Application of Image Processing Methods in CAD/CAM Systems for Knitting Industry Automation

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Abstract—**This paper treats the problems relate with image processing in CAD/CAM systems' software in knitting industry automation. The graphics images and theirs processing are the base part from the CAD/CAM systems' software. The other most important part of it is the design procedures for an automatic creation of execution units control programs. In the knitting industry, these programs control the knitting machines for creation of determined knitting structures and products, which is closely related with object images. In this paper, the image processing methods for knitting industry automation are suggested. The using methods suggested in this paper are: transformation of gray level images to binary images; path tracing for recognition of digital straight line. The trace algorithm is extended by operations: translation of the current dot; next dot searching in next levels. This method is reliable in a CAD/CAM system for cotton knitting industry automation. The algorithm is used is the CAD/CAM system's software.**

Index Terms—**Image processing, CAD/CAM system, cotton knitting industry automation**

I. Introduction

The CAD/CAM systems are used for **design process** automation including a set of activities: search, research, and design in the purpose of creation the necessary and sufficient description for a new product construction named **design object**.

The base part of a CAD/CAM systems' data includes graphics images of the design objects. Therefore the means of image coding and image processing are a considerable part of the software of these systems [1].

Besides object graphics design the CAD/CAM system requirements involve also an automatic control of execution units. Respectively, the other most important part of CAD/CAM systems' software is the design procedures for an automatic creation of execution units control programs. In the knitting industry, these programs control the knitting machines for creation of determined knitting structures and products.

Because of the direct relation between the design project and the particular industrial branch CAD/CAM system development needs a consideration with the specific features of the products. Respectively, the methods used for image coding and image processing are chosen according to the requirements of the procedures for knitting program automatic creation. These knitting programs realize knitting products.

This paper treats the problems related with image processing of knitting structure images in CAD/CAM systems for knitting industry automation. The current research is applied to CAD/CAM system development for cotton knitting industry automation. The **cotton knitting machines** belong to the class of **flat-bed knitting machines**. They have possibilities to knit the structures "**knitted net**" and "**point lace**" by a mechanism for loop transferring – **loop carrier jack**. The usage of the mechanism loop carrier jack leads to some limits, which add complexity to the knitting program creation [2], [3].

II. Transformation of Gray Level Images to Binary Images

The most used process in the knitting industry design is **rapport creation**. In this case the knitting structure object image is described by a **rapport** of the knitting structure. **Rapport** is a graphic description under the forms of a net with differently colored items (points, dots) or items coded with different symbols. For example, to code the structure "knitted net" different graphic symbols are used. Each symbol corresponds to one kind of the stitch. According to the knitting structure, for rapport description of loop transfer knitting structure the number of needed symbols varieties from 3 to 10 symbols [3].

Because of its small size this kind of image occupies a small part of the computer memory and for image coding the matrix usage is reliable. In this case, knitting structure image is represented as integer matrix:

$$P(N_1 x N_2)\ (P=P(n_1,n_2)), \tag{1}$$

where: $1 \le n_1 \le N_1$, $1 \le n_2 \le N_2$.

This kind of image belongs to the class of gray level pictures or to the class of color pictures; each color or each gray level is coded with integer value [4].

The matrix items correspond to the knitting stitches. The choice of matrix items' value is conformed to the kind of stitches and their technological implementation. According to the number of different kinds of stitches in the knitting structure, the image of the rapport can be defined as class 1 - gray level images (if there are more than two different items) or as class 2 - bilevel (binary) images (if there are only two different items).

To create knitting control program for knitting structure realization it is necessary to do image processing of the

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rapport to find the topology image features. These features are used in the process of choosing knitting control command series for each knitted row.

A feature of the cotton knitting structure design is the relation between knitted rows [1]. The choice of control commands for knitted row realization depends on the rest of the knitted rows. Therefore, it is necessary to determine the topology image features. First operation is transformation of gray level image to binary image.

Gray level to bilevel pictures transformation is preferred, because processing of bilevel pictures is simpler. For loop transfer knitting structure images this process is a separation of the items used for the next stage of the image processing. The result is an image with two kinds of items (or two kinds of stitches), which may be defined as an object (dark pixel) and background (white pixel). Example of this kind of image is shown in fig.1. This process is named also **segmentation** [4].

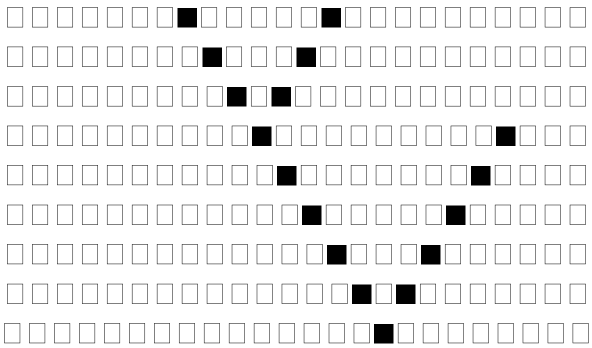


Fig. 1. Example of knitting structure image rapport

Let an image represented by matrix A consist of m different symbols [5], [6]. The result of image segmentation is a matrix division to m matrixes A1, A2.. Am. Each matrix contains two kinds of items: black pixels, which belong to the object and white pixels, which belong to the background To define matrix A_k the following formula is used:

$$A_k = \begin{cases} (a_k(i,j) : a_k(i,j) = a(i,j)), \\ \quad if\,(k = a(i,j)) \\ (a_k(i,j) : a_k(i,j) = 0), \\ \quad if\,(k \neq a(i,j)) \end{cases} \tag{2}$$

Following formula does original image restoration:

$$A = \bigcup_{k=1}^{m} A_k \tag{3}$$

Formula (2) is used to determine the positions of the stitch transfers – dark pixels. It is important for image processing of cotton knitting structure image.

III. Path Tracing for Recognition of Digital Straight Line

Straight lines and curves, and dots on the other hand belong to image class 3 and image class 4, respectively [4]. An image of class 3 consists of a dot sequence represented by dot's coordinates (x,y). Because of the relations between elements of the knitting design this kind of representation is non-efficient. Representing using the distance between two neighbors (Δx, Δy) is non-efficient too.

An efficient method of coding image of class 3 is **a chain code** [6], [8]. According to the method, the line is described as a sequence of direction vectors defined as shown in fig. 2.

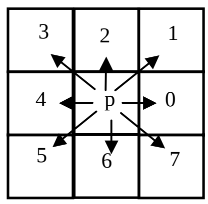


Fig. 2 Direction vectors in chain code

Line recognition is a particular case of path tracing. The classic rule of path tracing goes: *Search the first dot of the object in direction from above downward; from left to right. The next dot is found as one of eight neighbors by searching clockwise* [8], [9].

The direction of knitting structure realization goes from below upwards, so image processing is done in the same direction. According to this feature, in this paper the rule of path tracing is changed as follows: *As the first dot the first object's pixel reached by searching from below upwards; from left to right is chosen. As the next dot first right most pixel of the object is chosen. According to the rule, next pixel searching starts from the right pixel (vector 0) and it continues counter clockwise.*

The result is chain code generation as follows:

$$(Sx, Sy), d0, d1, d2, \ldots\ldots\ldots\, dn, (Ex, Ey), \tag{4}$$

where:
Sx, Sy – first dot;
Ex, Ey – last dot.

For example, the line shown on fig.1 are described as follows:

(16,1), 3, 3, 3, 3, 3, 3, 3, 3, 3, (8,9)

Description of the line is done from below upwards because it is necessary for next image processing.

IV. Modification of Path Tracing Represented by Chain Code

In image processing of knitting structure pictures the process of path tracing goes on directions determined by vectors 1, 2, and 3 as shown in fig. 2. It is not necessary to search for a dot the directions determined by vectors 5, 6, 7, 4, and 0. The direction vectors 0 and 4 determine the same knitted row [10]. This feature is used in a trace algorithm included in a CAD/CAM system's software for cotton knitting industry. In the particular CAD/CAM system development the trace algorithm is changed by the use of two operations:

- Translation of the current dot;
- Next dot searching in next levels.

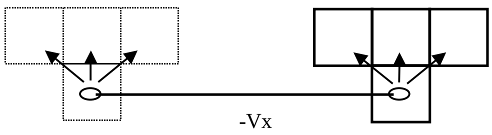
A. Translation of the current dot

To realize the knitting structure shown in fig 1, it is necessary that the black pixel's lines be recognized. These lines correspond to the loop carrier jack movement trace. These lines also represent the movement trace of the first transfer needle. When the stitch transfer direction is changed the last transfer needle becomes first and it determines the trace of loop carrier jack movement. This change is taken by a dot translation with a vector V:

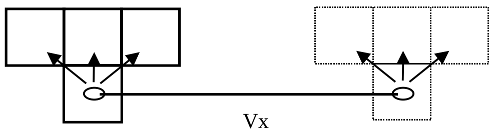
$$Vy=0;$$
$$Vx=Size\_right, \qquad (5)$$

where Size_right is the number of transfer needles.

This operation switches the transfer needle's positions. Example of dot translation is shown in fig. 3.



translation from outside to inside



translation from inside to outside

Fig.3 Translation with vector Vx

Although the trace algorithm is not classical it describes the exact path of the loop carrier jack movement and it determines stitch transfer direction. It gives information for creation of knitting control programs.

This approach complicates trace algorithm but it gives the exact trace of the loop carrier jack movement and it stores the whole technological information.

B. Next dot searching in next levels

If there are loop transfer processes, the path tracing of loop carrier jack movement is possible because the trace dots are also the stitch transfer positions. If there is no loop transfer process in the knitted row it is not possible to trace the loop carrier jack movement. To recognize this movement it is necessary to find the position of the next loop transfer on next knitted rows. For this purpose the next dot searching is done in a sector as shown in fig. 4.

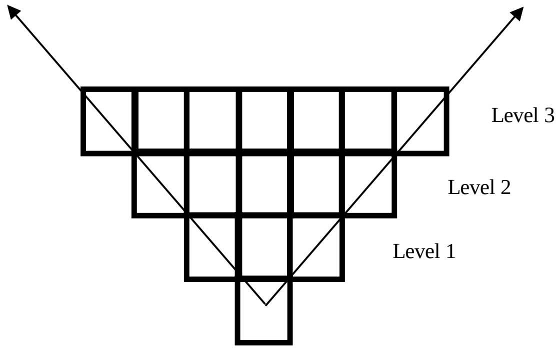


Fig. 4. Levels for next dots searching

The loop carrier jack movement is determined by formulas:

$$|x2-x1| = y2-y1, \qquad (6)$$

there is movement for each knitted row;

$$|x2-x1| = 1, \qquad (7)$$

there is movement only for a row with loop transfer;

$$|x2-x1| = 0, \qquad (8)$$

there is no movement.

The loop carrier jack movement trace is coded by a set of dots described by a set of: x coordinate; y- coordinate; direction of transferring.

V. Conclusion

This paper treats the problems relates with image processing in CAD/CAM systems' software in knitting industry automation. The using methods suggested in this paper are: transformation of gray level images to binary images; path tracing for recognition of digital straight line. The trace algorithm is extended by operations: translation of the current dot; next dot searching in next levels. This method is reliable in a CAD/CAM system for cotton knitting industry automation.

The program for the transfer mechanism movement is created on the base of the trace algorithm. This program defines loop carrier jack movement for realizing a particular knitted structure. C++ programming language is used. The program is a part of the whole CAD/CAM system's software for cotton knitting industry automation. The CAD/CAM system is made for the needs of "YANA – Pleven" Ltd.

References

[1] E. Zaharieva-Stoyanova, S. Milchev, Thecnological work automation for loop transfer knitting structures, Int. Conf. Automatics and Informatics'99, Sofia, Bulgaria, Oct. 19-22 , 1999, pp. 133-136.

[2] Monk Cotton 2002 Full Fashioned Knitting Machine, Monk Cotton group company, 1992.
[3] WIRKBAU-Flachkulierwirkmaschine Modell 5020 .
[4] Th. Pavlidis, Algorithms for graphics and image processing, Bell Laboratories, 1987
[5] E. Zaharieva-Stoyanova, N. Sinjagina, Image Coding In Cad/Cam System For Knitting Industry**,** Conf. CompSysTech'2000, Sofia, Bulgaria, June 22-23, 2000, pp. V12-1 - V12-5.
[6] E. Zaharieva-Stoyanova, Application Of Image Transforms Methods To Knitting Industry CAD/CAM Systems, Int. Conf. CompSysTech'2001, Sofia, Bulgaria, 21-22 June, 2001, pp. III.23-1 – III23-3.
[7] Z. Cai, Restoration of Binary Images Using Contour Detection Chain Codes Description, Computer vision, Graphics, and Image processing, Vol 41, 1988.
[8] S. Kim, J. Lee, J. Kim, A New Chain Coding Algorithm for Binary Images Using Run-Length Codes, Computer vision, Graphics, and Image processing, Vol 41, 1988.
[9] E. Creutzburg, A. Hubler, Geometric methods for on-line recognition of digital straight line segmentation, Computers and Artifical Intelligence, Vol. 7, N 3, 1988.
[10] E. Zaharieva-Stoyanova, Chain code application in image processing of loop transfer knitting structure, Int. Conf. Automatics and Informatics'2000, Sofia, Bulgaria, Oct. 24-26, 2000, pp. 46-49.