Research on Image Processing Based Component Localization Techniques

Jiawen Liu,Yixin Su
School of Automation.Wuhan University of Technology, Wuhan, Hubei, 430000, China
2287042927@qq.com

Keywords-image processing; workpieces localization; Hough Transform

Abstract—Affected by influence factors such as physical lighting environment or joining structures of the workpieces, etc., the positioning of workpieces by image processing may have huge deviation and are even not the location of the final target workpiece. This article realizes objective workpieces positioning by an optimization algorithm combining generalized Hough Transform and Contour extraction. In the algorithm contour extraction is introduced to carry out edge detection by using image binaryzation together with image corrosion technology. The boundary information of the template can be fabricated into a reference table (R-Table) and then to conduct matching voting. The simulation results show that this algorithm can pinpoint matching template workpieces which benefits the image scale measurement of workpieces later.

INTRODUCTION

The image localization method based on digital image processing technique has a myriad of merits such as non-contact, easy-to-analyze and high speed, etc. Nowadays, it has been widely applied in size measurement of industrial geometric sense, micro-size measurement and appearance detection of precision workpieces [1,2]. With the key localization techniques in image measuring process as the research content, this paper presents a method of the positioning of workpieces in image based on generalized Hough Transform. A drawback of the generalized Hough Transform algorithm is that it is only limited to single complicated graphs but incapable of finding the specific target out of the set of multiple complicated graphs [3].Proposing an optimization algorithm combined with generalized Hough Transform and contour extraction to match templates in localization so that it can be better applied in detection of multiple complicated graphs. Edge detection is performed after pre-processing to provide the position of graph contour which includes the location information as required. Afterwards, the optimization algorithm is used to match templates in localization. Finally, the well processed images are output for computer to measure and detect.

LOCALIZATION SYSTEM CONSTITUTION AND KEY TECHNICAL ALGORITHMS

A. System Constitution

The whole system mainly utilizes optical imaging principle to locate the to-be-detected components and magnify their local images, and then employs computer to perform data processing of the collected digital images, and finally trace and locate the components as required.

The images collected by the digital camera are namely the to-be-processed digital images. Interfering noise must exist due to the live environmental and instrumental influence. Therefore, the primary objective of image processing is to filter and eliminate noise and procure accurate and clear-cut image edges, and then to locate the to-be-detected images and perform matching detection, and finally to output the result of matching.

B. Noise Elimination

In filtering and eliminating noise, median filtering is rather an ideal nonlinear filtering method. It is based on the principle of using an odd number contained square window to substitute the median of all points within the window for the value of that point at the center of the window. $f(x,y)$ denotes the gray value of the image at (x,y) after filtering, and $Med\{\}$ denotes finding the median of the window, then the output of median filtering is:

$$f(x,y)=Med\{g(x-k,y-l),k,l\in Q\} \qquad (1)$$

where Q is the size of the selected window.

C. *Edge Detection*

Traditional edge detection methods remain a lot of tiny lines within the boundary image extracted by these operators. In order to eliminate the interference points within the boundary image and highlight the image's outline information, the image binaryzation and image etching combined edge detection technique is adopted here. The procedure of the algorithm is:

(1) Set a threshold value T to perform binaryzation processing of the image to produce Image1;

(2) Use a 3x3 template to perform etching operation of Image1 to produce Image2;

(3) Subtract Image1 from Image2 to produce Image Edge. Although there remain "burrs" in the extracted boundary image, this makes no difference to implementation of the algorithm.

Also, it is hoped that the boundary image can be refined to be made more elaborate. Here the ISEF algorithm (namely Infinite Symmetric Exponential Filter) is employed [4]. This operator is virtually an edge detection operator [5,6]. The practice is to find a filtering function such that the following expression C_N can achieve the minimum.

$$C_N = \frac{2\sqrt{\int_0^{\infty} f^2(x)dx \cdot \int_0^{\infty} f'^2(x)dx}}{f^2(0)} \tag{2}$$

where f(x) is the optimization filter's kernel of ISEF. The concrete procedure of ISEF edge extraction goes as the following:

(1) Decompose the 2D filter's kernel down into two 1D filters' kernels, filter the image along x and y directions before and after;

(2) Apply Laplace Filtering to the result of the previous step. The method is: Subtract the original image I(x, y) from the image y(x, y) via ISEF filtering to get:

$$B(x,y) = y(x,y) - I(x,y) \approx \frac{1}{4a^2} I(x,y) \cdot \nabla^2 f(x,y) \tag{3}$$

Then apply image binaryzation to B(x, y).

(3) Make judgment over the points in B(x, y) whose gray value is 255. If one point is edge point, compute the gradient direction of this point; else, ignore it.

So far, the accurate image edge and the gradient direction at the image's boundary point have been obtained.

D. *Contour extraction and Pattern Matching*

This paper adds some improvements to the generalized Hough Transform algorithm so that it can be better applied in detection of multiple complicated graphs.

Having undergone edge detection, the image is displayed as a discrete point set in the computer. This paper adopts the edge tracing algorithm of Freeman chain code [7] to extract the curve's edge, namely to join up the discrete edge points in series in a certain order point.In the order of the direction of eight vectors of Freeman chain code - V_0 to V_7, the binary image is traced. The first edge point to be encountered during this process is taken as the starting point of a chain code. Scanning and detecting whether there is/are edge point(s) among the eight peripheral points around this point in order. The chain code's length increases whenever an edge point is encountered. Discontinue scanning the eight peripheral points before setting this point as a non-edge point in order to avoid repetitive tracing. Circulation in this way is continued to form a chain code until there is no edge point around a certain point.

A reference point is selected, which is usually the image's center of mass, to indicate the location of the image. After finishing extracting the outline of all sub-images of the template image, the boundary information of the template can be fabricated into a reference table (R-Table). A specific image's R-Table can be jointly created by the boundary points of this image and the specified reference point. It is assumed that the reference point is $C(x_c, y_c)$, and then the distance from a point $P(x_i, y_i)$ on the boundary to the reference point is $r = \sqrt{(x_i - x_c)^2 + (y_i - y_c)^2}$, and the angle between the line *PC* and axis x is $j = \arctan\frac{y_i - y_c}{x_i - x_c}$. In setting up R-Table, save the vector $\vec{r} = re^{ij}$ as a function of the gradient direction q of point *P*. The boundary points saved in R-Table are classified with their gradient direction as index, as shown in Table 1.

TABLE I. R-TABLE

	gradient direction (table q)	Radius-sets $\{rq\}$, $r=\{r,j\}$
1	1^{o}	r_1^1 , r_2^1 , …… , r_{n1}^1
2	2^{o}	r_1^2 , r_2^2 , …… , r_{n2}^2
……	……	……
K	k^{o}	r_1^k , r_2^k , …… , r_{nk}^k
……	……	……
360	360^{o}	r_1^{360} , r_2^{360} , …… , r_{n360}^{360}

Pattern matching needs to be performed after outline extraction is done, in order to find the parts drawing as required. Begin by numbering the sub-graph outlines of the target image in order. Now the Hough Transform method is employed to conduct projection transformation over all the points on the outline of the to-be-detected object in reference to R-Table and find out the subset in R-Table with similar gradient values. The elements of the subset are superimposed separately onto the boundary and the cumulative voting is conducted for the result. Finally, the point with the most cumulative votes is selected as the target's central point of localization and then the result of matching is output. A matching process containing two sub-graphs is shown as Fig.1.

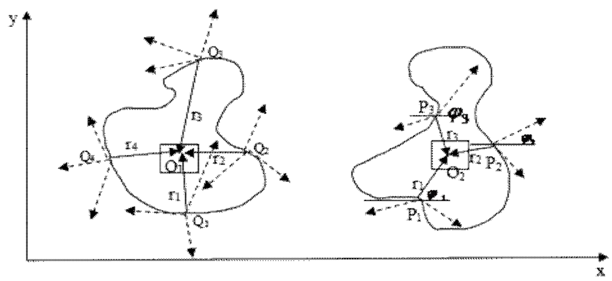
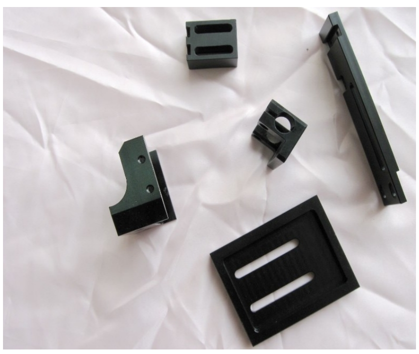


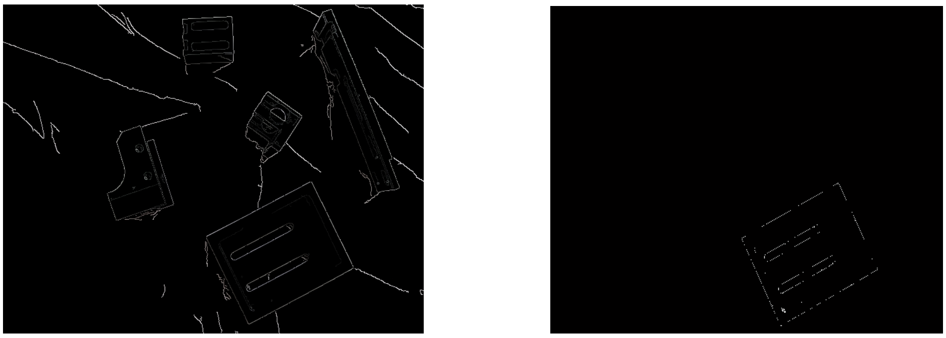
Figure 1. Matching Process.

THE STRUCTURE DESIGN OF SIPHONIC BEDPAN'S FLOW CHANNEL

The to-be-detected component is placed in front of a controllable background with uniform illumination. The multiple incomplete workpieces are placed around to test the reliability of the improved algorithm. The processing process and result are shown as Fig. 2.



(a) the original workpieces (b) the template



(c) edge detection (d) resule of localization

Figure 2. The processing process and result.

Fig.2(a) is the original component drawing, and Fig.2(b) is the template of the to-be-detected workpieces. The processing process goes as follows: Eliminate noise after the pre-processing, remove the vision-affecting irrelevant points on the image's edge and perform edge detection to derive the boundary information graph as Fig.2(c); finally, perform template matching. The optimization algorithm is performed on a regional basis during the voting. Different sub-images will be voted for separately at different moments. A majority of voting points fall onto the image's real central point, and the algorithm only records the coordinates of local peak points and the accumulated poll. All the voting points will be reset after the voting is over in each sub-region. Until the voting is finished for all the sub-images, the global peak points are withdrawn out of them as the ultimate result of localization. Namely, the non-target images are removed that are mismatched with the template, while the remained target image is shown as Fig.2(d).

After introducing the thought of outline extraction, the generalized Hough Transform secures the accuracy of the result of localization; moreover, this algorithm votes for the sub-images of the target image in a selective manner and also records the number of boundary points of this sub-image while creating the R-Table for the sub-images. If the images are similar, then the number of boundary points contained must be approximately equal, thus a threshold value can be set to sift the sub-images which are most likely similar. This way not only enhances the algorithm's accuracy, but also reduces the number of votes and raises the temporal advantage, so as to provide higher accuracy guarantee for the image measurement in the next step.

CONCLUSIONS

The experiment tests the application of the improved generalized Hough Transform algorithm in image localization technology. The result evinces the location can be identified basically. By adopting the digital image processing technique to implement the non-contact measurement of workpieces, the error of accuracy has been shrunk to within 0.01mm.The improved algorithm studied in this paper can also be combined with the speeding-up algorithm, such as image pyramid, to meet the need for high-speed localization in industrial application.

REFERENCES

[1] Ay Chyung, Young Chao-Wang. "Design of a single-cell positioning controller using electroosmotic flow and image processin,". *Sensors*, 2013, Vol. 13(5), pp. 6793–6810.

[2] GAO Xiang, ZHANG Xiao-jing."A method of key positioning based on laser virtual keyboard," *Journal of Measurement Science and Instrumentation*, 2014, Vol.5(2), pp. 27-30.

[3] Heike Ruppertshofen, Cristian Lorenz. "Discriminative generalized Hough transform for object localization in medical images," *International Journal of Computer Assisted Radiology and Surgery*, 2013, Vol. 4(8), pp. 593-606.

[4] Jun Shen. "An Optimal Linear Operator for Step Edge Detection," *Pattern Recognition*. 1995, Vol. 28(12), pp. 1871-1885.

[5] Bourennane E., P. Gouton, M. Paindavoine and F. Truchetet. "Generalization of Canny-Deriche Filter for Detection of Noisy Exponential Edge," *Signal Processing*, 2002, Vol. 82, pp. 1317-1328.

[6] Sharif M. A. Bhuiyan and Jesmin F. Khan. "A Novel Approach of Edge Detection Via a Fast and Adaptive Bidimensional Empirical Mode Decomposition Method," *World Scientific*, 2010, Vol. 2(2), pp. 171-192.

[7] Kabir.S. IEEE Freeman Chain Code with Digits of Unequal Cost, 2014, pp. 1-6.