Annual of the University of Mining and Geology "St. Ivan Rilski"
vol.44-45, part III, Mechanization, electrification and automation in mines, Sofia, 2002, pp. 93-97

AUTOMATIC RECONSTRUCTION FROM SCANNED IMAGE OF MECHANICAL DRAWING IN AXONOMETRY

Julian Dimitrov

University of Mining and Geology
"St. Ivan Rilski"
Sofia 1700, Bulgaria

SUMMARY

Because of ambiguity presentation, the qualitative transformation from raster to vector format meets definite difficulties. In the well-known commercial program products for vectoring of technical images are used only some semantically characteristics of the mechanical drawings. This is realized thoroughly only in the reconstruction of the symmetrical forms of the image.

Here is discussed a method for machine recognition of segments (segments of lines and arcs of circles) and basic constructive elements (features) in scanned image of a mechanical detail in axonometry. Here are enunciated conditions for reconstruction of the image that are suitable for computing realization.

Key words: recognition, vectorization of mechanical drawing, reconstruction, raster image,

INTRODUCTION

The scanned image of mechanical drawing is a rasterized copy, what contains additionally deviation from original, by reason of mistakes of the copying system. The raster formats of the images are not suitable for the used methods for treatment and graphical work with the copies of the mechanical drawings. It is necessary a special transformation of the image, that is connected with recognition of drawings elements and in a result of this, receiving a definite semantic way of preserving and presenting of the graphical information.

There exist many publications that contain methods and algorithms for recognition for decides definite tasks but they are not adapted for mechanical drawings. The realization of a qualitative transformation from raster to vector format of an image meets with some difficulties. From one side this follows from dissimilarity of the ways for replacement of raster presentation with vector, but from another side from unsolved questions that are connected with context dependent of the elements of the image.

There are established many methods and algorithms for recognition. Each one of these algorithms performs a part of the processing and they follow to be combined for a full decision.

The image of a mechanical detail in axonometry is two - dimensional, but it is easily perceived as three - dimensional. The establishment of the exact shape and position of one object and building the it's orthogonal projection on given it's image in axonometry and some necessary data is called reconstruction. The necessary data and restrictions for of the discussed objects are the conditions for reconstruction.

For the effective recognition of segments and arcs of circles in the image and for maximal approach to two - dimensional vector presentation is necessary to perform and reconstruction that includes:

- Determination of the technological features, that are basic geometrical bodies, constituting the object and concomitant with them simple geometrical figures;
- Building the orthogonal projection with additional denotations for the technological indications of the object;
- Semantically recognition of segments and arcs of circles in the context of the definite technological features.

THE PURPOSE

To present a method for recognition of a lines and arcs in axonometric drawing of detail. It automatic reconstruction on properties restrictions on complexity of detail.

RECOGNITION OF A LINE IN SCANNED IMAGE OF THE ORTHOGONAL PROJECTION OF MECHANICAL DRAWING

The lines are basic graphical elements in mechanical drawing, depicted in orthogonal projection. Vertical and horizontal lines predominate. Most of the lines are segments and arcs of circle. The lines are denoted in an exactly determined way in dependence of their aspect (BDS - ISO 128) and have standard:

- Shape: segment of line, arc of circle, continuous line with great bends and continuous wave line;
- Kind: continuous line, broken line, broken line with dot and broken line with two dots;
- Thickness and minimum elongation between parallel lines - according to standard requirements;
- Requirements for the way of realization.

The transformation from raster to vector format with the programs used for processing of scanned images of mechanical drawings meets with definite difficulties. A basis problem at vectorization is that the segments was not usual identified as one segment. It is relying for the thickness of the line and some mistakes was obtained in a case of not well - shown difference in thickness of different lines. There is not mechanism for context recognition and depends on operator's intervention to correct mistakes.

Processing of raster presented line

The basis characteristic of a raster represented line, is that it has definite thickness. For good visual perception it is necessary enough large dividing ability, so the width of the line to put in several pixels.

There exists a criterion for optimum choice of the dividing ability, that is called condition for compatibility (Pavlidis - 1988), so that raster representation to contain main topological characteristics of the curve. This criterion is arise out of heuristic considerations - is considered that if raster represented curve is well visual perceived, than it have all its characteristics. The aspiration for decreasing of the raster net is connected with this, that the number of raster elements is athwart dependent of the number of necessary operations for processing of line's image - i.e. the complexity of the image in this presentation depends from it. The decreasing of the number of pixels of the line or the presentation in another way by similar basis elements in preservation of the necessary characteristics for the transformation increases the informative character of the raster image.

The choice of the proper method for recognition of segment and arc of circle

Method for recognition depend of way for realization of the lines, the standard properties of raster depicted lines, the predominant defects in the raster image and presence the intersection of lines. It is a proper method, which interpret drawing of the lines by hands as consecutive plotting small segments with definite length d_e.

We call *basic vector* a segment of line with length d_e and characteristic: the length d_e to be sufficient, as that in presenting of a arc of circle is possibly the least radius on the drawing with sequence of segments with length d_e, the mistake must not exceed in advance definite value.

After applying of the standard method for contouring the received chain code is replaced by sequence of basic vectors, whose direction depended from direction of transition on the contour.

The presentation of the contour with segments with length d_e has the priority, because it overcomes defects as:

- Some alternating of missing or redundant pixels on the contour;
- Missing small groups or single pixels inside for the line;
- Defects only on one boundary of sectional area of the line;
- Redundant circumstantially presentation of the contour, which delay performance.

Every segment (part of the segment or arc of circle) presented with pair Γ_1 and Γ_2 multitudes of basic vectors approximating the contour (fig.1,fig.2). $\Gamma_r \subset \Gamma_1 \bigcup \Gamma_2$ is determined (defined) as a sequence of basic vectors with sufficient number, so it be able to determine the curvature of the segment and thence whether it is segment of straight line or arc of circle. The segment describes in vector format as an area – segment of straight line or arc of circle. There is applied the method of Hough (Гочев Г., 1998).

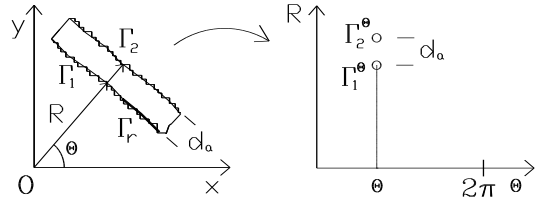

Figure 1: Representation of segment of line in (θ, R) *space*

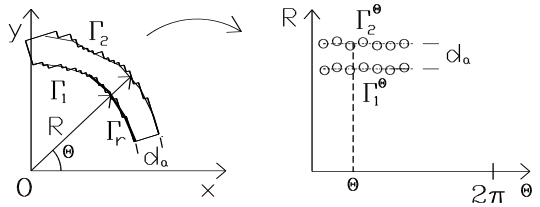

Figure 2: Representation of segment of a circle in (θ, R) *space*

RECOGNITION OF ARC OF CIRCLE IN SCANNED IMAGE OF MECHANICAL DRAWING IN AXONOMETRY

In the common case the circle depicts as ellipse. The recognition of the arc of ellipse most generally can become with interpolation of the pixels of the line with describing ellipse with parameters. With means of geometry the problem realizes more rational.

The determination of the conjugate radiuses of segment of ellipse and its complements to ellipse

After presentation of the segment of ellipse with basic vectors on Γ_r determines that the segment is not a part of straight line. Here uses the middle line of the segment between Γ_1 and Γ_2. When the arc is less of ½ part of ellipse here can applied the method illustrated on figure 3. The arc splits into three equal parts and on each 2/3 part construct (draw up) diameter and tangent line. Here uses that the conjugate diameter is parallel to the tangent line. The center of ellipse determines according two diameters. For addition of the segment to ellipse uses that each chord parallel to one diameter halves (divides into halves) from its conjugate diameter.

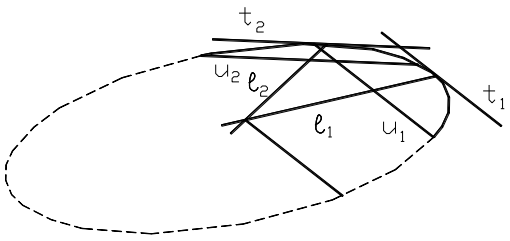

Figure 3: Building of the center of the ellipse and its conjugate radiuses by given segment of it

Reconstruction of circle, that is depicted in axonometry

The transformation of the ellipse into circle can become in different ways depending on the chosen affinity transformation. The problem has standard decision, when the circle lines in the coordinate plane. On the figure 4 is illustrated a transformation of arc of ellipse from plane Oxy into circle at oblique axonometry with scale units e'_x, e'_y, e'_z. The received circle is similar to the actual with the coefficient of similarity $k = \frac{e}{e_x}$. This transformation applies on the basic vectors and receives Γ_1 and Γ_2 for circle. It is named the method of Hough.

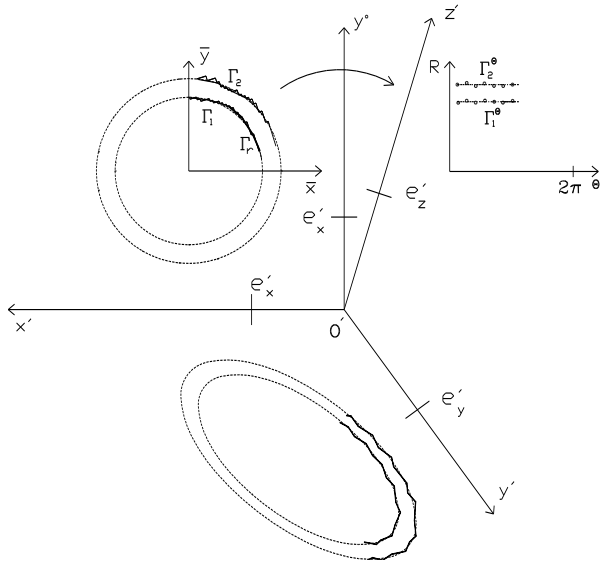

Figure 4:Reconstruction of arc of circle incumbent in co – ordinate plane

RECONSTRUCTION FROM SCANNED IMAGE OF MECHANICAL DETAIL IN ACSONOMETRY

We shall understand under reconstruction of scanned image in axonometry, the detecting of relation of the space coordinates and sizes of the segments of lines and of circles, representing the edges of the detail. The finite result will serves us for exactly depiction of the object in orthogonal projection or in axonometry.

By more complete decision of the problem for recognition from scanned image is necessary to use symbols for size. Here we will to restrict only to geometrical receiving of the sizes, what is sufficient to the purposes of representation.

Basic conditions for reconstruction

For the reconstruction of most simple body of right rectangular prism and right circular cylinder with base in Oxy is sufficient to give:

- The beginning of the frame of reference and sizes of three segments of lines, with directions that are parallel to the co-ordinates. They can be points of the foundation and edges of the represented body (fig.5);
- The edges of the base of the body must be denoted.

On such given conditions the lines of bodies fig.5 can easily to be recognized and described with theirs spatial dimensions. Here is used that:

- The parallel and identical segments have equal lengths;
- The sides,which are figures of a plane and have two contours of segments, which are parallel to co-ordinate plane, are parallel to this plane and have one fixed co-ordinate for all their points;
- The foundation of the cylinder is received in the way for reconstruction of a circle in a co-ordinate plane that is up considered;
- The identical ellipses are the images of equal circles from parallel planes.

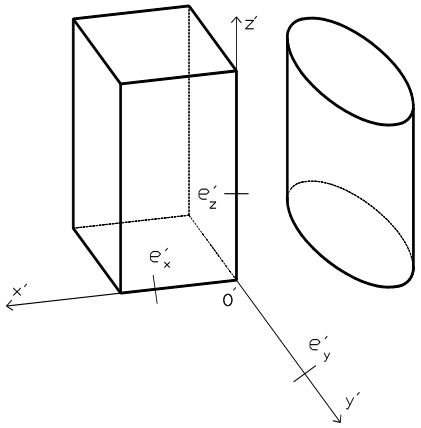

Figure 5: A prism and circular cylinder with given basic conditions for reconstruction

Additional conditions for reconstruction

We consider the question for reconstruction of a body, constructive presented as intersection, union and difference of right rectangular prisms and right circular cylinders. Such a form is most frequently meets in details in mechanical drawings. Usually in representation in axonometry the bigger part of the sides of the body are parallel to the co-ordinate planes and the body is lays with its base on the Oxy.

In the given basic conditions for reconstruction it is necessary, begin with lower point of the body can traced on of all its edges and it are determining co-ordinates of the end points of the edges. The tracing can perform at the same time with marking the sides of the body with filling on side determine the edges that restricted it. Here uses that the edges lay on

planes, which are parallel to the co-ordinate plane and it are determining the co-ordinates of its ending points.

The surfaces are three types:

Type 1 - planar figure, that is parallel to the co-ordinate plane;

Type 2 - planar figure or cylindrical surfaces, that is parallel only to one co-ordinate axis;

Type 3 - planar figure, that is not parallel to co-ordinate axis or not planar figure.

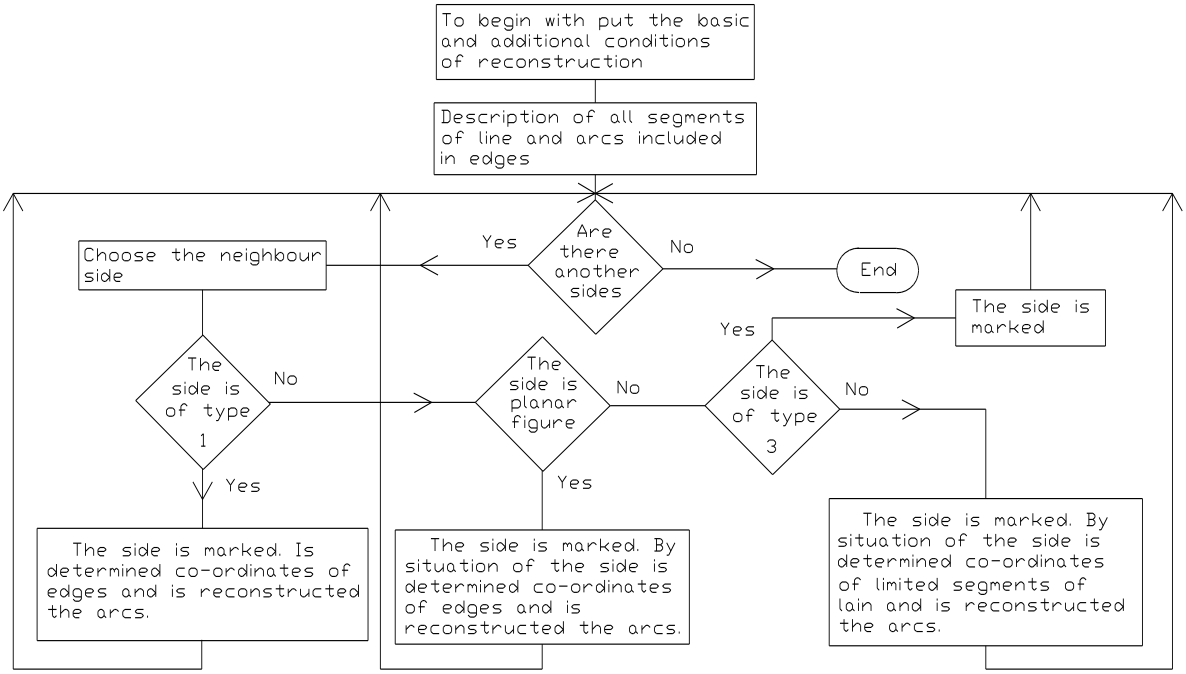

Figure 6: Logical scheme of the method of reconstruction on detail from scanning image of acxonomery

Additional conditions consists in leading from the operator the sides from type 3 and they are not participate in algorithm, represented on fig.6 for building the co-ordinates of the edges finite points.

Hidden information

The axonometric image is visual (clear), but it may not contains all graphical information. The detail that is depicted on fig.7 has hidden the sides and parts, which are not depicted. This information may be supplemented only if are given orthogonal projections of the object and eventually the necessary aspects and sections.

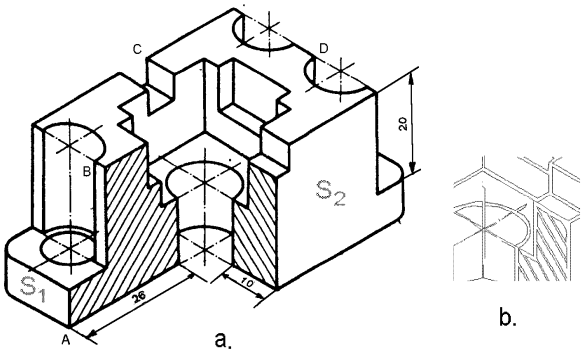

Figure 7: a. – scanned image a detail from mechanical drawing in axonometry; b. – a fragment from image after the tracing the contour of the edges

THE REALIZATION OF THE METHOD

For experimental realization is used a scanned from paper copy of mechanical drawing of a detail (fig.7) with dividing ability 300 dpi. The basic operations are executed in memory of a context unit for visualization with 256 colors.

The following algorithms are realized:

- Contouring;
- Describing of the contour with basic vectors;
- Recognition of segment of line and arc of circle;
- Separating (allocating) and recognition of the hatch – lines;
- Separating of size (dimension) lines and the symbols;
- Reconstruction of the axonometric image of circle from co-ordinate plane;

Here is introduced a parameter for length of basic vector, standard thickness of the lines and admissible curvature (torsion) of the segments. The hatched part determines from the thickness of the lines.

On figure 7 a. the surfaces from type 3 are denoted with s1 and s2. The beginning of the frame of reference is in point A . The points B, C and D are chosen for control of the calculations. The results are given in table 1.

Table1: Co-ordinates of the points A, B, C, and D are obtained at implementation of a method

	x	y	z
A	0.00	0.00	0.00
B	8.02	2.23	27.15
C	34.40	17.05	27.15
D	54.84	-2.45	27.15

On fig.7 b. is depicted a fragment from the image after contouring. From it immediately are observing important characteristics, that are using for recognition of the lines:

- Less thickness of the lines;
- Clearly expressed curvature of the arcs from edges;
- The ability for overcoming defects, as the received contour is approximating
- Very well expressed coherence of the inside contour with all edges restricting one side.

The discussed approach for recognition of an axonometric mechanical drawing of a detail contains the basic necessary context-dependent processing. Here is offered a rational method for recognition of the objects in (θ, R) space and reconstruction of the information for the basic figures of the image.

The enunciated problem for reconstruction of scanned copy of axonometrical image and the chosen approach can be used for automatically obtaining of the basic constructive features of a detail and creating a system for recognition with optimum using of the semantic of the object.

REFERENCES

Горанов П., 1999. Относно връзката между 2D CAD и системи чрез автоматично разпознаване на признаци, *Автоматика и информатика ½*.

Гочев Г., 1998. Компютърно зрение и невронни мрежи, София.

Димитров Ю., Ст. Иванов, 2001. Автоматично разпознаване на размерните линии в сканирано копие на машино-строителен чертеж, *Трета научна конференция "Смолян - 2001*".

Cheng F., M. Chen, 1989. Recognition of Hahdwriten Chines Characters by Modified Hough Transform Techiques, IEEE Trns. Pattern Anal. Machine Intell. Vol. II.

Pavlidis T., 1986. Algorithms for graphics and image processing, *Computer science press.*

Recommended for publication by Department of Mathematics, Faculty of Mining Electromechanics