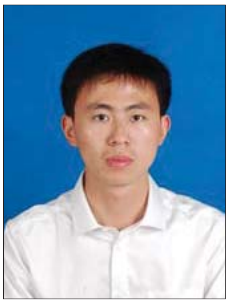


Huang Mingxin

STUDY ON THE METHOD OF ADHESIVE PARTS PARTICLE COUNTING BASED ON HALCON

DOI 10.15589/SMI20170211

Huang Mingxin Master degree candidate
841071841@qq.com

Yancheng Polytechnic College, Jiangsu, Yancheng, 224005, China

Abstract. In order to solve the problem of low efficiency and low accuracy in the traditional adhesive parts particle counting method, it is proposed to implement an improved watershed segmentation algorithm by means of the HALCON image processing technology based on the Euclidean distance transform and the Gaussian filter. First of all, the parts particle image is obtained with the help of an industrial camera. Then the image undergoes pre-processing. Afterwards, the image is subject to mathematical morphology processing. The last step is application of the improved watershed segmentation algorithm. The experimental results show that the algorithm can segment the adhesive parts particles effectively, providing a guarantee for an accurate count of the parts particles.

Keywords: adhesion; HALCON; distance transformation; Gaussian filter; watershed segmentation.

References

[1] Zhang Yujin. Image engineering: volume one image processing [M]. Beijing, Tsinghua University Press, 2006:1-3.

[2] Steger C., Ulrich M., Wieldemmann C. Machine vision algorithms and applications [M]. Germany, Wiley-Vch, 2007.

[3] Xu Wei Qin. Research on image analysis technique of adhesive particles based on watershed segmentation [D]. CHANGSHA, Central South University, 2011.

[4] Noble J. A. From inspection to process understanding and monitoring: a view on computer vision in manufacturing [J]. Image and Vision Computing, 1995, 13(3):197-214.

[5] Weszka J. S., Rosenfeld A. Histogram modification for threshold selection [J]. IEEE SMC, 1999, 9(2):28-37.

[6] Ni Zhiqiang, Ye Ming. Method of the segmentation of touching image based on watershed transform [J]. Computer System Applications, 2014, 23(6):93-97.

[7] Wang Wencheng. Design of gear defect detection system based on the Halcon [J]. Journal of Mechanical Transmission, 2014, 38(9):60-63.

[8] Jin Can, Research on printing image quality detection technology based on HALCON [D]. CHANGSHA, Central South University, 2013.

[9] Borgefors G. Distance transformations in digital images [J]. Computer Vision, 1986, 34(3):344-371.

[10] Jin Bei. The design of machine vision teaching experiment system based on HALCON [D]. Beijing, Beijing Jiaotong University, 2012.

[11] Sun Huaiyuan, Liao Yuehua, Zhou Fu-zhi, et al. Study on the batch detection technology of pharmaceutical bottles based on HALCON [D]. Shanghai, University of Shanghai for Science and Technology, 2008.

[12] Bianconi F., Ceccarelli L., Fernández A., et al. A sequential machine vision procedure for assessing paper impurities [J]. Computers in Industry, 2013, 65 (2):325-332.

Problem statement. With the development of computer science, the technology of digital image processing has been widely used in many fields [1]. In real life, the number of industrial parts is mostly counted manually or by weighing and counting. It is obvious that the traditional counting method has the disadvantages of low efficiency and low accuracy. Meanwhile, image processing can also be used to segment and count the adhesive objects. At present, the most commonly used image segmentation methods are concave point matching and watershed segmentation based on distance transformation. The former uses the concave point in the image to describe the concave condition of the boundary. The method easily recognizes the noise in the image as a concave point, so it is often used in the case of simple adhesion. Watershed algorithm features the phenomenon of over-segmentation when segmenting the images of particles with more serious adhesion [2]. In order to count the number of adhesive parts accurately, an improved watershed segmentation algorithm based on Euclidean distance transform and Gaussian filter is proposed in this paper.

BASIC MATERIAL

1. Improved watershed segmentation algorithm

Based on the general watershed algorithm, an improved watershed segmentation algorithm is proposed featuring Euclidean distance transform and Gaussian filter. The improved watershed segmentation process is shown in Fig. 1.

1.1. Distance transformation

For pixels that make up connected components, the process of calculating the minimum distance from the background to each pixel is called distance transformation. The result of the operation performed by distance transformation is the distance between each point in the calculated region and the point outside the nearest region. Distance transformation provides a distance estimation matrix for image pixel points. According to this matrix, binarized images can be transformed into gray images. Distance transformation can be defined as follows:

$$DT(p) = \min_{q\in A}\{d(p,q)\},$$

where p is the set of points in the calculated region; A is the set of points outside the calculated region; D is the distance function satisfying the measurement condition. The p and q represent two pixels with their coordinates being (x_p, y_p) and (x_q, y_q), respectively; $p \in P$, $q \in A$.

Considering the difficulty of calculation and the requirement of integer distance, 4-nearest neighbor distance d_4 (urban area distance) and 8-nearest neighbor distance d_8 (chessboard distance) are often used in distance transformation. Fig. 2, *a* and *b* demonstrate the values of the distances d_4 and d_8 at the center point, respectively. The distance transform is applied to the adhesive target object; it can effectively separate the connection between the adhesive parts [3].

1.2. Gaussian filtering

Gaussian filtering is a linear smoothing filtering method. It is widely used to eliminate the Gaussian noise in images or smooth them. The Gaussian filter employs the Gaussian function as the transition weight function to form a low-pass filter in the frequency domain. In brief, the Gaussian filter is the weighted average process of the image. The two-dimensional Gaussian function is expressed as follows:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2},$$

The Gaussian distribution of the two-dimensional Gaussian function is a bell-shaped curve; the closer to the center, the greater the value. When calculating averages, it is obviously not reasonable to use simple averages. In this case, the origin is chosen as the center point, the other points are assigned weights according to their position on the normal curve, and finally the weighted

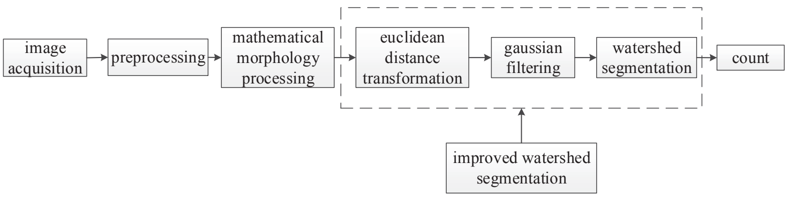


Fig. 1. Flowchart of improved watershed segmentation

				4				
			4	3	4			
		4	3	2	3	4		
	4	3	2	1	2	3	4	
4	3	2	1	0	1	2	3	4
	4	3	2	1	2	3	4	
		4	3	2	3	4		
			4	3	4			
				4				

a)

4	4	4	4	4	4	4	4	4
4	3	3	3	3	3	3	3	4
4	3	2	2	2	2	2	3	4
4	3	2	1	1	1	2	3	4
4	3	2	1	0	1	2	3	4
4	3	2	1	1	1	2	3	4
4	3	2	2	2	2	2	3	4
4	3	3	3	3	3	3	3	4
4	4	4	4	4	4	4	4	4

b)

Fig. 2. Distance map from the center pixel:
a — d_4 distance; *b* — d_8 distance

average is obtained. The specific operations of Gaussian filtering are the following. First, the pixels in the image are scanned with a convolution. Then, the values of the central pixel of the template are replaced by the weighted average gray values determined by convolution. In image processing, there are mainly two ways to implement Gaussian filtering: one is through the Fourier transformation, and the other is convolution with discrete sliding windows [4].

2. Experimental analysis

2.1. Composition of the counting system

The experimental equipment of the counting system mainly consists of a bracket, an industrial camera, a focus lens, a light source, a transparent plastic board, parts particles, and a computer. The structure of the experimental device is shown in Fig. 3. The parts particles stuck together are placed on the transparent plastic board, and the light source is placed under the board, so that each part can be evenly illuminated. The industrial camera is placed directly above the parts particles. The parts particles image can be real-time transmitted to the computer, where image processing software is installed on the operating system Windows 7. In the system, we consider the industrial camera MER-310-12UC manufactured by the Daheng Image Technology, the COMPUTAR mega pixel industrial lens M0814-MP2, the 5730 LED SMD light source, and the transparent plastic board 5 mm thick (MITSUBISHI acrylic board).

2.2. Acquisition of the parts image

By connecting the industrial camera to the computer, one can access the video directly and capture a continuous image of the parts.

In addition, one can first save the image captured by the industrial camera, and then read the pictures that need to be processed directly through the “read_image” statement of the following format: read_image (Image, “D:/Parts.jpg”). The original captured image is shown in Fig. 4.

2.3. Image preprocessing

Preprocessing is mainly intended for image binarization. The image captured by an industrial camera is colored and contains more information. Thus, it needs to be desaturated to be split conveniently. Afterwards, the image is binarized. The methods for selecting the proper binarization threshold are average method, Otsu method and iterative method. Selection of an appropriate threshold will have a great impact on image binarization. Different methods have their advantages and disadvantages, and the method of judging the threshold according to the gray histogram distribution is the optimal one [5]. The gray histogram of the experimental image is shown in Fig. 5, *a*. The gray image is divided into white target pix-

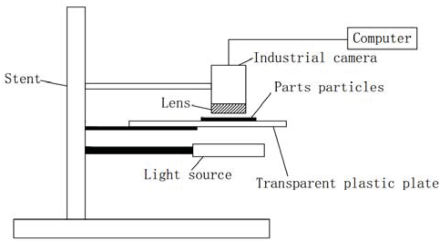


Fig. 3. Structure of the counting system

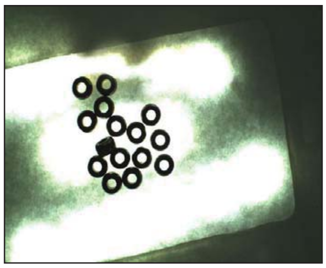
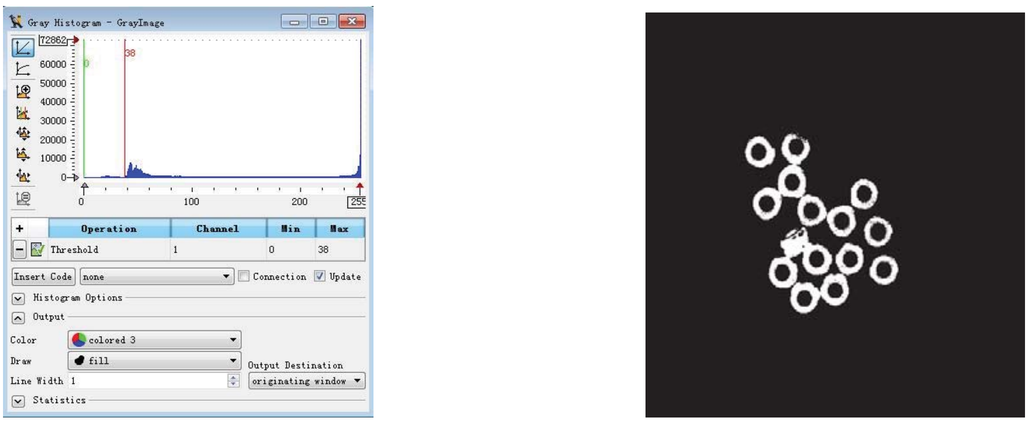


Fig. 4. Original image



a) *b)*

Fig. 5. Image binarization:
a — gray histogram; *b* — binarized image

els and black background pixels by choosing gray value 38 as the best threshold. The result of the image binarization is shown in Fig. 5, *b*.

2.4. Mathematical morphology processing

Mathematical morphology is a new method of image processing based on geometry. It mainly takes the morphological features of the image as the object of study. Its basic operations are corrosion, expansion, closing, and opening [6]. In HALCON [7-8], "opening_circle" and "closing_circle" operators are commonly used to operate and close binary images. In this experiment, the "closing_circle" operator is used to perform closed operation on the binarized image, and then the operator "fill_up_shape" is launched. The function of the command is to fill the hole in the parts. Finally, "select_shape_std", "smallest_rectangle1", "rectangle1_domain", and "intersection" operators are used to intercept the image of the part particles. The mathematical morphology procedure is illustrated in Fig. 6.

2.5. Improved watershed segmentation

The general watershed segmentation algorithm results in serious over-segmentation of larger particles, which affects the accuracy of the particle count. Therefore, this paper proposes a watershed segmentation algorithm, which combines the Euclidean distance transform and Gaussian filter. The original images undergo the mathematical morphology processing to eliminate the influence of impurities and abrupt points in the image on watershed segmentation. Then, the Euclidean distance transformation is applied to convert the features of the particles in the adhesive parts into uniform gray information. If watershed segmentation is performed directly afterwards, the image segmentation might only be partial for heavily adherent particles. Therefore, it is recommended to apply Gaussian filtering to eliminate the Gaussian noise and smooth the image, so as to accurately segment the image of the adhesive parts.

2.5.1. Distance transform

In HALCON, the statement used for distance transform features (RegionIntersection, DistanceImage, "octagonal", "true", Width, Height). Among them, "octagonal" stands for the Euclidean distance function. The image after distance transform is shown in Fig. 7.

The image type after distance transform is int4, while watershed segmentation requires the type of image to be byte, so the "convert_image_type" statement is used accrodingly. Next, the "invert_image" algorithm is applied to invert the image. Finally, the contrast of the image is increased by using the "scale_image_max" algorithm. The image after contrast enhancement is shown in Fig. 8 [9].

2.5.2. Gaussian filtering

As it has already been mentioned, the discrete Gaussian function is used to smooth the image after distance

a) *b)* *c)*

Fig.6. Mathematical morphology processing:
a — closing operation; *b* — images filled with holes; *c* — parts particle image

Fig. 7. Distance-transformed image

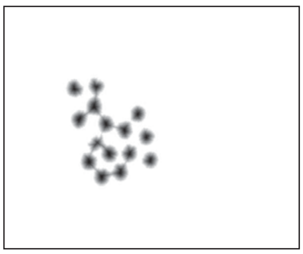


Fig. 8. Image of enhance contrast

transformation, so as to reduce the over-segmentation resulted from the watershed algorithm. In HALCON, the statement format is as follows: “gauss_image” (ImageScaleMax, ImageGauss, 11). The image after the Gaussian filter is shown in Fig. 9.

2.5.3 Watershed segmentation

Finally, watershed segmentation is performed on the filtered Gaussian images. In HALCON, the “watersheds_threshold” operator is used for this purpose. If the object does not split, the issue can be solved by gradually decreasing the threshold. The statement format is “watersheds_threshold” (ImageGauss, Basins, 10). The image after watershed segmentation is shown in Fig. 10 [10].

2.6. Parts particle count

After undergoing the improved watershed segmentation, the image can be divided into different parts, and finally “count_obj” is used to count them. The counting result is shown in Fig. 11. The number of the parts particles in the experiment is 15.

3. Experimental analysis

Fig. 12 demonstrates the results of the watershed segmentation algorithm based on general distance transformation, with the number of parts being equal to 20. We can see that this algorithm will feature over-segmentation when the particle adhesion is serious. Subsequently, the algorithm in this paper is used to test more images of adhesive parts particles, and the results show that the algorithm can accurately identify their number [11].

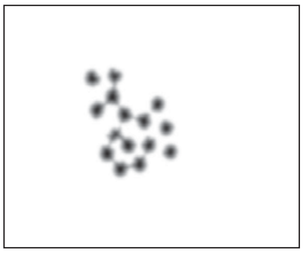


Fig. 9. Image after Gaussian filtering

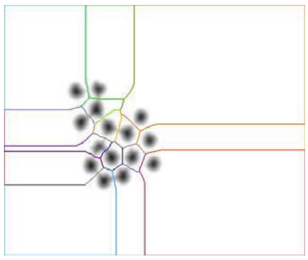


Fig. 10. Image after watershed segmentation

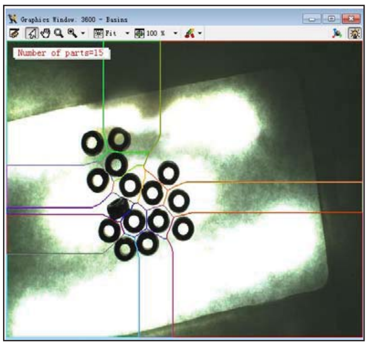


Fig. 11. Counting result

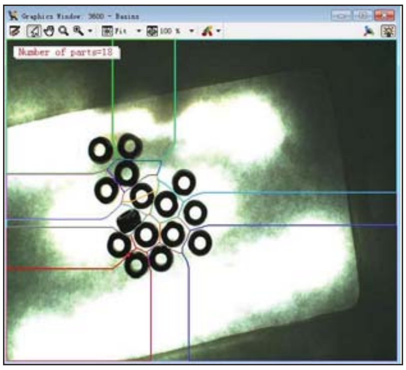


Fig. 12. Watershed algorithm based on general distance transformation

CONCLUSIONS. In summary, the improved watershed segmentation algorithm can expediently achieve the segmentation and counting of adhesion parts particles. The study on the method of particle counting for adhesive parts with the use of HALCON has a high application value and lays a foundation for further research on the defect detection of parts [12].

Статью рекомендует в печать
д-р техн. наук, проф. *А. А. Мочалов*