An Effective Approach In Computerizing The Paper Engineering Drawings With Some Understanding Capabilities

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Introduction- In putting large amount of existing engineering drawings into computers, manual digitization or recreation is time comsuming and error-prone, this paper introduces a Drawing Processing System that transfers existing paper drawings, especially hand-drawn ones, into electronic information with some understanding capabilities, which then can be stored and processed by CAD systems easily.

THE DRAWING CONVERSION PROCESS :

To convert existing paper drawings into CAD suitable format, the following steps were designed for intellectively extracting the useful information within drawings and correctly reproduce original ones.

(1) DRAWING SCANNING :
The target drawing is scanned by optical scanner. The minimal scanner resolution need in drawing conversion is 200 dpi. The larger scanner resolution results in larger image data size, yet better quality. Image data may be either compressed for storage purpose, or interactively viewed/edited by the raster editor.

(2) DRAWING PROCESSING :
The drawing processing unit is designed to convert the the raster image data into CAD compatible graphic data. The text string will be extracted by T/I/G separator and automatically converted into ASCII strings by OCR software (OCR process will be further discussed later). Graphical information is extracted by raster-to-vector conversion software/hardware and converted to vector data.

(3) RECOGNITION :
The recognition process includes optical character recogniton (OCR), graphic primitive recognition and symbol recognition. Primitive recognition will recognize vector data into geometric entities such as lines, polylines , arcs and circles (this part will be further discussed later).

(4) RASTER/GRAPHICS EDITING :
The raster editor is designed to modify the raster image by erasing unwanted noise, adding/deleting additional information. A vector-to-raster operation is integrated into the raster editor in order to provide the capability of creating new geometric entities in raster mode.

(5) GRAPHIC STRUCTURING :
The structuring software is designed to correct the reproduced drawing with dimensional and geometric inconsistency. It associates the dimensional information with the correspondent geometry entities in order to produce a dimensional based drawing.

(6) FILE CONVERSION :
Currently, two popular standard graphic data exchange format are produced, one is the AutoCAD's DXF file format, another is the IGES file format which is an industrial standard data exchange format for engineering drawing.

UNDERSTANDING THE ENGINEERING DRAWINGS :

To extract the useful information out of the engineering drawings, some pattern recognition techniques are invoked. The raster based text strings are converted into meaningful ASCII strings, while the high level geometrical primitives are recognized out of the graphic portion of the vector data.

(1) The Optical Character Recognition(OCR) process :
The characters image are processed by a recognition system described as follows in Fig. 1.

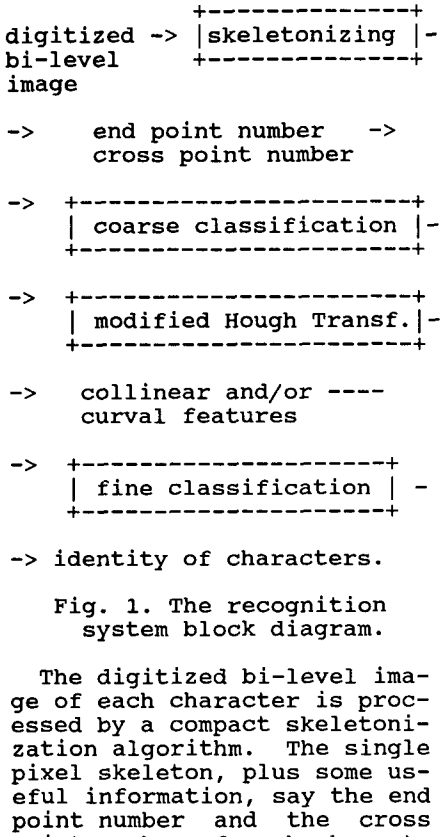

Fig. 1. The recognition system block diagram.

The digitized bi-level image of each character is processed by a compact skeletonization algorithm. The single pixel skeleton, plus some useful information, say the end point number and the cross point number of each character are derived. The OCR process uses those informaion for coarse classification, while the Modified Hough Transform is used for detecting the collinear and curval features out of the skeletons. When an unknown character is observed , its features are extracted, and then compared with the stored features created in the learning process. The recognition process reduces to " feature matching" when we classify the input character as belonging to a certain class with similar features.

The collinear features detection algorithm, as described in the following, is particularly attractive in the Engineering Drawings Processing at least for two reasons :

a. Still working when the drawings contain characters in a noisy background or characters contain lines composed of non-adjacent dark points.

b. In dealing with the rotated characters, it is still effective without elementary changes.

An algorithm in detecting collinear features based on Modified Hough Transform :

A coordinate system is defined on the 50*50 pixel matrix used to store the bi-level character image, the origin at the upper left corner, x increases to the right, y increases downward, rho and theta are defined as usual in the angle-radius parameterization of Hough Transform[1].

Step 1. For each dark point (x,y) in the skeleton, calculate the digitization of rho=x*cos(theta)+y*sin(theta) for theta = 0 to theta = 165 degrees with increment 15 degrees.

Step 2. For rho from -24 to 24 with increment 3, and theta from 0 to 165 degrees with increment 15 degrees, increment the weight for the corresponding (rho,theta) pair by 1 if it was previously calculated out in step 1.

Step 3. Sorting on all the weights of (rho,theta) pairs, those few from the heaviest indicate the best chosen collinear features of the character in that parameter space.

(2) The Geometrical Primitive Extraction Process :

Given the result of raster-to-vector conversion on the graphic portion of the Drawings, this process is designed to recognize the vector data into geometric entities such as lines, polylines, arcs and circles. The following functions are designed to achieve those purposes :

a. Vector Tracing : The vector data are traced for reconstructing the circular part of the graphics, if they are broken into subparts in the raster-to-vector process.

b. Template Matching : For the arcs and circles, the average centers and radii are calculated by first solving the center and radius out of any three selected points in the vector data, then get the average out of all those three points. The average center and radius are then served to form a template. We can set up a feasible region around the template, and count the ratio of points in vs. out of the feasible region, if the ratio is greater than an experimental value, the arc or circle is said to be recognized, otherwise rejected; for the recognized cases, the average centers & radii give a good numerical expression on the geometrical primitives extracted.

c. Segmentation :

For the rejected cases in Template Matching, the vector data need to be further segmented, the location of the segmentation points is derived by calculating the relative variation in the slope and clockwise/counterclockwise characteristics within vector data.

d. Orientation :

For the lines and polylines, the orientation characteristics should be checked and justified accordingly.

e. Composition :

The graphic portions need be recomposed at the final stage of geometrical primitive extraction process, so as to bridge the gap among the primitives.

After the above (1) & (2) steps, both the text and graphic meanings of the Engineering Drawings are ready for further use. They are essential for the useful tasks, say GRAPHIC STRUCTURING as described in the first part of this paper, and even the connection to NC machines.

Conclusion :

This paper introduces a Drawing Processing System for line art drawings, the original paper drawing is converted into the compact, CAD system suitable format. Some understanding capabilities are also included.

References :

[1]. A. Rosenfeld, Picture Processing By Computer. Academic Press, New York, 1969.

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