Key Techniques of Modern Graphical Symbols and Color Recognition Based on Arc Segmentation Algorithm

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Abstract

Modern graphic symbols are widely used in social life as information medium. The scanner or image processing system can transfer the graphs into computer and convert them into image data, which people can use conveniently and effectively for storage, management and transmission. Graphic symbols and color analysis and recognition are mainly about how to use computer vision, pattern recognition and other methods to convert the contents of paper documents or images on the Internet into the information which can be processed by the computer. The research of graphic symbols and color analysis and recognition has drawn wide attention in the world, and the research of related technologies has been making progress. However, there are still many unsolved problems. The graphs include two kinds of text documents and images. This paper aims to study the concrete symbols and colors represented by graphs. Based on the arc segmentation algorithm, the paper focuses on the recognition and graphs of the graphs (such as lines, arcs and curves) and symbol recognition and the like, in order to achieve an effective analysis and identification of graphical objects and colors.

Keywords: Arc Segmentation Algorithm, Modern Graphs, Color Recognition, Calculation Method.

1. RESEARCH BACKGROUND

1.1 Literature review

The advent of an information society has led to a trend of digitization of documents. On the one hand, the vast majority of documents that record the history and culture of human development are in the form of paper medium. All countries in the world are actively seeking ways to better preserve and utilize the tremendous wealth of this human civilization. However, paper documents are not easily preserved, which are easily damaged with low retrieval rate while occupying much space. These paper documents are to be digitized in the form of establishing a digital library is an effective solution to this problem (Li and Du, 2016). On the other hand, with the rapid development of the Internet, there are a large amount of digital image information captured by mobile phones and other devices on the Internet. In today’s digital library, a large amount of document image information is collected. Its management becomes challenging. In the construction of digital library, it is important to study how to efficiently transfer paper documents into the computer remain. The existing paper documents of a wealth of information cannot be transferred to the computer manually. Only canning or filming paper documents into document images which are transferred into the computer for further processing (Liu and Wang, 2016). Document Image processing can be divided into two categories, texture processing and graph processing. Document images, represented by engineering drawings, are abundant in daily life. Converting these drawings into electronic format can reduce the storage capacity and provide retrieval and sharing service in the digital library. The use of computer technology to digitize the engineering drawings is to identify and understand the main contents of engineering drawings. Research on identifying and understanding engineering drawings both at home and abroad has been going on for many years. However, most of the researches are focused on better-quality engineering drawings; the use of current methods proves to be unsatisfactory for a large amount of old drawings of poor quality.

1.2 Research purposes

This paper proposes a feature extraction method of statistical integration constraint histogram based on the key points. Image moment is a very powerful descriptor, which is used to extract the characteristics of symbols (Zhang, 2016). The multiple features is combined with multi-image and semi-supervised machine learning methods to identify symbols, and a semi-supervised drawing symbol recognition method based on multi-feature and multi-image is proposed. The experiment first evaluates the performance of various moments, analyzes the relationship
between the order of moments and the recognition rate, and finally discusses the performance of the symbol recognition method, in order to solve the problem of low efficiency when using a variety of features to calculate.

2. MODERN GRAPHICAL SYMBOLS AND COLOR RECOGNITION METHODS BASED ON ARC SEGMENTATION ALGORITHM

2.1 Arc recognition method

Not all seed segments can extend straight in the process of identifying a straight line. Arcs, ellipses, parabolas, or curves will be used for these seed segments. Due to the inability to determine the type of graph in which the seed segment is located, the arc, ellipse and parabola are used to approximate the graph and three error values are calculated (Wang and Qi, 2017). If the minimum error is less than or equal to the given threshold, the one with the smallest error value is the type of the graph in which the seed segment is located; if the minimum error is greater than the given threshold, it means that the graph of the seed segment is not a curve, an ellipse or a parabola. The arc is used to approximate the graph and the error value is calculated. If the error value is less than or equal to the given threshold, the graph is arc; if the error value is greater than the given threshold, the graph is represented by other types of graphs.

To determine whether the graph is arc, the following three steps are used. The first step is to calculate the seed segment. Unlike the square calculation of seed segments when determining straight lines, a fixed radius auxiliary circle is used to calculate the seed point, as shown in Figure 1. Scanning the image of the black pixel P as the center of the circle with a fixed length as a radius can form an auxiliary circle. Calculate the intersection point $A_i$ $(i=1, 2)$ of the auxiliary circle and the point P (Zhang, 2015). The intersection $A_j$ $(j=3, ..., n)$ along the expanding radius with P as the center of the circle is obtained. The calculation the intersection point can use line width to remove some of the noise point, so as to ensure that the number of n intersection points are located in the same graph.

![Figure 1. Calculation of Seed Points](Image)

The second step is to calculate the parameters. Based on the focal points $A_i, A_j$ and P from the random selection of focus crowd, circle parameters can be calculated according to the line surface formula. The final circle center coordinates $(a, b)$ and the radius R can be obtained by way of working the averaging for many times. Suppose

$$x_1 = A_i.x, y_1 = A_i.y, x_2 = P.x, y_2 = P.y, x_3 = A_j.x, y_3 = A_j.y, h_1 = \frac{y_1-y_3}{x_1-x_2}-\frac{y_1-y_2}{x_1-x_3}$$

$$g_1 = x_2 - x_3 + \frac{y_2^2-y_3^2}{x_1-x_2} - \frac{y_1^2-y_3^2}{x_1-x_3}$$

Then $b = \frac{1}{2} \frac{g_1}{h_1}$, suppose $h_2 = \frac{x_1-x_2}{y_1-y_2} - \frac{x_1-x_3}{y_1-y_3}$, $g_1 = x_2 - x_3 + \frac{y_2^2-y_3^2}{x_1-x_2} - \frac{y_1^2-y_3^2}{x_1-x_3}$.
Then $\bar{a} = \frac{1}{2} \cdot \frac{g_2}{h_2}$, the radius $\bar{R}$ is calculated based on the above formula with the number value of $\bar{b}, \bar{a}$.

$$\bar{R} = \sqrt{(x_1 - \bar{a})^2 (y_1 - \bar{b})^2}$$  \hspace{1cm} (3)

The third step is to calculate the error value. The total error for the number of n focal points is calculated using the formula

$$\sum_{i=1}^{n} |y_i - a \ast (x_i - h)|^2$$

according to the center coordinates $(a, b)$ and radius $R$. $A_i, x$ and $A_i, y$ represent the x, y coordinates respectively of the point $A_i$. The threshold is set as $\theta$, and if the total error is less than $\theta$, then the graph is considered as arc, otherwise the other type of graph is used to approximate the graph (Wang and Cang, 2015).

2.2 Parabolic identification method

The process of parabolic graphs identifying the graphs is divided into three steps. The first step is to calculate the seed segment. The number of n of intersection points has been obtained while approaching the graph with an arc, and these intersection points will continue to be used in the subsequent calculations. The second step is to calculate the parameters. Three points are randomly selected from the number of n intersections, and the curvature of the graph formed by the three points needs to be greater than a given threshold (Chu, 2015). The condition is to ensure that the selected points are located as close as possible to the vertex so that a more accurate parabolic parameter can be calculated. Selecting multiple sets of data that satisfy this condition, the final parabolic parameters $h$, $a$, and $k$ are determined through multiple averaging calculation. The parabolic parameters are calculated in the cases of $A_u, A_v$ and $A_w$.

Suppose

$$x_1 = A_u, x, y_1 = A_u, y, x_2 = A_v, x, y_2 = A_v, y, x_3 = A_w, x, y_3 = A_w, y;$$

$$A_1 = (y_1 - y_2) \ast (x_1 - x_3), A_2 = (y_1 - y_3) \ast (x_1 - x_2), A = A_1 / A_2, x_{12} = x_1 + x_2, x_{13} = x_1 + x_3.$$

$$\bar{h} = \frac{A \ast x_{12} - x_{13}}{2(A - 1)}, \bar{a} = \frac{y_1 - y_2}{(x_1 - x_2) \ast (x_1 + x_2 - 2 \ast \bar{h})}, k = \frac{y_1 - \bar{a} \ast (x_1 - \bar{h}) \ast (x_1 - \bar{h})}{(x_1 - \bar{h})^2}$$  \hspace{1cm} (4)

The third step is to calculate the error value. The total error is calculated using the formula

$$\sum_{i=1}^{n} |y_i - a \ast (x_i - h)|^2$$

based on the parabolic parameters $h$, $a$ and $k$. If the threshold is less than $w$, the graph is a parabola; otherwise other similar graphs are used to approximate the graph.

3. CALCULATION BASED ON FITTING OF PARAMETERS OF MODERN GRAPHICAL SYMBOLS

3.1 Seed Point Selection Method

**Input:** N seed points(SPs)

**Output:** Good SPs

1. Use method of Section 3.2.1 to compute line width $W$ of graph having N SPs;
2. if $W \times 2^{i-1}$
3. for $i$ to N
4. Find the middle pixel around the $i$th SPs, every time move a pixel;% Find the pixels in the middle position
5. Save the good SPs;%Preserve the appropriate seed points
6. if $W \times 2^{i-1}$
7. Thin graph to get the two middle pixels;%Find the most intermediate two lines of pixels
8. for $i$ to N
9. Find the outer(or inner) pixel, every time move a pixel;%Find the appropriate pixels
10. Save the good SPs;

**Figure 2.** Selection of Seed Point Methods

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When calculating the seed points, the noise is produced with the to-be-processed graphs, which will seriously affect the precision of the graphic parameter. In order to get the right seed point, the line width can be used to exclude the noise with different line width of the point P (as shown in Figure 2). According to the parity of line width, different strategies are adopted to obtain a more appropriate seed point.

When the line width is an odd number, a line width of 3 pixels is taken as an example as shown in Figure 3. A black pixel indicates a portion of the graph to be processed, and white square pixels are suitable seed points because the middlemost pixel is likely to be on the same graph with fewer outermost layers or the most inner pixel. When calculating seed points, the white points of the multiple points encountered are selected as seed points (Kong and Zhang, 2010). Based on the same principle, when the line width is an even number, a line width of 2 pixels is taken as an example. The black block represents a part of a circular arc. If a certain seed point selects a circular block, the remaining points select the circular block; if a seed point selects the square block, the remaining points select the square block, so as to ensure that these seed points are located in the same graph. When the line width is a multiple of 2, the pixels are refined from both sides of the arc at the same time, and only the middlemost black pixel is used to calculate the seed point.

![Figure 3. Line Width of Three Pixels](image)

3.2 Line width calculation method

![Figure 4. Line Width at the Point P of the Calculation Point](image)

Line width is a property of graphs (lines, arcs, ellipses, parabolas, etc.), and finding the exact line width helps calculate the proper seed point. Scanned engineering drawings are binary images against a white background. When a black pixel P is encountered as shown in Figure 4, in order to obtain an accurate line width, the number of pixel points in each direction is calculated from four directions of horizontal direction, vertical direction and two diagonal lines with the number of pixels in each direction as the weight of the direction. From these four directions, the same weight and the biggest number of values are selected as the line width value of the point.
(Zhang, 2016). There are 11 pixels in the horizontal direction of the graph, that is, the weight of such direction is 11; there are 3 pixels in the vertical direction, and there are 3 pixels and 5 pixels in the two diagonal lines respectively; then the total number of 3 pixels is 2, the number of 11 pixels and the number of 5 pixels are both 1, so the line width of point P is 3 pixels. Sometimes the line width is the same in all four directions at point P, which must guarantee the same line width in both directions at least, which is the selection criterion for the dead point (Li and Lv, 2017). The line width values at the other seed points are calculated in the same way, of which the most frequent value is taken as the line width of this arc. There are two advantages of adopting the most frequent value as the line width of the point. On the one hand, the accuracy of the calculation result can be guaranteed; on the other hand, the method can reduce the error if the graph contains noise.

3.3 Performance of fitting method

The performance of IIVE is assessed and the performance of IIVE is compared with the performance of IVE and AG. The experiment uses the classical data with a total of eight coordinate points, and the fitted circle has the smallest sum of errors to the eight points, which is the best. The fitting results of the visual map are shown in Figure 5, judging from which the IIVE and AGE fitting results are better than the IVE algorithm fitting effect. Among the fitting results and errors, the IIVE algorithm has the smallest error, so the fitting effect of IIVE is better than that of IVE and AG.

![Figure 5](image)

**Figure 5.** Comparison of IIVE, IVE and AGE with Classical Data

4. MODERN GRAPHIC SYMBOLS AND COLOR REMOVE METHOD

4.1 Geometric segmentation

4.1.1 Use constraint to remove noise points

Since the line width of the arc where the noise point P14 is located is the same as the line width of the arc where the point P is located; since P14 and P are not located on the same arc, there are white pixels in the line segment between two adjacent seed points P3 and P14 (Chen and Fang, 2017). The process is as follows, starting from the dead point, they are spread to both sides. The point of intersection with the auxiliary inner circle is calculated, that is, to examine whether the pixel points of the line between PP3 and pp12 are all black. If some pixels are not black, then the seed points added later are noise points, which should be removed. If all the pixels are black, then continue to expand them to the side, with P3, P12 connected to the points intersected with the excircle on the same side, namely, P3 are connected to P4 and P14 respectively to form lines P3P4 and P3P14, and P12 is used to connect P13 to form line segment p12p13. According to the strategy, there is white pixel between line segments P3P14, and P14 is removed.
4.1.2 Use auxiliary inner circle to remove noise points

After calculating the coordinate of the seed points $P_1$ and $P_2$ through the auxiliary inner circle $C_1$ processing arc $C_3$. The coordinates of the two seed points can be calculated by $y = f(x)$ running through the two seed points. $P_0$, $P_3$ and $P_4$ must be on both sides of the line, and the coordinates of these seed points satisfy the following relationship:

$$
(y_{p0} - f(x_{p0})) \cdot (y_{p3} - f(x_{p3})) \cdot (y_{p4} - f(x_{p4})) \leq 0
$$

(5)

If calculating the coordinate of the seed points $P_3$ and $P_4$ through the auxiliary excircle $C_2$ processing arc $C_3$ fails to meet the above relationship, then the seed points are noise points. When the radius of the processed arc $C_3$ is similar to the radius of the auxiliary excircle $C_2$ of the auxiliary inner circle $C_1$, it is easy to find a suitable seed point. With these seed points, the accurate arc parameters can be calculated (Xu, 2013). The calculated arc parameters will not be accurate enough when the radius of the arc to be processed is larger than the radius of the auxiliary inner circle and excircle.

4.2 Arc Identification Method

After the center coordinates and the radius are calculated, the arc trajectory can be redrawn by using the classical Bresenham circle algorithm. The principle of the algorithm is shown in Figure 4-11. That is, a point (x, y) can be obtained by using four symmetry axes to obtain the other seven points, drawing a complete circle required with only a point from an arc of one-eighth. The Bresenham algorithm can also be used to differentiate the arc. The process is to obtain the coordinates and radius of the circle center. Bresenham algorithm is used to generate all the auxiliary points on the auxiliary circle. The auxiliary points are the pixels in the image. Each auxiliary point corresponds to an angle value and a of the angle values range from 0 to 360 degrees. By comparing the size of the angle values, the sequencing order can be obtained between these auxiliary points (Wang, 2012). Since each auxiliary point is a pixel in the image, there is a grayscale value at that location. The black pixel is the point on the arc and the white pixel is on the background. In order to determine whether the arc is a full circle or a partial circle, the grayscale values of all the auxiliary points are checked one by one according to the angle. If all the auxiliary points are black pixels, then the arc is a complete circle, otherwise it is a partial circle. It is inefficient to perform inspections in terms of increasing angles. The difference between the angle values of adjacent points in the box may be as small as 0.01 (or even less), while the increase in angle is too small which needs to be inspected multiple times to find the point at which the angle value changes significantly, which is more pronounced when
the arc being processed is a full circle or near full circle (Yang, 2012).

![Figure 7. Bresenham Algorithm](image)

The number of pixel points on the circumference is divided into two types, redundant point and non-redundant point. Redundant point refers to the auxiliary points of the same angle values. When the arc radius is 450 pixels, Bresenham circle-drawing algorithm can draw a circle. If there are redundant points in the circle, the total number of points is 59548. If these redundant points are removed, then the number of the points on the circle is 2644. Finding the following points of different angle values need an average of 25 times for differentiating (Li, 2014). When the radius of a circle is larger, the number of differentiating times is larger. Based on the above analysis, this paper uses the method of uniformly distributed points to judge the arc to improve the efficiency. The core idea of this method is to distribute the points with different angle values on the circumference, so that the arc can be quickly identified.

5. CONCLUSION

This paper focuses on the recognition of modern graphic symbols and colors. The graphic elements are ubiquitous among the graphs. Accurately handling the graphic elements can better understand the specific graphic connotation. In dealing with the graphs, the types of graphs should be identified first, the type of graphic parameters should be calculated, and at last these graphs should be segmented. There are many types of modern graphic symbols, different colors, and different sizes and shapes of symbols with noises which needs conversion of rotation. Therefore, the scientific use of circular arc segmentation algorithm can further identify different kinds of graphic symbols and corresponding colors, which can improve in-depth exploration and development in relevant fields and provide favorable reference for feasible solutions.

REFERENCES

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