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Computerized Isodensity Mapping

A scheme is devised to produce "contour" lines which represent equal photographic density.

Introduction

The delineation of contours (isolines of density, height, or other suitable data) greatly enhances two-dimensional displays of three-dimensional data matrices[1] (e.g., hydrographic charts utilizing contour lines to indicate depth and gradient information). The quantitative measurement of density variations in a photograph, as a function of position on the film, can reveal details which may not be visible to the eye, even under magnification. This is due to the integrating behavior of the eye, and to the eye's inability to discern minute tonal changes in a very dense region of a photographic image. The display of X, Y, and density information in the form of visual representation, and often enables one to observe these subtle tonal changes.

Abstract: *This paper presents a new concept in the display and enhancement of quantitative density or height information recorded from selected areas of photographic imagery. This represents an improvement over established procedures in density data display. Any three dimensional data system (in digital form) may be displayed through the use of a computer-aided symbol selection, and an associated cathode ray xy-plotter. With only minor modifications, the program can become a search and display mechanism for any given density, brightness, height or other digital value. The program gives rise to the displaying of and area computations of unknown and irregularly shaped data systems. This is accomplished through the search of the data matrix for a preselected data value of set contraints.*

Background

Prior to this date, one available means to achieve this isodensity tracing was by the use of a Joyce-Loebl microdensitometer coupled with National Instruments Laboratory's (NIL) Isodensitracer. The unique aspect of the resultant isodensity map was the possibility of determining the relative density displayed bands of dots, dashes (lines), and blank spaces. Figure 1 shows a typical isodensity tracing prepared with the NIL Isodensitracer/microdensitometer combination. Through the use of various gray wedges, apertures, and commutators, it can produce an unlimited number of isodensity tracings (if infinite time were available for the scanning and rescanning of the specimen). The run time for a typical 8×10-inch output size may approximate five hours and, in practice, to achieve the optimum usable pattern, three or more such isodensity tracings are frequently required. Thus, two days of instrument usage may be required to obtain the best pattern representation. Prime disadvantages of the NIL Isodensitracer are the limited size of the display due to the output table size (8×10 inches), and extreme difficulties encountered in attempting to mosaic these instrument isodensitracings. The mosiacking difficulties are due to the balanced-pen method of relative density measurements that the Joyce-Loebl microdensitometer uses. Upon interruption of this balanced mode the instrument will create a mode change. For example, the dots will be replaced by the dashes or spaces, which can occur whenever the microdensitometer is turned off, the light source burns out, or due to uncontrollable system transients.

Procedures

In using the Joyce-Loebl Microdensitometer, a considerable amount of duplicated

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effort was being expended in correcting instrument variables and rescanning the specimen until the optimum pattern was achieved. In order that the maximum utility of the density mapping display be realized, a better method than cut-and try became necessary, and a larger display than 8″×10″ size was needed. Also, after delivery of the GAF Model 650/100 microdensitometer system, (which is incompatible with any existing isodensitracing attachment) it was desirable to have a density mapping capability for this instrument as well. The simplest and fastest solution to meet these requirements was a computer plotting program[2], which was also particularly desirable from the standpoint of time expenditure.

Within these contraints, a computer simulation density (or height) contour display program was developed. This program has proved to be an extremely versatile display mechanism which is unrestrained by matrix size or any physical limitations except specimen resolution. As an added advantage, various symbols are available to be used in the display. The number of plottable symbols has been increased from the dot, dash and space to encompass 51 different symbols, thus allowing the selection of virtually any desired symbol for a special purpose. In extreme instances of detrimetal signal-to-noise ratio, the use of five or more different symbols has proved to be valuable, as this decreases the frequency of symbol rollover and enables easier identification of density banding. High-noise instances may thus be made to yield more detailed information through more effective analysis of the deprived patterns. Five or more simulated apertures can be applied to five contour outputs during one computation submission, thus reducing the signal-to-noise ratio.

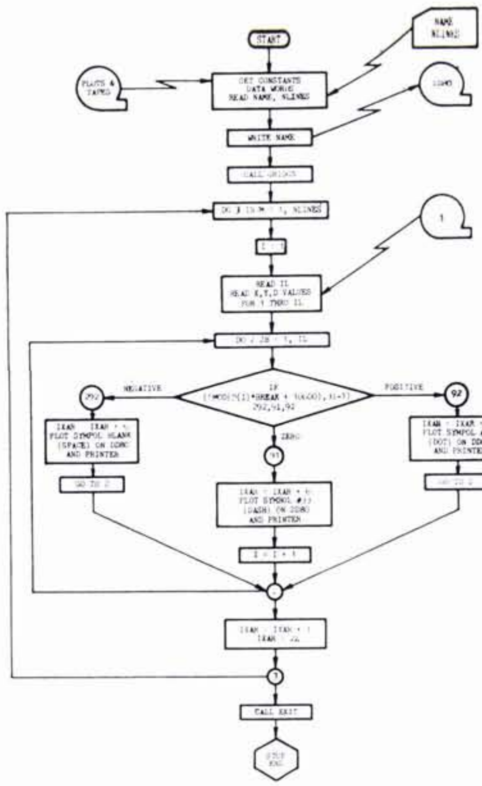

FIG. 2. Flow diagram of the computer plot routine.

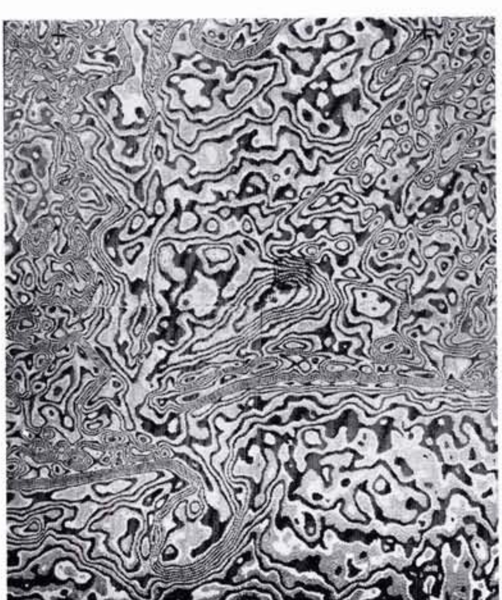

FIG. 1. A typical isodensity tracing prepared with the NIL Isodensitracer/microdensitometer combination.

The IDT program, as it has been named, provides for a point-by-point evaluation of the data and a corresponding point-by-point display of the computed symbol on the 35mm cathode ray x and y plotter.

THE IDT PROGRAM ANALYSIS

Program IDT, as described below for density (although other data could be contoured), reads from punched cards a title or name that has 13 six-character words, the number of scan lines to be processed, DINTVL (the density bandwidth interval at which the program is to change symbols), and NTROL (a flag to indicate the type of data tape the program will

FIG. 3. Unwanted high-frequency noise can be eliminated by using a broader density bandwidth. That on the left is with 0.5 units, and on the right 0.1.

expect to encounter.) The last input value was incorporated solely to accommodate the various tapes that were used in the schedule of evaluation and testing that was conducted on program IDT.

The IDT program executes in the following manner. From an input data tape, the program reads into memory one scan (line) of density data. These data are then tested point-by-point to determine the appropriate symbol for each point. This symbol is, in turn, plotted on a suitable xy-plotter (such as the DD80), and also on the on-line printer, until the entire scan has been processed. This allows a single parameter z to be coded and displayed, provided it was recorded or calculated in a three dimensional system, x, y, z, and the xy-relationship known. The program plotter output as it is currently in use handles data 240 lines by 240 points on a single 35mm frame. All data values in the input matrix that lie at greater values than $x=240$ or $y=240$ are written onto scratch tape, and the program, in a controlled sequence, steps through the remainder of the matrix until all points have been processed. Figure 2 shows a flow diagram of the IDT plot routine that was developed. The basis of symbol selection lies in the following Fortran V test statement:

```
(IF((MOD(IFIX(D(I) * BREAK + 1000000, 3)
                                    -1))))101, 102, 103
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by which the symbol assignment is determined. The above Fortran statement, expressed in algebraic terms, is:

1. $X=(D_n \times B+10{,}000)$
2. $W=X/3$ and the decimal part is truncated making W an integer
3. $Y=(X-W\times 3))$
4. $Z=(Y-1)$

where D is the input density value, B is the selected bandwidth interval, and n is the counter index.

IFIX is a function subprogram which converts D into an integer value after (step 1) multiplication and addition, by truncating the decimal part. The constant 10,000 is added to keep any value from being negative at this time.

The IF statement tests the computed values of Z for being negative, zero, or positive. These values are used to control the selection of the symbol plotted on the CRT plotter and the printer.

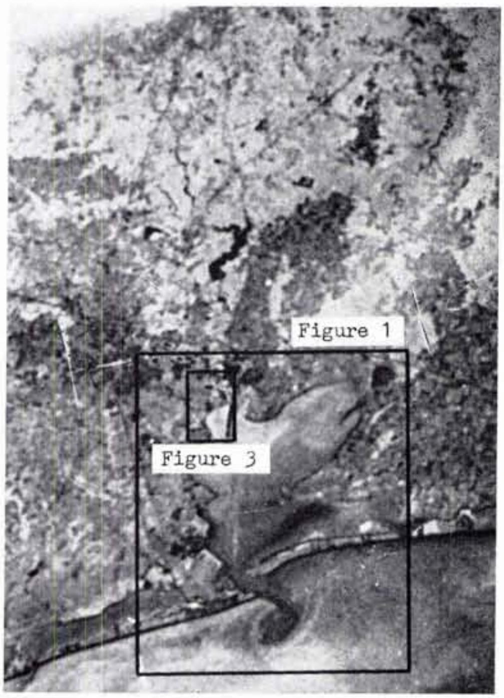

FIG. 4. Location photo for Figures 1 and 3.

Results

Figure 3 shows how unwanted high-frequency noise can be eliminated by using a broader density bandwidth. Both of these displays were generated during the same computer run. Comparable displays prepared on the Joyce-Loebl microsensitometer would have taken an experienced operator at least eight hours. Figure 4 is a "location" photo indicating the relative locations of Figures 1 and 3.

Acknowledgement

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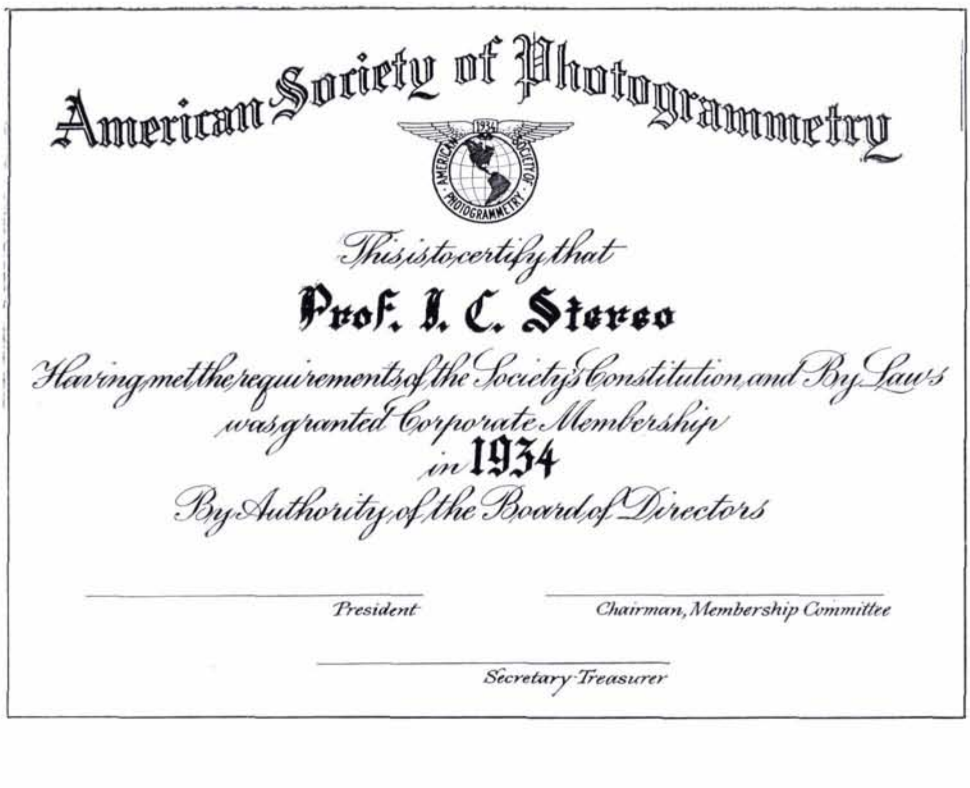
References

1. C. S. Miller, F. G. Parsons, and I. L. Kofsky, *Nature*, 202, 1196 (1964).
2. I. L. Kofsky, Reduction of Pictorial Data by Microdensitometry (paper presented at the Symposium on Aerospace Measurement Techniques held at Massachusetts Institute of Technology on 7–8 July) 1966.



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