols for the drafting stage of the map production. This is to be achieved in two steps.

I   Symbolization: Symbol models are digitized and this information is collected in a data base

II Drawing of a symbol on the map: The symbol is subjected to an affine transformation including a change of scale and orientation. The position is given by co-ordinates.

Symbols are coded by numbers chosen as to minimize the need for memory space. The symbol file is contiguous and consists of 500 symbols.

Synopsis

The purpose of this project is to establish a symbol generator
to draft cartographic symbols in the computerized production
of maps.

The generation of symbols shall be accomplished in two stages:

I   Storage of Symbol Data

The co-ordinates of a symbol are entered by digitizing and
transformed to a symbol co-ordinate system. Included are also
data concerning pen information, circle information, etc. This
information is binary coded and stored in a contiguous symbol
file. The system assigns an appropriate number for the symbol.

II   Drafting a Symbol on a Map

The final form of a symbol is determined at the drafting stage
by applying an affine transformation to change the scale and
orientation of the basic model according to requirements.

By assigning any controlled number of objects to each data
block, the symbol data may be retrieved by one access. The sym-
bol file holds 500 symbols.

1 INTRODUCTION

Developments in computer technology have paved the way for effi-
cient collection, storage, processing and presentation of carto-
graphic data, all of which have resulted in extensive hardware
and development costs. For this reason, a gradual transition to
numerical control is envisaged.

In Sweden, computer-aided map production systems are under de-
velopment by the Royal Institute of Technology, the Department
of Photogrammetry, the National Land Survey of Sweden, the
Swedish Road Administration and VIAK AB, consulting engineers.

2 EQUIPMENT FOR COMPUTER-AIDED MAP PRODUCTION

The manufacture of computers, digitizing instruments and plot-
ting equipment continues to expand and there are at present
numerous makes available on the market.

2.1 Digitizing

For purposes of numerically controlled plotting, it is essential
to know the co-ordinates for the points which are to be mapped.
Co-ordinates may be determined by geodetic methods, photogram-
metry or by digitizing available material (drawings, basic maps,
etc).

In the latter case, digitizing equipment consists of a digiti-
zing table and a reference body. Most electronic digitizing
tables consist of an orthogonal raster connected to an electro-
nics unit.

The reference body, normally in the form of a magnifying glass or wand, contains a coil through which pulses are sent. In other types of digitizing tables, plot positions are obtained by linear or rotating generators on a grid (co-ordinatograph with two axes) or with angle generators and fixes using the polar method. The electronics unit uses these pulses to record the position of the reference body. The reference body is equipped with buttons which may be assigned varying significance according to the object being digitized.

2.2 Computer Equipment

Minicomputers are often used as process computers in capture and display equipment. The central processor is often somewhat larger to provide the capacity required. Furthermore, there should be display terminal linkage capability to monitor program steps.

2.3 Drafting Equipment

Basically, a drafting system consists of three main components: Control computer, wave generator and drawing table. Drafting information is normally input from punch tape, punch cards or magnetic tape. The drafting equipment may also be on-line to the computer for direct information interface without intermediate storage.

Maps are produced on various types of paper or plastic. Drafting equipment may be equipped with different types of drawing devices for different purposes. In normal circumstances, ink, lead pencils, ball points or engraving tools are used, but printing and photographic heads are encountered.

3 SYMBOL GENERATION

3.1 Purpose

Computer-aided map production involves the drawing of cartographic symbols. The preferred method is through program software. The following goals were established for the project:

- A symbol generator shall increase the variation capability of the final shape and content of the map

- Symbol generation shall take place in two stages:

    I   Storage of symbol data.

         A symbol is defined through its origo in a free symbol co-ordinate system

    II   Drafting a symbol on the map.

         Computation of scale factor, table co-ordinates, symbol height and rotation required to achieve a full description of the appearance and location of the symbol on the map

- Minimum number of accesses
- The symbols are coded by a number assigned by the system.

This will ensure optimum storage utilization

- Functions for updating
- The operator shall use a graphic display to communicate with the system
- Fault conditions, if any, shall be reported to the operator during the execution run
- User-oriented.

3.2 Work Methodology

1 Identification of types of information required to furnish a full description of a symbol

2 Selection of preferred file type for storing symbol data

3 Limitation of symbol extent in X and Y

4 Programming in FORTRAN for symbol generation

5 Drafting of map symbols on suitable digitizing equipment

6 Digitizing of symbol plots

7 Drafting symbol on graphic display

8 Storage of symbol data

9 Symbol is assigned a free number by the system

10 Decoding of symbol file.

3.3 Equipment

An ARISTOGRID 100 digitizing equipment with a table area of 120 x 150 cm is used to enter co-ordinates for the symbol plots.

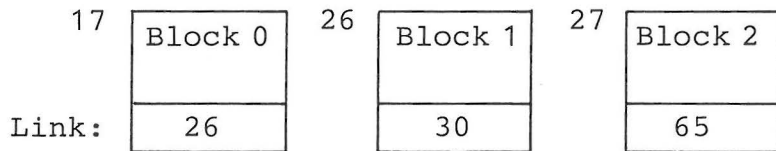A NOVA 3/D miniprocessor is used for computer work.

The operator is able to follow the digitizing process from a TEKTRONIX 4014 graphic display connected to the digitizing table via NOVA 3/D. Physical copies of the display picture may be obtained from a hard copy unit connected to the video display. A Kongsberg DM 1215 will be used to draw the symbols. The drafting process will take place off-line via punch tape.

4 SYMBOL STORAGE

A file may be described as an organized collection of records. The computer files to be used here will be stored on disc and three types of files may be used.

1 Sequential files

2 Random files (direct access files)

3 Contiguous files.

4.1 Sequential Files

```
    17  ┌─────────┐  26  ┌─────────┐  27  ┌─────────┐
        │ Block 0 │      │ Block 1 │      │ Block 2 │
        ├─────────┤      ├─────────┤      ├─────────┤
Link:   │   26    │      │   30    │      │   65    │
        └─────────┘      └─────────┘      └─────────┘
```

Characteristics:

- contains 255 or 254 words/block
- the last block in each word is used to state the address for the next block
- permits only sequential processing
- files increase in size as information in store grows
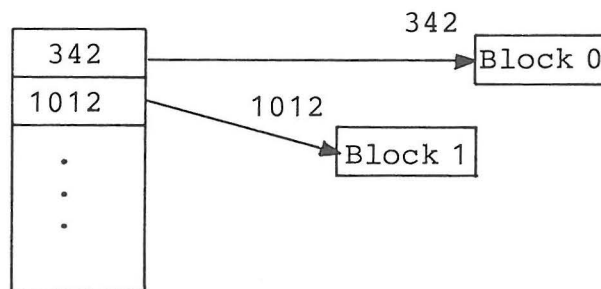- may not be used for non-buffered read/write.

4.2 Contiguous Files

```
┌─────────┬─────────┬─────────┐
│ Block 0 │ Block 1 │ Block 2 │
│         │         │         │
└─────────┴─────────┴─────────┘
```
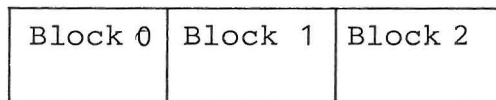
Characteristics:

- 256 words per data block (512 bytes)
- blocks have sequential addresses
- used for sequential or direct access processing
- file size is determined on creation
- used for buffered and non-buffered reading/writing.

4.3 Direct Access (Random) Files

```
                              342
        ┌──────────┐               ┌─────────┐
        │   342    │──────────────▶│ Block 0 │
        ├──────────┤               └─────────┘
        │   1012   │─┐   1012
        ├──────────┤  │   ┌─────────┐
        │    .     │  └──▶│ Block 1 │
        │    .     │      └─────────┘
        │    .     │
        │          │
        └──────────┘
         Index blocks
```

Characteristics:
- 256 words (512 bytes) per data block
- index block(s) contains record addresses
- 255 or 127 addresses per index block
- index blocks constitute a small sequential file
- used for sequential or direct access processing
- variable size

- may be used for buffered and non-buffered reading/writing.

4.4 Pros and Cons of the Different File Types

Characteristics / File type	Access	Variable size
Sequential	-	+
Random	+	+
Contiguous	+	-

I have chosen the contiguous type symbol file. Each block is accessed in sequence and items are linked by a pointer.

5 DESCRIPTION OF METHODOLOGY

5.1 Choice of Information Types

The description of a symbol will require information on:

- The origo of the symbol, or the point in the symbol which will serve as a reference point when drafting

- Orientation: The final form of a symbol is determined at the drafting stage by using affine transformation to change the scale and orientation of the basic model according to requirements

- Information for the formation of an arc.

  A semi-circle is indicated by quoting the co-ordinates for the start and end points. The end point contains a pointer which assumes the value 1 if the symbol is a circle and in all other cases the value 0. If the value 1 is given, it will be found in the X and Y from the starting point of the arc to its centre. The right-hand arc (clockwise rotation) assumes the value 1 and the left-hand arc the value 0

- A signal indicating that symbol information is at an end. If a symbol has been fully described, the signal will be 0, if not, 1.

5.2 Basic Model

By creating a free symbol co-ordinate system and limiting its extent in X and Y to -31 l.u. (length units) and +31 l.u. all symbols will be as far as possible, integral units.
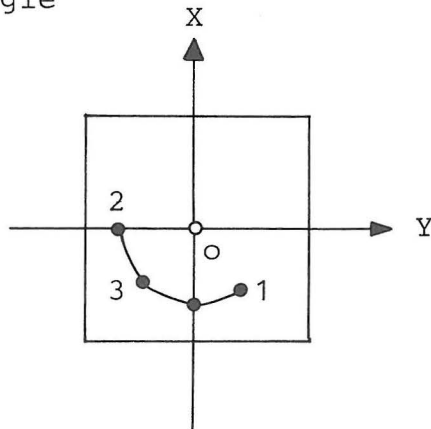
Figures 5:1 and 5:2 show what typical information for different types of symbols can look like.

- symbol plot
- o origo
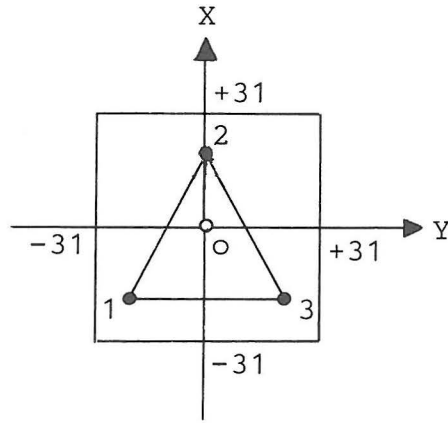
Plot No	X	Y	Pen info	Pointer info	Signal info
1	X	Y	0	0	1
2	X	Y	1	0	1
3	X	Y	1	0	1
1	X	Y	1	0	1
0	X	Y	0	0	0

Figure 5:1 Triangle

Plot No	X	Y	Pencil info	Pointer info	Signal info
1	X	Y	0	0	1
2	X	Y	1	1	1
3	DX	DY	0	0	1
0	X	Y	0	0	0

Figure 5:2 Arc

5.3 Co-Ordinate Plotting

Symbols destined for store are drawn with a predetermined shape
on suitable digitizing equipment. The keys on the cursor key-
board have been assigned different pen functions when digitizing
the different symbol plots.

5.4 Helmert Transformation

Four corner plots are transformed to a symbol system if their
board co-ordinates are recorded and their co-ordinates in the
symbol co-ordinate system are known. In this case, the X and Y

300.

co-ordinates are oriented in the same direction in both systems and the following equation will apply:

$$XG = (XB-XB_O) \cdot m \cdot \cos\alpha + (YB-YB_O) \cdot m \cdot \sin\alpha$$

$$YG = (YB-YB_O) \cdot m \cdot \cos\alpha - (XB-XB_O) \cdot m \cdot \sin\alpha$$

m is the scale factor by which the board co-ordinates should be multiplied to achieve the same scale as the symbol co-ordinates.

If $A = m \cdot \cos\alpha$ and

$B = m \cdot \sin\alpha$, the equations may be written as follows:

$$XG = XO + A \cdot XB + B \cdot XB$$

$$YG = YO + A \cdot YB + B \cdot XB$$

$$m^2 = A^2 + B^2$$

$$\alpha = \arctan B/A$$

A, B   transformation parameters
XG, YG   co-ordinates in symbol co-ordinate system
XB, YB   co-ordinates in the table co-ordinate system
XB_O, YB_O position of the symbol co-ordinate system origo in
              the table co-ordinate system
α positive   rotation   from XG to XB direction
m   scale factor.

If XO = YO = 0 (zero point suppression) the equation may be written as

$$XG = A \cdot XB + B \cdot YB$$

$$YG = A \cdot YB - B \cdot XB$$

After some calculation,the unknown transformation parameters A and B can be resolved as

$$A = (\Sigma \, XB \cdot XG + \Sigma \, YB \cdot YB)/(\Sigma \, XB^2 + \Sigma \, YB^2)$$

$$B = (\Sigma \, YB \cdot XG + \Sigma \, XB \cdot YG)/(\Sigma \, XB^2 + \Sigma \, YB^2)$$

5.5 Fault Status Control

When a symbol has been recorded, it is presented for checking on the TEKTRONIX 4014 graphic video display. The operator is given the interactive possibility of determining whether the symbol shall be approved and stored or rerecorded.
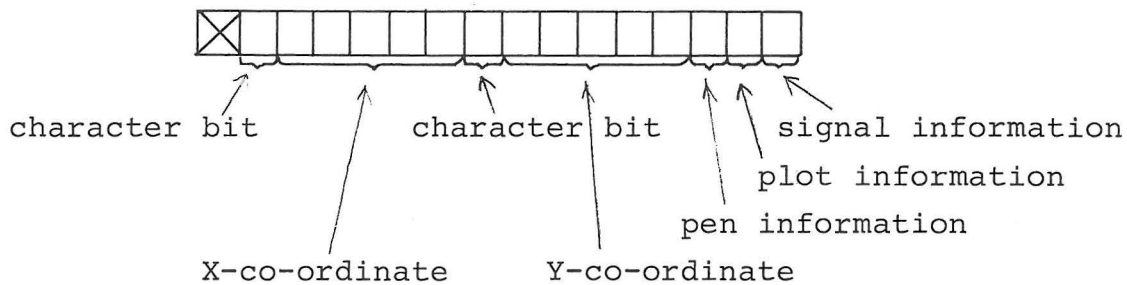
5.6 Coding Symbol Data

When an operator has decided to approve a symbol, it will be stored in processor memory and coded with number selected by the system. The symbol file is of contiguous type and the contents of each data block is limited to a maximum of 20 symbols. Each block consists of 256 words, or 512 bytes. The first 20 words in a block contain a pointer to the word in which the first plot of the symbol is stored. Symbol data are always in one and the same block. Sequential search for unoccupied storage is done. The initial search is to determine whether a block is "full", that is to say contains 20 symbols. Unless this is the case, a test
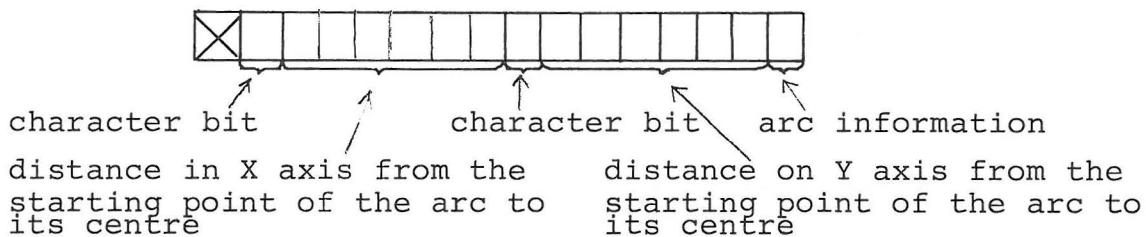
is conducted to see whether all symbol plots can be accommodated in one and the same block. The search will continue to the next block in the absence of sufficient storage space and so on.

The information on a symbol plot consists of two bytes. A division is made as follows for binary coding.

a   plot object

character bit   character bit   signal information
                                          plot information
                                          pen information

X-co-ordinate   Y-co-ordinate

b   circle object

character bit   character bit   arc information

distance in X axis from the   distance on Y axis from the
starting point of the arc to   starting point of the arc to
its centre   its centre

5.7 Decoding Symbol File

By assigning a fixed number of symbols to each block, it is possible to calculate the block in which the required symbol is located when decoding the file.

When data for a symbol have been retrieved from a block and a new symbol is required, a search is first conducted to see if the symbol is in the same block before a new block is read in to the system from the symbol file.

6 LIMITATIONS

This solution involves certain limitations. The contiguous file contains 500 symbols. Furthermore, a symbol may consist of a maximum of 20 plots.

The operator is unable to determine the symbol number. By permitting the system to assign a suitable symbol number, the method ensures an efficient utilization of memory capacity.

The capability of contiguous storing of symbols with a known high frequency is only possible by creating new symbol files. This may be desirable to achieve faster drawing on a CRT (Cathode Ray Tube).