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AUTOMATIC RECOGNITION OF SCALES, GRIDS AND TABLES IN SCANNED MECHANICAL DRAWING

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ABSTRACT
Complete solution for advanced automated conversion from paper copy of mechanical drawing to electronic format is still missing.
In this paper the method for recognizing the elements scales, grids and tables from symbolic set of a mechanical drawing are discussed. It uses an automatic description of functional dependencies. Key words:Image recognition, mechanical drawing, scale, grid, table

INTRODUCTION

For the purposes of technical documentation are used electronic copy of plan the received by scanning the paper. The raster graphical formats of mechanical drawings contain defects and they are not appropriated for processing. It is necessary a transformation of the image as recognition elements of drawing and at the final result the presentation is received in vector format.

There exist many program products, which transform from raster to vector format but it is carried out with participation of operator. At the same time there is a lot of publication that contain great number of methods and algorithms for recognition of graphical image (Dimitrov J., 2001). They can be used as basis for receiving of hybrid decisions of task for recognition of elements of the mechanical drawing.

THE PURPOSE

To present in this paper an algorithm for processing of images of scales, grids and tables of scanned copy of mechanical drawing.

To discuss and realized an appropriated method for automatically recognition of this elements and analytical description of the functional dependencies that are given graphically with diagram.

METHOD FOR RECOGNITION OF SUCCESSION OF PARALLEL SEGMENTS OF LINES

The projection elements of mechanical drawing consist basically from segments of line and arcs of circle. Exclusions make diagrams that can express more complicated functional dependencies.

After contouring of given element of the image and description of contour with basic vectors with definite length, the image can be put to the following processing (Dimitrov J., 2002).

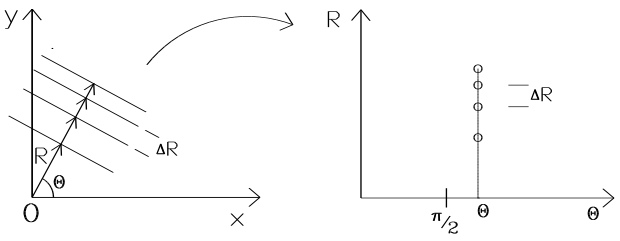

Figure 1: Succession of parallel segments of lines and their Hought transformation

We consider an element of the image consisted from alternatively parallel segments of line. Such configuration meets in the nets and in the tables, where are used two mutually orthogonal systems from such segments of lines. For the recognition we will use Hough transformation, such as this is madden in Dimitrov J., 2002. for stroked lines. The algorithm is added with determination of the functional dependence that describes the alteration of the distance ΔR between the parallel lines. The distance ΔR is accounted by secondary axis in (θ, R) space. A final result of recognition is the information in (θ, R) area complemented with analytical description of the dependence for ΔR, the as the method for its description is discussed bellow.

RECOGNITION OF THE SCALES, GRIDS AND TABLES

The basic part of these elements consists from segments of lines. The symbols and signs that are used have typical shape.

- They have not big parts of the contour with rectilinear form or form near to arc of circle.

- The length of the enveloped contour is small.
- The symbols are recognizing by OCR programs. So the basic part of element is separated as the symbols are recognized and them appropriate coordinates and associated with its destination.

In the case of the scale we have straight line that is presenting number axis and it is intersected by the stroke. This configuration is recognized as succession of parallel straight lines and together with recognized symbols of the sign includes the whole information lines and together with recognized characters of the sign includes the whole information.

On fig.2 is presented a logarithmic grid received after determination of the sign and its Hought transformation.

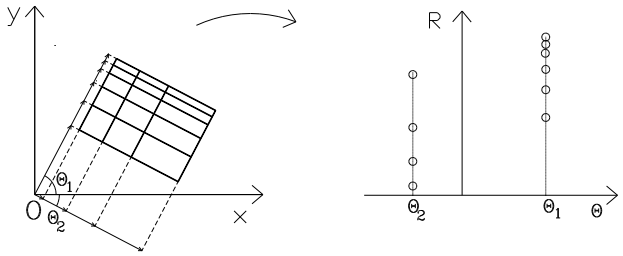

Figure 2: Logarithmic grid and its Hought transformation

APPROXIMATION OF THE FUNCTIONAL DEPENDENCE

The element scale, grid and diagram of mechanical drawing contain graphical description of dependencies, to which is necessary to give analytical expressions. There uses a transformation reducing

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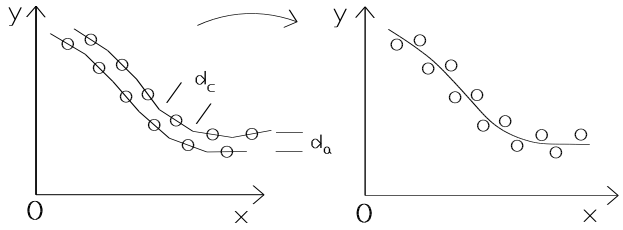


Figure 3: A Transformation that follows basic vectors to points and a approximation of dependence

the basis vectors from contour to points (fig.3).Two contrary contours of the graphic of dependence are processed for more exact presentation. Optimum speed of the processing receives with appropriate choice of the length of basic vector.

The received image of the drawing is approximated with functions given with parameters from sort

$$y = \sum_{k=0}^{n} a_k \varphi_k(x), \qquad (1)$$

as polynomial or another that are linear functions of the parameters. This procedure can be executed and with partial intervention of operator with introducing suitable structural description of the formula of the dependence and if is necessary to delete the drawing on parts for approximation every part individually.

The choice of appropriate formula for approximation and the precision of analytical presentation makes or from the operator, or automatically. The precision of graphic presentation ε of the dependence is restricted from the thickness of the image of the drawing d_a and from the length of basic vector d_c. Let

$$\Delta x_i = x_{i+1} - x_i \qquad (2)$$

are the differences for the chosen points for approximation and m is their number, then for the precision ε we have

$$\varepsilon \geq \frac{2}{d_a d_c} \sqrt{\sum_{i=1}^{m} \frac{\left(1/\Delta x_i\right)^2}{m}} \geq \frac{m d_a d_c}{2(b-a)}, \qquad (3)$$

Where $b-a$ is the length of the interval on the axis x where is performing approximation . After giving the accuracy of the approximation ε choices a most simple formula for approximation as it is possible so that

$$\min_{a_k} \frac{1}{m} \sum_{j=1}^{m} \left[\sum_{k=0}^{n} a_k \varphi_k(x_j) - y_j \right]^2 \leq \varepsilon^2. \quad (4)$$

As have in mind, that most frequently meted are the linear and logarithmic dependence. Than the recognizing must begin from them.

The procedure for recognition of dependence follows in next sequence:

- Recognition of linear dependence

Program module for analytical presentation at first attempts to determine linear dependence;

- Recognition of the logarithmic dependence

If in attempt for approximation with linear function the precision ε is overstepped then uses the change of the variables

$$\begin{aligned} x' &= \ln(x) \\ y' &= y \end{aligned} \qquad (3)$$

and verifies for linear dependence - verifies for dependence from sort:

$$y = C \cdot \ln(x) + D \qquad (4)$$

- Recognition of another dependencies

Can be envisage verification and for another functional links as $y = \frac{1}{x}$, $y = \sqrt{x}$, $y = x^2$ and another.

The possibility for automated testing for linear and logarithmic dependence can be used in description of the strokes of scales and lines in most often nets.

The transformation that is illustrated with fig.3 can be chosen and as that the middle of the basic vectors depicts in a properly selected parameter space and in it to perform approximation.

REALIZATION AND CONCLUSIONS

An experiment is performed with scanned paper-copy in 300dpi (fig.4, fig.5 and fig.6).

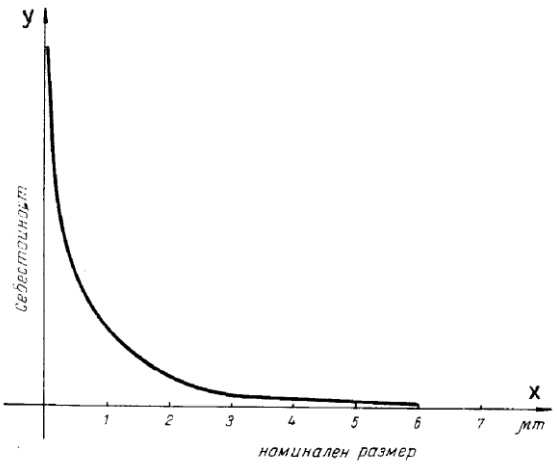


Figure 4: Scanned copy of diagram

There are realized the algorithms contouring, depicting of the contour with basic vectors, recognition of scales and succession of parallel segments of lines, separation of symbol and receiving formulas for analytical dependencies. As a result are received the dependencies $y = 1.1/x$ for the drawing on fig.4 and $C_{HO} = 2 - 0.41/(h-1)$, $C_a = 3.7h$ for fig.5. Is received and information for respective succession of parallel segments of lines and recognized symbols.

On fig.7 and fig.8 are depicted the results from making in vector format of the grid from fig.5 and the table from fig.6.

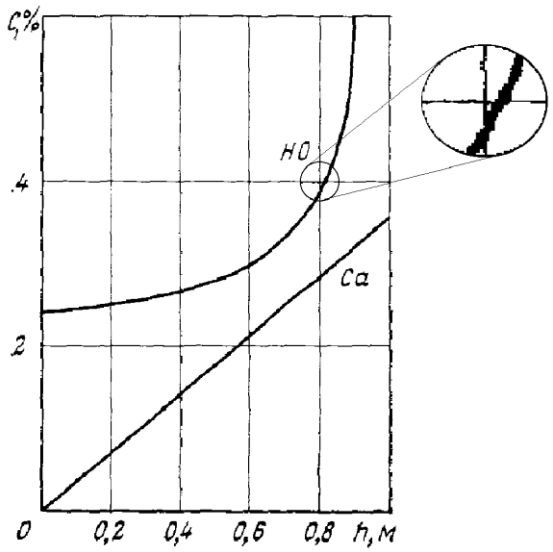
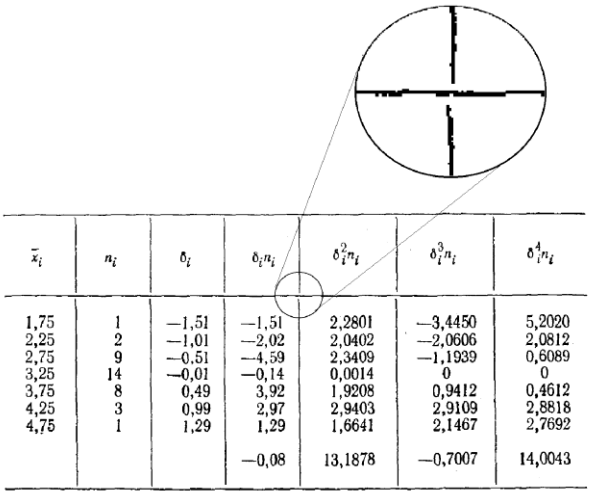


Figure 5:Copy of uniform grid with two diagrams



$\bar{x}_i$	n_i	δ_i	$\delta_i n_i$	$\delta_i^2 n_i$	$\delta_i^3 n_i$	$\delta_i^4 n_i$
1,75	1	—1,51	—1,51	2,2801	—3,4450	5,2020
2,25	2	—1,01	—2,02	2,0402	—2,0606	2,0812
2,75	9	—0,51	—4,59	2,3409	—1,1939	0,6089
3,25	14	—0,01	—0,14	0,0014	0	0
3,75	8	0,49	3,92	1,9208	0,9412	0,4612
4,25	3	0,99	2,97	2,9403	2,9109	2,8818
4,75	1	1,29	1,29	1,6641	2,1467	2,7692
			—0,08	13,1878	—0,7007	14,0043

Figure 6: Scanned copy of table

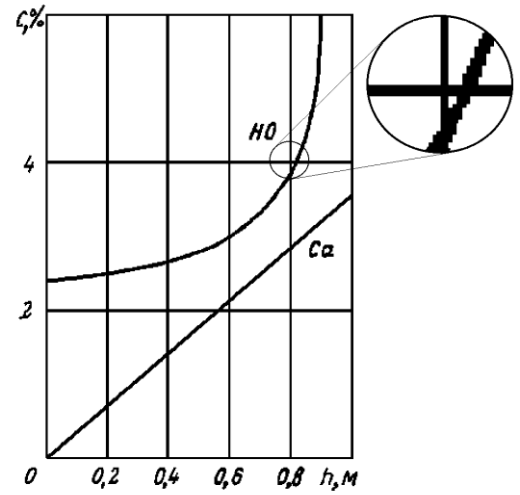
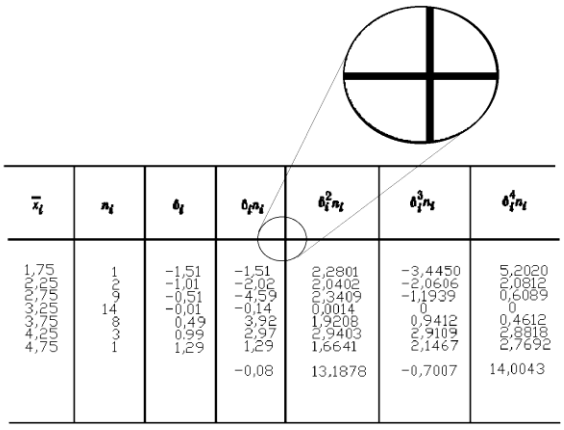


Figure 7: Copy of grid in vector format

The realized software product finds application as a part of a program for automatic recognition of mechanical drawing. It can be used and for receiving of formulas on given diagrams from publications with scientific purpose.



$\bar{x}_i$	n_i	δ_i	$\delta_i n_i$	$\delta_i^2 n_i$	$\delta_i^3 n_i$	$\delta_i^4 n_i$
1,75	1	-1,51	-1,51	2,2801	-3,4450	5,2020
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3,75	8	0,49	3,92	1,9208	0,9412	0,4612
4,25	3	0,99	2,97	2,9403	2,9109	2,8818
4,75	1	1,29	1,29	1,6641	2,1467	2,7692
			-0,08	13,1878	-0,7007	14,0043

Figure 8: Copy of table in vector format

The discussed method can be use for creating program for processing and another sorts of diagrams, tables and schemes in dependence of the area of application.

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