The Mapping Algorithm of Triangular Vertex Chain Code from Thinned Binary Image

Lili A. Wulandhari, Habibollah Haron, and Roselina Sallehuddin

Department of Modeling and Industrial Computing
Faculty of Computer Science and Information Systems
Universiti Teknologi Malaysia
81310 UTM Skudai, Johor Bahru, Malaysia
lili.wulandhari@gmail.com, {habib,roselina}@utm.my

Abstract. Image representation has always been an important and interesting topic in image processing and pattern recognition. In 1999, Bribiesca introduced a new two dimensional chain code scheme called Vertex Chain Code (VCC). VCC is composed of three regular cells, namely rectangular, triangular, and hexagonal. This paper presents the mapping algorithm that covers one of the VCC cells, the Triangular VCC cell. The mapping algorithm consists of a cell-representation algorithm that represents a thinned binary image into triangular cells, and a transcribing algorithm that transcribes the cells into Vertex Chain Code. The algorithms have been tested and validated by using three thinned binary images: L-block, hexagon and pentagon. The results show that this algorithm is capable of visualizing and transcribing them into VCC; it can also be improved by testing on more thinned binary images.

Keywords: Vertex Chain Code, Triangular Cells, Thinned Binary Image.

1 Introduction

Image representation is an important component in image processing and pattern recognition. One of the ways to simply and efficiently represent an image is by using chain code [1]. The first use of chain code was introduced by Freeman in 1961 that is known as Freeman Chain Code (FCC) [2]. This code follows the contour counter–clockwise and keeps track of the direction as we go from one contour pixel to the next. The codes involve 4–connected and 8– connected paths. In the 8-connected FCC, each code can be considered as the angular direction, in multiples of 45^0, through which we must move to go from one contour pixel to the next. Freeman [3] states that, in general, a coding scheme for line structures must satisfy three objectives. The three objectives are somewhat in conflict with each other, and any code necessarily involves a compromise among them.Bribiesca [4] introduced the Vertex Chain Code (VCC) in 1999; it complied with the three objectives that Freeman proposed. Some important characteristic of the VCC are: (1) The VCC is invariant

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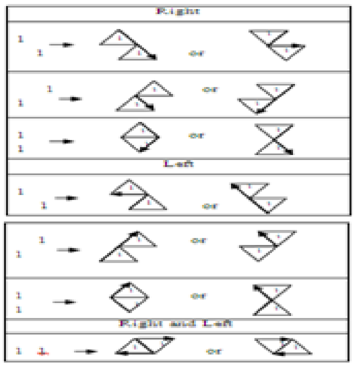
under translation and rotation, and optionally may be invariant under starting point and mirroring transformation. (2) Using the VCC it is possible to represent shapes composed of triangular, triangular, and hexagonal cells. (3) The chain elements represent real values not symbols such as other chain code; are part of the shape; indicate the number of cell vertices of the contour nodes; and may be operated for extracting interesting shape properties. (4) Using VCC it is possible to obtain relations between contours and the interior of the shape. An element of VCC indicates the number of cell vertices, which are in touch with the bounding contour of the shape in that element position. In the Vertex Chain Code, the boundaries or contours of any discrete shape composed of regular cells can be represented by chains. Therefore, these chains represent closed boundaries. The minimum perimeter of a closed boundary corresponds to the shape composed of only one cell. An element of a chain indicates the number of cell vertices, which are in touch with the bounding contour of the shape in that element position [4]. This paper presents two algorithms that are used to derive the triangular cells of VCC from a thinned binary image and to transcribe the cells into Vertex Chain Code. The algorithms are tested and validated using three thinned binary images: L-block, hexagon, and pentagon.

2 The Mapping Algorithm of Triangular -VCC

2.1 The Cell-Representation Algorithm

Triangular cell is one of the basic cells in digital geometry. The structure of the triangular cell is much more complicated than rectangular one [5]. The triangular elements have alternating orientation; hence, the arrangement of peripheral elements will vary accordingly.As the previous explanation, triangular cell is more complicated than the rectangular one. It is not difficult to represent a thinned binary image into rectangular cell while to represent thinned binary image into triangular cell there are some rules must be considered. It is brought on by a condition as follows: It represents a thinned binary image that used two coordinate values, x and y. It has caused not every coordinate point is lied in the corner of the triangular, while every cell must be started from the corner, not in the middle of the triangle edge.Therefore, to avoid starting point in the middle of triangle edge, it is important to commit a step as follows: In this triangular cell system, every y = odd point. It causes every x point is in the middle of triangle edge. Therefore, for every cell that is started from this (x, y) point, they must be moved 0.5 point to the left. The cell-representation completely is given below (Table 1). It depends on the shape of triangle; upper or lower triangle and the representation is distinguished by where its position, in the right or left of the triangle. The Triangular cell-representation is created based on Table 1. The input is a thinned binary image that is defined as an array variable in MATLAB. The cell representation is moved in a clockwise manner. The algorithm is given below.

Table 1. Triangular Cell Representation



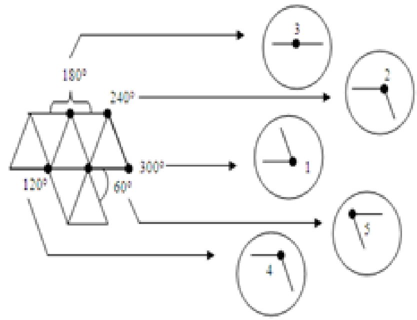


Fig. 1. Vertex Chain Code of Triangular Cell

Triangular Cell-Representation Algorithm:

1. Input: Thinned Binary Image (TBI)
2. Check number of TBI rows and columns
3. Divide the area of the image into 2 parts; left and right
4. Scan the thinned binary image from the top to the bottom, left to the right.
   If it finds code 1 and satisfy:
   - TBI (row, column) = TBI (row, column+1) = 1, or
   - TBI (row, column) = TBI (row+1, column) = 1, or
   - TBI (row, column) = TBI (row +1, column–1) = 1, or
   - TBI (row, column) = TBI (row+1, column+1) = 1

     Draw the segment of the cells according to Table 5.1, start from vertex of TBI (column, row).
5. Repeat step 4 until all of code 1 from the thinned binary image is represented on triangular cells.

However, the Triangular cell-representation algorithm is similar with the rectangular one but triangular cell is more complicated. It is important to note that there is a movement in the coordinate if the point touches the middle of triangle edge. The result of this algorithm is used as the input of the next algorithm

2.2 The Transcribing Algorithm

Transcribing algorithm is used to transcribe the triangular cell into vertex chain code. The Transcribing algorithm of triangular cell is not as complicated as the cell-representation. If the cell representation has been obtained, the vertex chain code of the thinned binary can be obtained. The algorithm is created based on Figure 1.There are 5 different codes; 1, 2, 3, 4, and 5 for triangular cell. It depends on the corner that is formed by each triangle in the cell. The algorithm to transcribe the triangular cell into vertex chain code is given below. The code starts from the starting point that is chosen continuously in a clockwise direction.

The Triangular Transcribing Algorithm

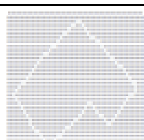
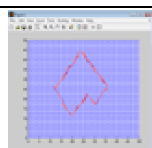
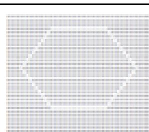
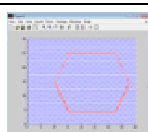
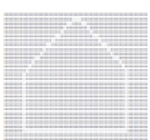
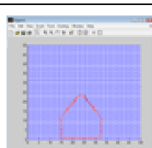
1. Input: Boundary of thinned binary image Cell-representation
2. Determine the starting point
3. Scan the boundary
   if180^{o} is found, then VCC=3
   else if 240^{o} is found then VCC=2
   else if 300^{o} is found then VCC=1
   else if 60^{o} is found then VCC=5
   elseVCC=4
   end
4. Repeat step 3 until the starting point is reached back.

3 Results and Discussion

3.1 Experimental Results

All the algorithms are tested and validated using three thinned binary images, L-block, hexagon, and pentagon. Table 2 shows the result of the experiment using the cell-representation and transcribing algorithm. Thinned binary images are transformed into triangular-VCC by using the cell-representation algorithm; The Triangular-VCC is transcribed into Vertex Chain Code using the transcribing algorithm. The entire algorithm is called Mapping Algorithm. The result of the experiment is analyzed to see how the algorithm works for the input. It will disclose that the algorithm is capable to represent the thinned binary image into the cell, and transcribe it into VCC.

Table 2. The Triangular Cells Mapping Result

NO	Thinned Binary Image	Triangular Cells	Triangular VCC
1			1241515152415151515234151515 1522415143333332151523345151 5151432515143223341515143333 3331514325151515151515143351 5151434
2			133333332341515151515 1515151333333333323333 33332333333333331515151 5151515151515
3			2241515152341515152333 24242424242424133333333 3333333333224242424242 4233332515151432515151 4

3.2 Result Analysis

Every experiment, no matter how careful it was done; there is an associated error inherent with the result of the experiment. It is difficult to get the exactly same result with the true value. The magnitude of the error is due to the precision of the experimental system.To determine the error associated to the experiment, scientists often refer to the precision and accuracy of the experiment measurement. The precision of the experiment is a measure of the reliability of the experiment, or how reproducible the experiment is. The accuracy of an experiment is a measure of how closely the experimental results agree with a true or accepted value. Related to the precision and accuracy, it is only close to the expected value, the error is still possible happen. The error could be calculated by error percentage formula. The error percentage calculated the error between our value measurements and the accepted value with the following equation:

$$\text{Error percentage} = \frac{|measured \ - Actual\,|}{Actual} x100\,\% \tag{1}$$

In this paper there are 3 kinds of error percentage calculated, namely cell-representation of thinned binary image based on code 1 number error percentage, cell-representation of thinned binary image based on coordinate error percentage, and cell-representation of vertex chain code error percentage. The error percentage is calculated by using Equation 1 and will be shown in the table below.

Table 3. Error Percentage of Triangular Cell-Representation from TBI Based on Total of Code 1

Kinds of Error Percentage	Error Percentage
Error Percentage of Cell-Representation from TBI Based on Total of Code 1	2%
Error Percentage of Cell-Representation from TBI Based on Coordinate	0.02%
Error Percentage of Cell-Representation from VCC	1%

4 Conclusion

The mapping algorithm has been tested and validated by using three thinned binary image objects, L-block, hexagon, and pentagon. Those thinned binary images have been represented as triangular cell and the cell has been transcribed into VCC. The results show that the cell-representation algorithm is capable of representing thinned binary image as triangular-VCC cells. Reciprocally the transcribing algorithm is capable of transcribing the triangular-VCC cells into Vertex Chain Code and the entire algorithm is called the Mapping Algorithm of Triangular Vertex Chain Code.

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