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Simplified Representation of Image Contour

Suk Won Yoo

SeoKyeong Univ., Dept. of Computer Science, Seoul, Korea
swyoo@skuniv.ac.kr

Abstract

We use edge detection technique for the input image to extract the entire edges of the object in the image and then select only the edges that construct the outline of the object. By examining the positional relation between these pixels composing the outline, a simplified version of the outline of the object in the input image is generated by removing unnecessary pixels while maintaining the condition of connection of the outline. For each pixel constituting the outline, its direction is calculated by examining the positional relation with the next pixel. Then, we group the consecutive pixels with same direction into one and then change them to a line segment instead of a point. Among those line segments composing the outline of the object, a line segment whose length is smaller than a predefined minimum length of acceptable line segment is removed by merging it into one of the adjacent line segments. As a result, an outline composed of line segments of over a certain length is obtained through this process.

Keywords: *Edge Detection, External Boundary Generation, Line Segment, Edge Merge, Image Processing, Image Analysis, Feature Extraction*

1. Introduction

By the development of the information industry these days, we use convergence technologies that combine video equipments and computer systems in many places. Image processing [1] and recognition technology [2] are required to use video equipments in computer systems. Digital image processing is a process that is executed to obtain useful information from an input image to a computer. The input image becomes better through the image processing process, and the recognition rate [3] of the object in the input image becomes higher in the next recognition process. In addition, the efficiency of the image recognition process [4] is improved by reducing the amount of information representing a given input image through the image processing process. Image recognition is a process of extracting features of an object in input image and recognizing the object by comparing it with the DB models stored in the recognition system. Better recognition result might be obtained according to the image processing procedure executed previously.

2. The Related Works

Image processing and recognition processes are used in various fields. Public institutions use identification system for security [5], and fingerprint recognition or face recognition is used in the identification process. Generally, the identification system first generates an input image using a camera system and then detects line

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Corresponding Author: swyoo@skuniv.ac.kr
Tel:+82-2-940-7181
SeoKyeong Univ., Dept. of Computer Science, Korea

segments representing the face region in the image. Then, a contour line connecting ear, chin, and forehead portions is detected to form a contour line of the face. The face contour line is compared with face data stored in the computer system in order to identify the suspicious person. This type of recognition technique might be used by the police to detect criminals. In the production field [6], the finished product is recognized and classified automatically, or the product being manufactured is compared with DB models stored in the database during the product assembly process to detect errors occurring in the manufacturing process and to remove defective products. Therefore, the image processing and recognition process are important parts of the unmanned automation process using the camera system. In the medical field [7], various imaging devices are used to diagnose patient's health conditions. The outlines of the body organs in the medical images are extracted, and the changes of the outlines of a time period are examined to understand the progress of the illness of the patients.

3. The Main Subject

In this paper, we first obtain line segments for an object in the input image by applying line segment detection method for the input image. Because the line segment detection method uses the entire area of the input image as input, it detects not only the outlines but also the line segments representing the inside of the object in the image. The positional relationship between the pixels constituting the outline is investigated to maintain the connection condition of the outline, and the unnecessary pixels are removed to generate the simplified outline. Finally, the positions of the pixels constituting the simplified outline are stored in the array. For each of the pixels stored in the array, the positional relationship between the pixel and the next pixel is examined to determine the direction of connection of the pixel. Then, we make the consecutive pixels with the same direction into one group, change it into a line segment, and calculate the length of the line segment. The remaining pixels other than the pixel at the start position of the line segment are removed because they are meaningless pixels. At the end of this process, all line segments in the array have different directions. After that, while the lengths of all line segments stored in the array are iteratively examined, a line segment with a length smaller than a predefined minimum length is removed by combining it with to a shorter segment among the two neighboring line segments according to the length and direction conditions of the two neighboring segments. As a result, the proposed method obtains the effect of defining the object in the input image as a set of small number of vertices by representing the outline of the object in the image as a simplified outline shape.

3.1 Simplified representation of image contour

How to simply express the outline of the object in input image is explained through the following steps.

Step 1) To briefly describe the whole process, we apply the adaptive thinning algorithm [8] on the black and white input image to extract the outline of the object in the input image. In this process, the adaptive thinning algorithm first executes the edge detection process for the object in the input image using the edge detection technique for the entire input image. Then, we ignore the line segments representing the interior of the object and select only the line segments representing the outline of the object. In this case, every two consecutive pixels constituting the outline of the object have relations of either direct neighbors or indirect neighbors. The final step of the algorithm is to minimize the number of pixels composing the outline of the object by eliminating unnecessary direct neighbors while maintaining the connection condition of the outline by examining the positional relationship between the pixels constituting the outline. The adaptive thinning algorithm generates a simplified outline of the object in the input image through this process.

Step 2) Because input image is a black and white image, the background is white color and the outline of the object is black color. The starting point of the contour line of the object in the input image is found from the top of the screen center. The color of the pixel at the starting point changes from black to red in the sense of visiting, and the position of the pixel is stored in the array. The structure of the array has a record type that stores five information, (flag, x-position, y-position, direction, and length).

Step 3) We examine pixel value of each of the eight pixels constituting the neighbor of the pixel stored in the array. The order of visiting these eight pixels is as follows: left > top-left > bottom-left > top > bottom > top-right > bottom-right > right. If the color of the visited pixel is black, then change it to red because it is the pixel that has visited for the first time and then store the pixel position (x-position and y-position) in the array. If the color of the visited pixel is red, then it is ignored because the pixel has been already visited. If the color of the pixel is white, it is also ignored because it is background.

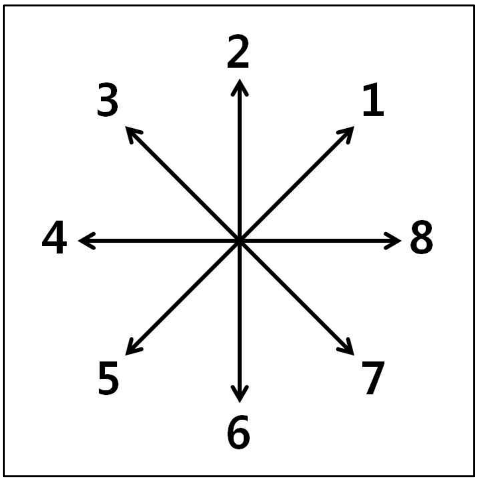

Figure 1. 8 Directions of Current Pixel with Comparison of the Position of Next Pixel

Step 4) The pixels stored in the array represent the outline of the object in the input image. For each pixel in the array, we check the position relation with the next pixel and determine the connection direction of the pixel as shown in Fig. 1 and then store the direction information in the array. Because the outline of the object is in the form of a connected closed curve, the direction of the last pixel in the array is determined by examining the positional relationship with the first pixel in the array.

Step 5) The pixels stored in the array have current position information and direction information. For each pixel in the array, we group consecutive pixels with same direction together into a line segment instead of a set of points. The length of the line segment is stored in the pixel at the start position of the segment, and its flag is set to 1 to indicate that the pixel is a meaningful pixel. The flags of all other pixels constituting the line segment are set to 0 to indicate that they are meaningless pixels. For the last pixel in the array, its length and flag value are decided by examining them with those of the first line segment in the array.

Step 6) For each pixel stored in the array, the meaningless pixels with flag 0 are eliminated. At the end of this process, all line segments in the array have different directions. The x-position and y-position of each line segment mean the starting position, the direction is the direction of the line segment, and the length is the length of the line segment.

Step 7) Edge_Length_Thresholding_Value is the predefined minimum length representing the outline of the object in the input image. Thus, the lengths of all line segments stored in the array is repeatedly examined in the following manner, and line segments with lengths smaller than this value are removed by merging it into one of the neighboring line segments.

Step 7.1) Find the line segment with the shortest length among the line segments stored in the array.

Step 7.2) If the length is greater than or equal to Edge_Length_Thresholding_Value, the adaptive thinning algorithm is terminated because the lengths of all line segments in the array are greater than or equal to the minimum length of the line segment representing the outline of the object.
Step 7.3) If the length is less than Edge_Length_Thresholding_Value, the line segment is removed by merging it into one of the two neighboring line segments according to the lengths and directions of the two neighboring line segments in the following manner.
Step 7.3.1) Let the current line segment be CLS(Current Line Segment), the previous line segment PLS(Previous Line Segment), and the next line segment NLS(Next Line Segment).
Step 7.3.2) If the direction of the PLS is same to the direction of the NLS,
Step 7.3.2.1) If the length of the PLS is less than or equal to the length of the NLS, then add the length of the CLS to the length of the PLS and remove the CLS from the array.
Step 7.3.2.2) If the length of the PLS is greater than the length of the NLS, then add the length of the CLS to the length of the NLS and remove the CLS from the array.
Step 7.3.3) If the direction of the PLS is different from the direction of the NLS,
Step 7.3.3.1) If the length of the PLS is greater than or equal to the length of the NLS, then add the length of the CLS to the length of the NLS and remove the CLS from the array.
Step 7.3.3.2) If the length of the PLS is less than the length of the NLS, then add the length of the CLS to the length of the PLS and remove the CLS from the array.
Step 8) In order to show the calculation result on the screen, draw outline of the object by drawing line segments stored in the array continuously.

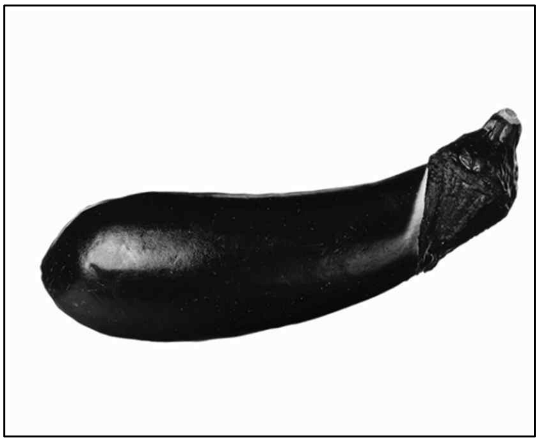

Figure 2. Black and White Input Image of Eggplant

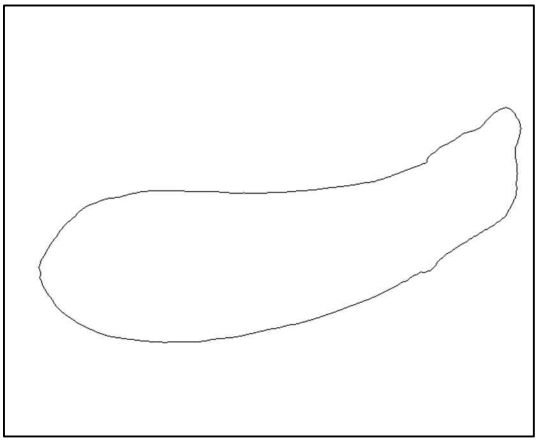

Figure 3. Outline of Eggplant in Input Image with 1320 Pixels

3.2 The Results

Figure 2 shows a black and white image of eggplant as an input object. Figure 3 shows the simplified outline of the eggplant obtained by applying the adaptive thinning algorithm [8] after applying edge detection method to the input image and then extracting the whole line segments of the eggplant in the input image. The outline of the eggplant shown in Figure 3 consists of 1320 number of pixels. Figure 4 shows the selected 93 number of pixels above the outline in Figure 3 when Edge_Length_Thresholding_Value is set to 9. Figure 5 shows new outline created by connecting every two consecutive pixels of 93 number of pixels representing the outline of the eggplant in a straight line. Comparing Fig. 4 and Fig. 5, the outline in Fig. 5 looks more angled at the corners when compared with the outline in Fig. 4 because it is formed by connecting those pixels in straight lines. Figure 6 shows the selected 54 pixels above the outline in Figure 3 when Edge_Length_Thresholding_Value is set to 15. Figure 7 shows new outline made by connecting every two consecutive pixels of those 54 number of pixels in straight lines. Comparing Fig. 5 and Fig. 7, the outline in Fig. 7 looks more angled at the corners when compared with the outline in Fig. 5. As a conclusion, the larger the Edge_Length_Thresholding_Value is, the more line segments are removed, so the outline of the object becomes more simplified.

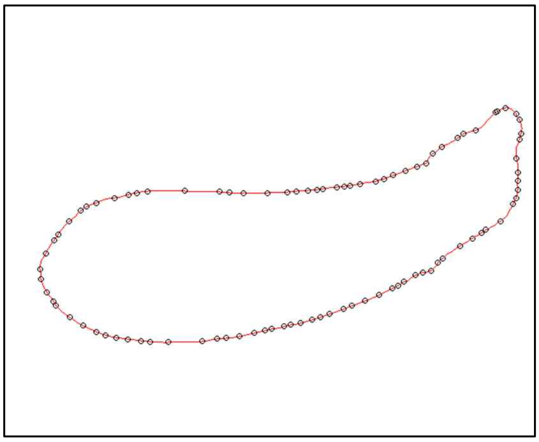

Figure 4. 93 Pixels Composing Outline of Eggplant in Input Image

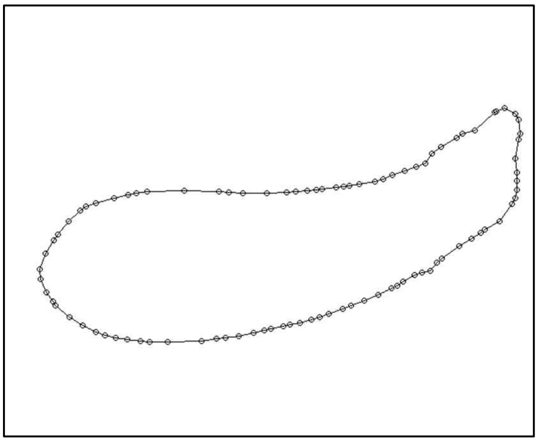

Figure 5. New Outline Made by Drawing Two Consecutive Pixels of 93 Pixels in Straight Line

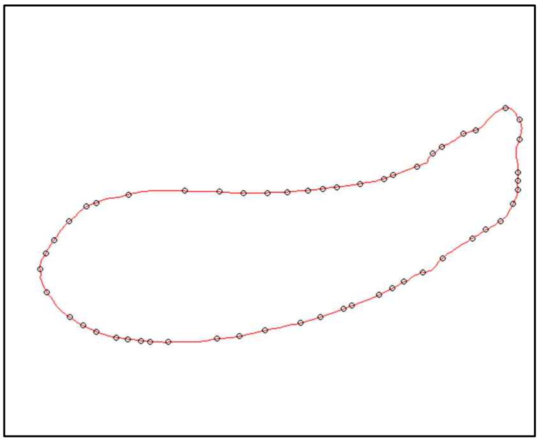

Figure 6. 54 Pixels Composing Outline of Eggplant in Input Image

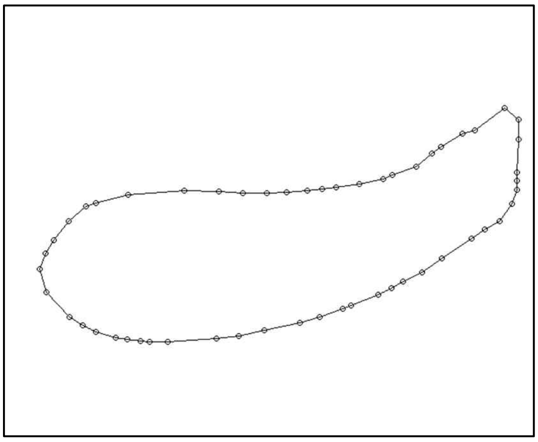

Figure 7. New Outline Made by Drawing Two Consecutive Pixels of 54 Pixels in Straight Line

3.3 The Pros and cons of the proposed algorithm

Like other image processing techniques, there are pros and cons in the proposed method. Advantages include: 1) The amount of information representing the input image might be reduced by simplifying the outline of object in the input image. 2) It is possible to simplify the object recognition process by expressing the outline of the object with a small number of pixels. The disadvantage is that different results might be obtained depending on the minimum length of the line segment representing the outline of the object in the input image.

4. Conclusion and Future work

In this paper, we proposed a method to simplify an object in the input image by expressing the information of 2D image as a set of vertices. Through this process, the amount of data to be processed in the recognition process might be reduced by defining an object in the input image as a set of small number of vertices. As a future research, we are studying a method of creating 3D objects in real space by using the simplified outline representation method of objects developed in this paper.

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