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CODEDT: A program for editing digitized coordinates

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In the broadest use of the term, digitizing encompasses almost any conversion of analog information to discrete digital form. This discussion is directed at a particular kind of digitizing, the encoding of X,Y coordinates in machine-readable form from photographs, images, graphs, maps, and other plane representations. Digitized X,Y coordinates are commonly used, and, at first, digitizing may seem to be a very simple task, particularly when done with one of the numerous commercial electronic devices (Orr, 1978, Table 2, pp. 66-69). However, it is clear that there are many desirable adjustments before the coordinates are suitable for use in an application program. These adjustments may involve scaling, translation (stepping in the X or Y direction), reformatting, test plotting, and operations to correct for digitizing-induced errors. These operations may be variously described as editing or validating, and these are the operations CODEDT performs. More complex operations, such as detecting subtle errors or matching and merging with existing data bases, are not considered here, since they are usually unique to the specific application.

Many programs exist to do some or all of these things, but we are unaware of any that are essentially hardware independent and available for general distribution at little or no cost. These are important features. Most readers do not have access to the more sophisticated and specialized digitizing hardware that has recently become available (Hunka, 1978; Tolson, 1978). CODEDT is particularly suitable for applications that are not integrated with dedicated hardware systems (Santi, Fryhofer, & Hansen, 1980). These may include, besides conventional mapping, the recording of eye movements, picture analysis (16-mm film or cell photomicrographs), or analysis of oscilloscope traces that have been photographed (Revlin & Rayner, 1979, p. 164). CODEDT, an acronym for "coordinate editing," is reasonably close to the ANSI 1966 FORTRAN standard. Points of departure are clearly identified, with suggestions for equivalent constructions or code. The program is about 3,300 lines of FORTRAN source code, but approximately two-thirds of that derives from extensive use of a modular subroutine structure, with numerous labeled COMMON blocks and inclusion of copious comments.

Program Characteristics. CODEDT is designed primarily for interactive use at a terminal, to be "user friendly," but it can be run as a batch job. The command syntax is somewhat like that of the MINITAB or OMNITAB statistical packages. Each command is recognized as a key word that must begin a line or record, followed by the appropriate arguments in free format on the remainder of the line or record. The commands may be entered in any order and may be changed at will, until the execution command is given. It is not difficult to add more commands, if desired, since extensive program comments identify important variables.

CODEDT can accept virtually any kind of coordinates as input. However, several features are included that provide special processing of the coordinates produced by the publicly available digitizer at our installation, a Summagraphics Series ID-2. With other brands of digitizers, these features can be ignored, modified to provide similar special processing for that equipment, or removed from the program. These features are independent of the actual mechanical or electronic process by which the digitizer determines locations (e.g., by strain waves, acoustics, or whatever). They are dependent on the format of the coordinates produced. Our digitizer is set to produce coordinates in the form: @dsnnnnnsnnnnn<cr–lf>, where "@d" represents a delimiter that precedes each coordinate pair and consists of the @ and a single digit in the range of 1-8; where

Table 1
Available Commands

CANCEL [option] [ALL]
COMMANDS [ ]
DEFER [ ]
DELIMITER [delimiter]
DUPLICATE [tolerance]
END [ ]
EXIT [ ]
GO [ ]
HELP [ ]
INFILE [filenm.ext]
INFORMAT [(format)]
NEWS [ ]
ORIGIN [x,y]
OUTFILE [filenm.ext]
OUTFORMAT [(format)]
PENMODE [up]
PLOT [CONTINUOUS] [DISCRETE]
PSCALE [scale]
PXOFFSET [offset]
PYOFFSET [offset]
QUIT [ ]
ROTATE [degrees]
SCALE [scale]
STATUS [ ]
STOP [ ]
SUMMAGRAPH [ ]
SUPPRESS [ ]
SWITCH [ ]
TITLE [title]
XOFFSET [offset]
YOFFSET [offset]

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"snnnnn" represents a five-digit coordinate preceded by a plus or minus sign, first the X-coordinate, and then the Y-coordinate (we ordinarily record in thousandths of inches, but the system can record in centimeters); and where "<cr–lf>" is a carriage return and line feed that mark the end of a record on our system. The delimiter is useful in separating the coordinates from preceding

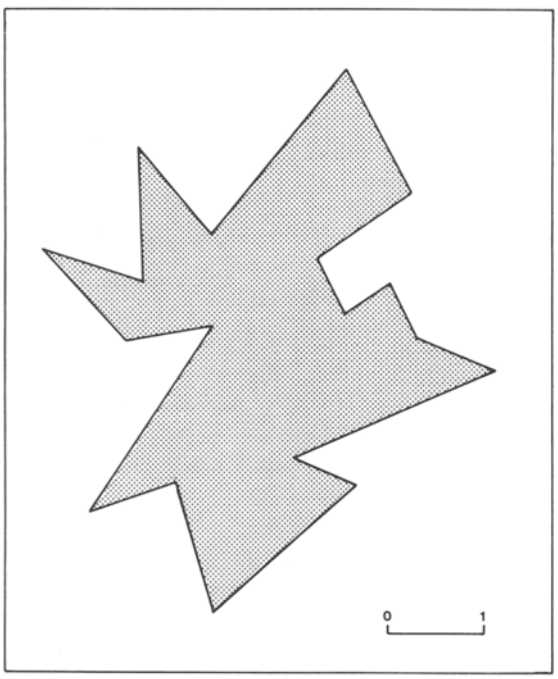

Figure 1. Polygon to illustrate the digitizing process.

```
ORIGIN@1+00000+00000
SCALE LEFT@1+04005+00380
SCALE RIGHT@1+05010+00365
BORDER BEGIN@1-00010+00020
@1+00030+06910
@1+05765+06865
@1+05720-00050
BORDER END@1-00005+00015
BEGIN LOWEST CLOCKWISE@1+02185+00630
@1+01795+01960
@1+00880+01685
@1+02185+03590
@1+01285+03440
@1+00410+04405
@1+01465+04060
@1+01420+05450
@1+02185+04555
@1+03600+06260
@1+04275+04980
@1+03295+04305
@1+03580+03730
@1+04050+04025
@1+04320+03470
@1+05140+03115
@1+03045+02235
@1+03680+01925
END LOWEST CLOCKWISE@1+02180+00630
ORIGIN@1-00005+00015
```

Figure 2. File "DIG.IN," read by CODEDT.

```
CODEDT VERSION 4 (06-JUN-79)

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TYPE HELP FOR HELP

*TITLE CODEDT DEMONSTRATION

*INFILE DIG.IN

*OUTFILE DIG.OUT

*DELIMITER @?

*PENMODE @4

*SUMMAGRAPH

*DEFER

*PLOT CONTINUOUS

*SCALE .001

*PXOFFSET .5

*PYOFFSET .5

*GO


OPTIONS IN EFFECT:

CODEDT DEMONSTRATION

OPTION      ARGUMENT(S)
--------------------------------------------------------------------------------
DEFER
DELIMITER       @?
INFILE          DIG.IN
OUTFILE         DIG.OUT
PLOT            CONTINUOUS
PENMODE         @4

PXOFFSET                0.50000
PYOFFSET                0.50000
SCALE                   0.00100
SUMMAGRAPH
TITLE           (SEE ABOVE)


[NOW PROCESSING.]


PROCESSING SUMMARY:

FIRST POINT FOUND IN INPUT FILE: X=          0.00000 Y=          0.00000
LAST  POINT FOUND IN INPUT FILE: X=         -5.00000 Y=         15.00000
NUMBER OF INPUT ERRORS.........................        0
NUMBER OF RECORDS READ.........................       28
NUMBER OF POINTS PROCESSED.....................       28
NUMBER OF POINTS EXPECTED BUT NOT FOUND........        0
NUMBER OF RECORDS FOUND WITH NO DELIMITER......        0
NUMBER OF RECORDS WITH SHORTENED EXTRANEOUS INFO       0
NUMBER OF RECORDS ACTUALLY OUTPUT..............       28
NUMBER OF POINTS OUT OF PLOTTING RANGE.........        0

ROTATION IMPLIED BY SUMMAGRAPH OPTION (IN DEGREES, COUNTER CLOCKWISE):
  COMPUTED FROM FIRST POINT AND FIFTH POINT.....    0.24875
  COMPUTED FROM FIRST POINT AND SEVENTH POINT...    0.50082
  AMOUNT ACTUALLY ROTATED (AVERAGE OF ABOVE)....    0.37479

*QUIT
```

Figure 3. CODEDT processing dialog.

text and in representing changes in pen mode. An "@2" can be used for pen up and an "@1" for pen down. This also allows direct keyboard entry of entire lines of identifying text. If an auxilliary menu is used in digitizing, menu items will be treated like all other coordinates (see Davis, 1978, or Hewitt, 1978, on the use of a menu).

Command Structure. Table 1 contains a list of the available CODEDT commands, in alphabetic order. The allowed arguments are shown in square brackets on the same line with the command name; if the command does not take arguments, empty brackets are shown. Most of the commands merely set options and are not really "action" commands.

Of particular note are the commands that allow for test plotting of the digitized material. These include PSCALE, PXOFFSET, PYOFFSET, and PENMODE. The program manual describes the options that take precedence over or preclude others.

Example. To illustrate the use of CODEDT, the processing for a simple example follows. The object for digitizing is an irregular polygon contained in a border, with a scale bar (Figure 1). It was digitized on-line to our central computer by starting a general file-building program (SOS on the DECsystem-10) to accept the output from the digitizer. Phrases were typed at various junctures in the digitizing, to form an explicit record of what was done. The contents of this input file are shown in Figure 2.

The processing dialog shown in Figure 3 was used to convert the coordinates to the desired form. Note that the SUMMAGRAPH option was used and that a test plot was requested. The resulting output file is shown in Figure 4. The output coordinates could be used in an application program, or as input, again, for further processing by CODEDT.

Implementation Considerations. There are several parts of the program likely to require attention in a new implementation. These can be categorized as language extensions or deviations, plot subroutines, and assembly language subroutines. The language extensions are as follows: OPEN and CLOSE statements for files, END= parameter in READ statements, REREAD statement, ENCODE statement to pack an array, and the use of A5s instead of A4s for alphanumerics. All points at which these occur (except for A5s) are marked in the code with special comments beginning "C DEC-10***". The plotting subroutines used are the basic CalComp type, namely: "PLOTS" to initialize the plotter, "PLOT" for point to point plotting, "SYMBOL" for annotation, "WHERE" to return present pen position, and "NEWPEN" to change pens. There should be little trouble adapting these routines. Of course, there is no necessity to plot the points, but it is a very useful option in practice.

Two small assembly language subroutines named BTCHJB and WHRLOC are used. BTCHJB determines whether the program user is indeed on a terminal or running batch; this is done "automatically" from a user's perspective. If this option is impractical on another machine, it is merely necessary to disable or dummy out BTCHJB and set the input/output units accordingly. The WHRLOC routine determines where the user is "located" for purposes of routing output. This prevents the user's trying to queue test plots to a destination that has no plotter. WHRLOC allows the user to exit from the program, reset the destination, and reenter the program where processing left off. If the program is run on a batch-only machine, this routine is best dummied out.

```
 0.00000         0.00000 ORIGIN@1
 4.00243         0.40619 SCALE LEFT@1
 5.00751         0.39776 SCALE RIGHT@1
-0.01013         0.01993 BORDER BEGIN@1
-0.01520         6.91005 @1
 5.71997         6.90256 @1
 5.72020        -0.01258 @1
-0.00510         0.01497 BORDER END@1
 2.18083         0.64428 BEGIN LOWEST CLOCKWISE@1
 1.78214         1.97170 @1
 0.86896         1.69072 @1
 2.16147         3.60422 @1
 1.26247         3.44833 @1
 0.38118         4.40759 @1
 1.43841         4.06950 @1
 1.38432         5.45917 @1
 2.15516         4.56920 @1
 3.55897         6.28341 @1
 4.24233         5.00786 @1
 3.26677         4.32646 @1
 3.55552         3.75334 @1
 4.02358         4.05141 @1
 4.29721         3.49818 @1
 5.11951         3.14856 @1
 3.03032         2.25487 @1
 3.66733         1.94903 @1
 2.17583         0.64425 END LOWEST CLOCKWISE@1
-0.00510         0.01497 ORIGIN@1
```

Figure 4. File "DIG.OUT," output by CODEDT.

Availability. A source tape and manual will be sent on request, at cost of copying and mailing. Write to the senior author.

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