Deletion of Ellipse Enclosing Characters

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Abstract

In this paper, we introduce a new simple proposal for deletion of ellipse enclosing character in documentary images. In this proposal, ellipse enclosing character is labeled, parameters for the center point of an ellipse are found using circumscribing rectangle of the labeled ellipse, the parameters for half-lengths of the major axis and minor axis are determined by finding the farthest point and the nearest point on labeled ellipse from the center point, the ellipse orientation is determined by finding the angle between major axis and horizontal direction, then the ellipse is modeled using these parameters. Ellipse detection is conducted counting the number of black pixels on the ellipse model. Finally, ellipse enclosing characters are distinguished from characters having an ellipse shape. Results of the experiments using appropriate images showed the effectiveness of our proposal. The sections that follow detail problems overcome and our projected work.

1. Introduction

The detection of objects is an extremely interesting area in image processing. In this paper we propose a new effective method to detect the ellipses in the images. Many existing direct methods for ellipse detection use Hough Transform[1 〜 4]. But the classical Hough Transform is very time consuming and requires precise data for accuracy. A fast method of ellipse detection is introduced by Xie et al. [5]. This method takes advantage of the major axis to find the ellipse parameters. In comparison with the Hough Transform a one-dimensional accumulator array is necessary to accumulate the length information for the minor axis. Our method is more simple and less time consuming than above methods. The main objective of our work is to detect and delete the ellipses enclosing characters in documentary images. Specifically, when the ellipses enclosing characters are detected, only ellipses should be deleted, without deleting characters. In the documentary images, there are some letters like the “O” in the English alphabet and the 0(zero) in digits which are almost the same as an ellipse. The documentary images which are used for experiments are written in Japanese or English. Some of the Japanese and English characters include elliptical parts. One main feature of our proposed method is to be able to distinguish ellipses from these kinds of characters.

Character recognition is a developing technology in pattern recognition [6〜9]. Sometimes the ellipses enclosing characters in documentary images interfere with character recognition. Character recognition software such as the OCR(Optical Character Reader) often considers these ellipses as a character, and creates unexpected results in recognition. Our method can be used to delete these ellipses on documentary images to improve character recognition.

This new proposal has the ability to detect ellipse and circle enclosing characters at the same time, because it consider the circle as a specific shape of an ellipse. Before applying the proposed method as pre-processing, images should be binarized keeping a white background and black objects.

2. Related Works

Some ellipse detection methods are related to Hough Transform(HT)[1 〜 4]. The classical HT is very time consuming and requires precise data for accuracy. However, a generalized HT and its applications to machine vision problems, including the detection of circles, ellipses and free-formed shapes are discussed by Davis et al. [2]. This generalized HT needs a model description to search for and an extension for rotation and scale invariance comes with higher computational time. Ho and Chen [10] constituted two midpoint arrays by considering pairs of edge points in the same horizontal and vertical positions. From these two arrays the straight lines are detected separately by the HT and their intersections provide possible centers for ellipse. Then three other parameters of the angle and their major and minor axes remain to estimated. The method introduced by Xie et al. [5] takes the advantages of the major axis of an ellipse to find ellipse parameters fast and efficiently. It only needs an one-dimensional accumulator array to accumulate the length information for minor axis of the ellipse. A.S. Aguado et al.
use the parameteric polar representation to extend the application of edge directional information from circle to ellipse extraction. As a result they obtain a mapping which decomposes the parameter space required for ellipse extraction into two independent sub-spaces and one final histogram accumulator. The mapping includes the tangent of the angle of the first and second directional derivatives. These tangents are computed by considering edge direction at two border points. Qiang Ji et al. [12] introduce a statistically efficient method for detecting ellipse in an image. Given a set of digital arc segments, they introduce a geometric criteria to select possible pairs of arc segments belonging to the same ellipse. One main objective of our work is to detect and delete the ellipse enclosing character without affecting characters. Above conventional methods are not effective enough for this objective, because, they cannot distinguish elliptical characters from the ellipses enclosed character and most of them are very time consuming.

3. Ellipse Deletion

This section describes the pre-processing and mechanism to detect the ellipses.

3.1 Pre-processing

In this study, binarization and tilt correction processes are applied to the input image as the pre-processing. In the binarization process, Ohtsu’s method using discriminant analysis is applied [13][14]. In this method threshold for binarization is determined automatically. The LPP(Local Projection Profile) method is used for tilt correction [15].

3.2 Proposal for Deletion of Ellipse Enclosing Characters

In this section, we introduce a new mechanism to delete ellipses enclosing characters in documentary images. In this method, image is scanned on vertical parallel lines for detecting the ellipses as shown in Fig. 2. Here, the general equation for ellipse having a different orientation is applied for detection. This general equation is shown in following Equation (1). The algorithm for this proposal can be described as below.

\[ \frac{(x-x_0)\cos\theta+(y-y_0)\sin\theta}{a} \cos\theta - \frac{(x-x_0)(y-y_0)\cos\theta}{b} = 1 \]

Algorithm for ellipse Deletion

Step 1: The image is binarized using Discriminant Analysis and tilt correction is conducted using LPP method.

Step 2: The image is scanned on vertical parallel lines keeping the distance between two consecutive lines as 30 pixels (Fig. 2).

Step 3: If the scanned pixel( i , j ) is black, conduct labeling process starting from it, setting the same label for all connected black pixels.

Step 4: Determine the circumscribing rectangle of labeled area in Step 3.

Step 5: The following processing is conducted according to the size of the circumscribing rectangle determined in Step 4

(i) If the size of the circumscribing rectangle (width x height) is less than 35 x 35 pixels go to Step 11.

(ii) If the size of the circumscribing rectangle (width x height) is greater than 35 x 35 pixels, assume that an ellipse exists belonging to the middle point of circumscribing rectangle as the center point and calculate the middle point \((x_0, y_0)\) as Fig. 1. The center point of the circumscribing rectangle and the center point of the ellipse is the same point. In Fig 1, green indicates the labeled area and purple indicates the circumscribing rectangle. Go to Step 6.
Step 6: The major axis direction of the assumed ellipse in Step 5 (ii) is decided depending on the width and height of the circumscribing rectangle, and the half length of the major axis is determined as below.

(i) If the width is greater than the height the assumed ellipse has a nearly horizontal major axis. Find the farthest point from center point \((x_0, y_0)\) in the right side of the labeled area. The distance between the center point and farthest point \((a_x, a_y)\) becomes half length of the major axis \(a\) as shown in Fig. 1. Go to Step 7.

\[
\tan \theta = \frac{a_y - y_0}{a_x - x_0} \quad \text{…………………(2)}
\]

\[
\theta = \arctan\left(\frac{a_y - y_0}{a_x - x_0}\right) \quad \text{…………………(3)}
\]

(ii) If the width is less than or equal to the height, the assumed ellipse has a nearly vertical major axis. Find the farthest point from center point \((x_0, y_0)\) in the upper side of the labeled area. The distance between the center point and farthest point becomes half length of the major axis \(b\). Go to Step 7.

Step 7: Calculate the inclination of the line connecting the center point \((x_0, y_0)\) and found farthest point \((a_x, a_y)\) in Step 6 as Equation (2). Obtain the ellipse orientation \(\theta\) using calculated inclination following Equation (3). Determine the equation for the line which crossing the center point \((x_0, y_0)\) and perpendicular to the major axis obtained in Step 6. In Fig. 1, this line is indicated by a dash line.

Step 8: The following processing is conducted according to the direction of the determined line in Step 7.

(i) If the determined line is nearly vertical, find the farthest point on it from the center point \((x_0, y_0)\) in the upper side of the labeled area, and calculate the distance between this farthest point \((b_x, b_y)\) and center point \((x_0, y_0)\). This distance becomes half length of minor axis \(b\) as shown in Fig. 1.

(ii) If the determined line is nearly horizontal, find the farthest point on it from the center point \((x_0, y_0)\) in the right side of the labeled area, and calculate the distance between this farthest point and center point \((x_0, y_0)\). This distance becomes half length of minor axis \(a\).

Step 9: Form an ellipse model using the center point \((x_0, y_0)\), half length of the major axis, orientation, and half length of the minor axis obtained in the above steps.

Step 10: Count the black pixel rate on the created ellipse model in Step 9 following Equation (4) and conduct the following processes.

(i) If the black pixel rate on this model is less than 0.7, go to Step 11.

(ii) If the black pixel rate on this model is greater than 0.7, detect the black pixels on the model as an ellipse. Delete these detected black pixels setting them to white pixels.

Step 11: Move to next pixel \((i, j)\) in raster scanning and return to Step 3.

\[
\text{black pixel rate} = \frac{\text{The number of black pixels on ellipse model}}{\text{The number of black and white pixels on ellipse model}} \quad \text{………(4)}
\]

In the above algorithm, the size of the rectangle \((35 \times 35\) pixels\) which circumscribes the connected component was determined by a preliminary experiment. In this experiment, first the widths and heights of twenty ellipses were measured. The minimum height and width of those twenty ellipses were 38 pixels and 39 pixels respectively. Tentatively we decided to use \((width \times height)\) as 35 \(\times\) 35 pixels.

3.3 Distinguishing Ellipse Enclosing Characters from Characters Having an Ellipse Shape

Above algorithm for ellipse deletion can distinguish ellipses enclosing characters from the elliptical characters automatically, when characters are smaller than a certain size, because, it can detect ellipses having a circumscribing rectangle \((width \times height)\) greater than 35 \(\times\) 35 pixels. However, the larger size characters (greater than 35 \(\times\) 35 pixels) have same shape as ellipse can also be deleted as an ellipse enclosing characters.

A simple method is introduced to solve this. The ellipse enclosing characters includes black pixels inside the ellipse, but elliptical characters such as the ‘O’ in the English alphabet and the zero(0) digit do not. In this method, if the ellipse is detected, decide whether it is the ellipse enclosing the character or a character has same shape as ellipse, by counting the number of black pixels inside. A threshold is set to make this decision. We use 20 black pixels as threshold. If the number of black pixels inside the ellipse is less than 20, it is considered as a character has an ellipse shape, otherwise it is considered as an ellipse enclosing character.

4. Experimental Results and Discussion

In this paper, all the experiments were conducted using a Pentium iv 2.8GHz PC. The appropriate images of documents for experiments were created by a digital image scanner with a resolution of 300 dpi. The size of created images is 2480 \(\times\) 3508 pixels.
Fig. 3(a) Extracted image from a documentary image

Fig. 3(b) The result after ellipse deletion for Fig. 3(a)

Fig. 4(a) Extracted image from a documentary image

Fig. 4(b) The result after ellipse deletion for Fig. 4(a)

Fig. 5(a) Extracted image from a documentary image

Fig. 5(b) The result after ellipse deletion for Fig. 5(a)
Fig. 6(a) Extracted image from a documentary image

Fig. 6(b) The result after ellipse deletion for Fig. 6(a)

Fig. 7(a) Extracted image from a documentary image

Fig. 7(b) The result after ellipse deletion for Fig. 7(a)

Fig. 8(a) Extracted image from a documentary image

Fig. 8(b) The result after ellipse deletion for Fig. 8(a)
Six documentary images including 56 ellipses enclosing characters were used for the experiments. They were processed for binarization, tilt correction, and ellipse deletion in order.

4.1 Results

Figure 3(a), 4(a), 5(a), 6(a), and 7(a) show the extracted images from different documentary images including ellipses enclosing characters. Their ellipse deletion results are shown in Fig. 3(b), 4(b), 5(b), 6(b), and 7(b) respectively. Figure 8(a) also an extracted image from a documentary image and its ellipse deletion result is shown in Fig. 8(b). This includes two accurate deletions and two false deletions. This proposal could delete ellipse enclosing characters with a success rate of 87.5%(49/56).

4.2 Discussion

In this paper, we introduce a new simple proposal for deletion of ellipse enclosing characters in documentary images. The algorithm which was introduced to delete ellipses enclosing characters was effective with a success rate of 87.5%. In this algorithm, ellipses were deleted regardless of the ellipse orientation and the entire image was not scanned for ellipses detection. This algorithm finds the ellipses determining its circumscribing rectangle. In the case when the ellipse is connected to other objects outside, it was not be able to find the real circumscribing rectangle for the desired ellipse. As a result of this, some ellipses were not detected effectively in the experiments. Figure 8(b) is an example for failure deletion.

In the experiments, no character was deleted that has same shape as ellipse, as this algorithm can distinguish the characters has same shape as ellipse from the ellipses enclosing characters, when character is smaller than certain size automatically. And if the character is bigger, our proposed method for distinguishing ellipse enclosing characters from characters having an ellipse shape could identify the difference. The documents used for the experiments were almost entirely written in Japanese. But, some places are written in English as well. Some Japanese and English characters have elliptical parts. This algorithm did not affect those parts as well.

5. Conclusions

In this paper, we introduce a new simple proposal for deletion of ellipse enclosing character in documentary images. In this proposal, ellipse parameters were found by labeling the ellipse and entire image was not scanned for ellipse detection. After finding the ellipse parameters, ellipse is modeled. Ellipse extraction is conducted counting the number of black pixels on the ellipse model. Finally, ellipse enclosing characters are distinguished from characters having an ellipse shape. Experiments using appropriate images showed the effectiveness of our proposal. In the case when the ellipse is connected to other objects outside, it was not be able to detect the ellipses. As a future work, we plan to improve this algorithm to solve this problem.

6. References


