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A PROCESS FOR PRODUCING TACTUALLY PERCEPTIBLE IMAGES OF LINE DRAWINGS FOR USE BY THE BLIND

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Abstract

A working prototype computer controlled process is described for automatically converting line drawings into raised line images perceptible to the touch. The process uses an automatic digitizer for input and a milling machine for output.

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Historical Background

The development of this process for producing tactually perceptible images from line drawings closely parallels that of "Computer Modulated Drawings" [1], the idea for which was conceived in spring 1973 while preparing material for slides presented at the National Computer Conference [2]. A visit to the Division for the Blind and Physically Handicapped, The Library of Congress, Washington, D.C. in February 1974 confirmed that a high speed device for creating raised line representations of drawings was of great importance for producing materials for educating the blind. I met with Richard H. Evenson, Special Assistant to the Chief, and other blind individuals who concurred that such materials are currently so difficult to prepare that blind children are simply not exposed to diverse visually oriented concepts which they are otherwise capable of comprehending by touch. As a result these children are needlessly denied exposure to a large segment of our culture which is readily available to sighted persons. It was pointed outto me for example that a blind child may conceive of a tree always being shaped as (say) an oak, for that was the only shape he was shown. It has been my experience that blind adults often lack the concept of the visual projection of three dimensional shapes onto two dimensional surfaces, again I believe through lack of experience, not lack of ability. I do not believe that tactile descriminating has sufficient resolution to allow sophisticated viewing by touch, but I do believe such perceptions can be tuned through diverse experiences to recognize a broader range of elementary shapes and figures.

The computer modulated drawing process was developed in spring 1974 and used in a computer graphics course taught at VPI&SU that quarter. It resulted in modulated plots and was extended to a numerically controlled Bridgeport milling

machine with the aid of Dr. Charles A. Stevens of the Virginia Tech Industrial Engineering and Operations Research Department.

The initial raised-line impressions were of a "Peanuts" cartoon by Charles Schultz with a plot representation of beaded rectangles. The spacing (0.05 inches) of these points proved to be too close and the paper was so perforated that it tore easily. The choice of subject material was also unfortunate for though the results were pleasing to the eye, they were too complex to be discerned by touch.

Further material was then automatically digitized by Broomall Industries and another attempt made using heavier paper and a point separation of 0.065 inches. The results, obtained Christmas Eve 1974 using Picasso's "Femme au Collier" were successful and were tried out on a blind individual, Dr. Virgil A. Cook of the Virginia Tech English Department. He was able to discern the facial features on the document but was confused by the hair ornamentation.

The prototype process is automatic but cumbersome. The output from the computer modulation step is punched cards which are then converted to the paper tape used by the milling machine. The commands for the machine are incremented positional steps in X and Y. The paper is impressed by a punching motion, the stroke length of which is controlled by a set screw.

The digitization of "Femme au Collier" was accomplished in roughly one minute on a Visicon Automatic Digitizing System [3] sampling at 100 points per inch. The resulting 7007 data points were then processed in 53 seconds by Graphic Collation and Computer Modulated Drawing software [4] on an IBM 370/158 digital computer with output to digital plotter and punched cards. The paper impression by the Bridgeport milling machine needed roughly 25 minutes for the 2419 dots which compose the drawing. The latter time can probably be reduced to one third if a solenoid driving force is employed rather than the current pneumatic one.

(It should be pointed out that milling machines are designed for totally different applications than this, and the times recorded were highly commendable under the circumstances.) The "Femme au Collier" drawing was also rendered onto lucite using drilled holes of 0.04 inch diameter--a process requiring about 50 minutes. The results are pleasing to the eye but are not easily discerned by touch.

Among the individuals contacted during the year concerning this project were:

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Considerable help was obtained from R. Eugene Dillon and Arnold H. Price of the Virginia Tech Mechanical Shop of the Industrial Engineering and Operations Research Department. Their knowledge and aid considerably increased the speed and enhanced the quality of transfer of information from the paper tape to the raised-line drawing produced on the milling machine.

The Process:

1. A hard-copy source document (map, electronic schematic, flowchart, drawing, diagram, etc.) is placed on an automatic digitizer (e.g. Visicon GC-3) and transduced into digital raster information designating the black and white areas on the drawing.

2. The resultant data is converted into a computer data base by the Visicon graphic collation software programming package (3) operating on a digital computer. This data base can provide a geometric as well as a topological description of the black areas (lines) on the drawing.

3. The data base is then used to derive an ordered sequence of (x,y, pencode) points which become commands to a paper imprinting mechanism acting in a manner similar to that of an incremental plotter (Broomall, Calcomp, Houston Instrument, Gerber, etc.). The parameter fields X and Y describe the cartesian coordinates of a point on a line, and the pencode specifies whether the new point is to be connected by a straight line with the last output point. The drawing is thus to be reconstituted by a series of straight line segments in a manner similar to that employed by currently standard incremental plotters (5). This raster-to-lineal conversion may employ line thinning techniques, a replot of the peripheries of black areas, or a combination of both. Computer modulated drawing techniques may be used to achieve an output in the form of center points of dots. The accompanying "Beaded" drawings are a visual representation of drawings converted to a raised dot form perceptible by touch. The spacing of these dots is controlled through modulation parameters.

The raised image on the paper is to be sensed by touch in a manner similar to that employed in detecting Braille. Such embossing of diagrams has been accomplished in the past using stereotyping machines (6), but the process has proven to be slow and expensive. The process described herein should prove to be rapid, reasonably expensive, with a considerable range in the acceptable quality of source documents. I have personally seen the use of computer flowcharts scribed by hand onto celluloid, and believe that comparable quality material could certainly be produced by automatic means.

The imprinting mechanism may be accomplished by a variety of mechanisms.

1. A scribing device may be driven in a manner similar to that of a plotter pen. The appropriate output medium for this may be a celluloid-like paper capable of accepting a crease. Resch (7)

has scribed paper for artistic effects, and his device may prove useful here. Ruby-lith scribes have been used for years in the preparation of integrated circuit masks (8).

2. A stamping mechanism may be employed by which paper is embossed by a hammer blow. It is logically (though not mechanically) immaterial whether the embossing stamp is moved relative to the paper or the paper is moved relative to the stamp.

3. A perforating mechanism is employed which represents lines by a series of pin pricks on paper.

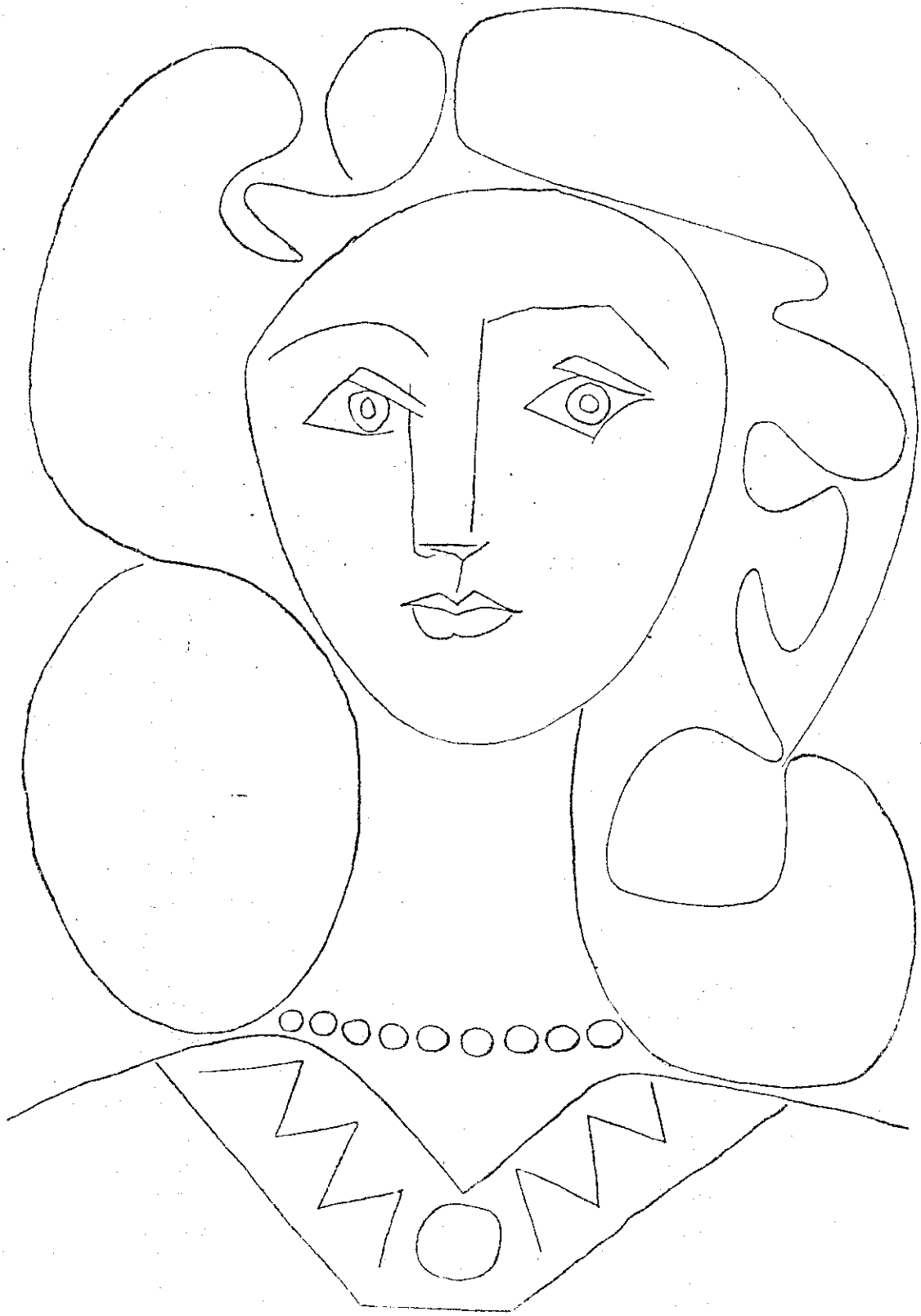
The particular method used to transfer the information to paper must be chosen relative to the tactile ability of a human to resolve the results. The research of James M. Gill (9) concerning the computer production of tactually discriminable symbols may be of use in this regard. The speed of data transfer will probably be similar to that of incremental plotters (2-7 inches per second).

The incorporation of the computer is a critical factor in the success of the process as it may perform useful transformations on the transduced image. For example, small documents or small symbols may be enlarged by performing simple mathematical linear transformations to the data points before they are plotted. Such enlargements may allow the tactile resolution of fine line structures not discernible otherwise. Moreover, similar transformations can be performed to facilitate the formation of mirror images required if documents are to be sensed from the raised side.

Of greater significance perhaps, is the fact that line information can be recoded by the computer so that it is more discernible to the touch. The incorporation of the topological (network descriptive) data into the algorithm may allow the enhancement or recoding of corners or places of line juncture if that proves to be of value. This information may also be used to remove noise from poor source material so that a document is produced which is of higher quality than the original. The accompanying Peanuts cartoon was produced from low quality newspaper print.

Currently, equipment does exist for tactually sensing documents. The Optacon device (10) manufactured by Telesensory Systems, Inc. of Palo Alto, California is an optical sensor which activates vibratory needles to be sensed by the fingers. It is reported to work well but its unit cost ($3450) is high for personal use. The unit cost (perhaps $35,000) for the proposed equipment would be higher but each unit would serve a large public. Analogously, individual Xerox machines ($8,000-$36,000) are expensive but costs of reproduction are low.

84. LA FEMME AU COLLIER



29 Mars 1947. Format 62 × 42.
Grand dessin à la plume sur zinc.
5 épreuves d'artiste. 50 épreuves numérotées et signées. Zinc effacé.

Figure 1 Photocopy of Source Drawing by Picasso

Figure 3 "Beaded" Reproduction of a cartoon by Charles Schultz. The source figure was on low quality comic book paper.

Figure 2 "Beaded" Reproduction of Figure 1.
Each rectangle represents a raised dot perceptible by touch.

References

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