Research on key technologies of medicine grain defect detection system based on machine vision

Yueqiu Jiang*, Yujun Wang, Hongwei Gao, Shuang Ma

School of Information Science and Engineering, Shenyang Ligong University, Nanping Str. 6, 110159 Shenyang, China

Received 1 March 2014, www.cmnt.lv

Abstract

In the process of medicine grain production may generate many kinds of defects. If these unqualified medicine granules are not timely detected, it will not only affect the company's reputation but also the health of the patient. This paper mainly studied how to detect the unqualified medicine grain base on machine vision. It mainly consists of three kinds of common defects segmentation and defect area calculation. Firstly, preprocess the medicine grain image for the following procedures. Secondly, obtain the defect region by improved segmentation algorithm, in order to deal with three different drugs grain defects this paper improved three segmentation algorithms, for the damaged tablets propose a local edge detection algorithm that based on grey level difference, for the irregular-shaped tablets adopts the ellipse detection algorithm, which based on Hough transform technology, for the Capsule has air uses the multi-scale Canny edge detection operator. Finally, adopt Chain code contour tracking algorithm and Three-point method calculate the area of the damaged tablets, determine whether the tablets meet the requirements. Experiments show that the system can detect unqualified medicine granule quickly and accurately, it is of great practical value.

Keywords: image processing, median filtering, defect detection, region segmentation, area calculation

1 Introduction

In recent years, many developed countries in Europe and America have carried out deeply research on product quality real time detection, and have made a great progress in the online quality detection and production control [1, 2]. But the technical details strictly confidential to the outside world. In china, due to the research starts late, the domestic pharmaceutical testing is mainly relay on manual that production efficiency relatively low, so there often comes out error detection or misses detection and other undesirable phenomena. It does not be able to satisfy the efficient industrial automation requirements. So study on the drug quality inspection has a very good social significance [3-5].

Three common unqualified medicine granules are: damaged tablets, irregular-shaped tablets, Capsule has air bubbles. The medicine grain defect detection is to detect the unqualified medicine grains on the production line. This task includes two main parts: the granule region segmentation and the damaged areas calculation. Image segmentation is dividing image into non-overlapping regions which based on the image grey, texture, shape and colour. According to the prior knowledge separate the target area and background. Through analysis three types of medicine grain image find that each type has their own characteristics. Because of the tablets interior region high connectivity features, it can use the SUSAN edge detection algorithm get edge information. But SUSAN operator is sensitive with threshold lead to edge detection unstable. Therefore, based on the grey level difference propose a local edge detection algorithm. This algorithm can effectively solve the problem. For the irregular-shaped tablets detection, it adopted the ellipse detection based on Hough transform technology. For the bubble capsule, this paper mainly uses the multi-scale Canny edge detection operator [6]. After obtained the defect region, in order to quantify the damage rate [7], this paper mainly uses a method based on Freeman chain code [8]. Because the medicine grains image has the connectivity characteristics, so adopt the algorithm that chain code combined with pixel count to calculate the area. In order to prevent misjudge, in this paper for first time proposed the “three point method” to calculate the area.

2 Image preprocessing

2.1 IMAGE GREY PROCESSING

Dealing with colour images is complicated and needs a long operation time. RGB image does not reflect the morphological characteristics. It is better to convert the colour image into grey image, which only contains brightness information with 256-level grey scales. The conversion Equation for grey image and colour image is:

$$Y = 0.299R + 0.587G + 0.114B, \tag{1}$$

**Corresponding author* e-mail: missjiangyueqiu@sina.com

2.2 MEDIAN FILTER

In the process of collection and transportation, the image may be added noise, so there will be influence the image quality [9]. Median filter can smooth the image to reduce the noise effects.

When the noise is rarely and evenly distributed, median filter can better reduce noise in the image [10]. But the noise distribution in the image is relatively concentrated, traditional median filtering effect obviously cannot meet the requirements of the system [11, 12].

In order to meet the requirements that the median filter not only effectively remove the concentrated distribution noise, but also preferably preserve medicine grain image detail [13]. We propose an improved median filter algorithm. The main idea is to get rid of the maximum and minimum values in the sliding window, get the median of the two pixels, denoted m_p. Then get the difference between m_p and the value of the corresponding pixel within the window, values Δ_p. If Δ_p is within a predetermined range of threshold ΔTH, use the mean value m_p replace the grey value of the pixel point.

Let W_n(i,j) window size is $n \times n$ its centre (i,j). Improved filtering algorithm detailed steps are as follows:

Step 1: First assign $n = 3$, find out the maximum and minimum grey value $p_{\max}$ and $p_{\min}$ in window W_n(i,j).

Step 2: Statistics the number of pixels value is not equal to $p_{\max}$ or $p_{\min}$ in the window and make it as c_n.

Step 3: If c_3 less than or equal to 1, then let $n = 5$ execution Step 2.

Step 4: If c_5 equal to 0, then let $n = 7$ execution Step 2.

Step 5: Within the sliding window, calculate the median of all elements pixel values:

m_{p3} = median (the number of pixels in the window W_3(i,j) and the grey does not equal $p_{\max}$ or $p_{\min}$;

m_{p5} = median (the number of pixels in the window W_5(i,j) and the grey does not equal $p_{\max}$ or $p_{\min}$);

m_{p7} = median (the number of pixels in the window W_7(i,j) and the grey does not equal $p_{\max}$ or $p_{\min}$).

Step 6: Calculate the overall average m_p.

$$m_p = \begin{cases} m_{p3} & c_3 \geq 2 \\ m_{p5} & c_5 > 0, c_3 < 2 \\ m_{p7} & c_5 = 0 \end{cases}. \tag{2}$$

Step 7: Filtering result $F(\mathrm{i},\mathrm{j})$ is calculated by the original pixel values and median values according to the Equation (3).

$$F(\mathrm{i,j}) = \mathrm{a}_1 \cdot E(\mathrm{i},\mathrm{j}) + \mathrm{a}_2 \cdot m_p , \tag{3}$$

Where a_1 and a_2 are the weighting coefficients satisfy the condition $\mathrm{a}_1 + \mathrm{a}_2 = 1$, wherein a_2 is determined by the Equation (4).

$$a_2 = \begin{cases} 0 & \left|E(\mathrm{i},\mathrm{j}) - \mathrm{m}_p < TH_1\right| \\ \dfrac{E(\mathrm{i},\mathrm{j}) - m_p - TH_1}{TH_2 - TH_1} & TH_1 \leq \left|E(\mathrm{i},\mathrm{j}) - \mathrm{m}_p\right| \leq TH_2 \\ 1 & \left|E(\mathrm{i},\mathrm{j}) - \mathrm{m}_p\right| > TH_2 \end{cases}, \tag{4}$$

where parameters TH_1 and TH_2 are preset threshold.

Step 8: Go Step 1, processing the next target pixel.

3 Medicine grain of region segmentation algorithm research

Because there is no segmentation algorithm can adapt to all situations [14, 15]. According to the characteristics of each medicine grain image it proposes three different image defect detection segmentation algorithm based on machine vision.

3.1 REGIONAL SEGMENTATION FOR DEFECT TABLETS

Image edge is often accompanied by grey mutation that is to say the grey value of edge pixels satisfy discrete criteria [16, 17]. According to the principle, this paper put forward the improved edge detection algorithm based on local greyscale difference. The core of the algorithm includes computing greyscale differences, selecting candidate point, determining threshold value and refining edge. Details as follows:

Firstly, obtain candidate edge pixels. It can use the formula to quantify the grey step.

$$\delta = A - B. \tag{5}$$

Before determine *A* and *B*, first define a constant metric *n*. When use a 3×3 template traverse the image, *n* can measure the number of valid point in the template. According to the actual circumstance of medicine grain of image detection, here $n = 3$. Sort the pixels within the coverage area of the template, taking the top *n* larger pixels summation assigned to *A*, taking *n* smaller pixels summation assigned to *B*. For each pixel x_i, difference in local greyscale δ constantly changes with different x_i position. When x_i is located in the edge, δ is larger. So edge candidate can be selected according to the size of the value of δ, the greater of the value, this point the more likely is edge pixel.

After traversing the whole image, local differences in per-pixel can be respectively calculated. According to the ideas of the SUSAN algorithm, here need to set a threshold to determine the candidate edge points. In order to avoid the shortcoming that SUSAN algorithm is affected by the threshold is too big. It can get the adaptive threshold according to the Equation (6):

$$T_{hr} = \frac{1}{M}\sum_{i=1}^{M}\delta_i . \quad (6)$$

If a pixel is the centre of 3×3 area and its greyscale difference δ is greater than T_{hr}, and then the pixel is the candidate edge point, otherwise not edge point.

Secondly, get the ultimate edge.

While get a set of candidate edge points, it still need to further refine the edge. Refinement idea as follows:

1) Use a sliding window size 3×3 traverse the whole image.

2) If the pixels is the candidate edge points, Calculate as Equation (7):

$$t = \delta\frac{x_i}{x_M} \quad (7)$$

where x_M is the average of the three largest grey value in the 3×3 neighbourhood which centre is x_i.

(3) Set the mean of t in the whole image as the threshold, if t is greater than the threshold, this point as edge points.

3.2 REGIONAL SEGMENTATION FOR IRREGULAR-SHAPED MEDICINE TABLETS

According to the detection index of a pharmaceutical company, irregular drug testing need not quantify different degrees, only need to detect whether medicine grain of aliens.

This section is mainly to detect the ellipsoid medicine granule whether irregular, so it can use Hough transform to determine the centre coordinate. According to the results of the Hough transform locate the tablets centre. When we got ellipse parameters, plug the tablet edge point coordinates into elliptic equations to calculate its value, if get the value greater than 1 means that the oval medicine grain is qualified, or medicine granule irregular.

The main idea of Hough transform is to map the point of original image space to the line of parameter space, or do the opposite process. If directly using the Hough principle testing ellipse centre, in the image space $(\mathrm{x,y})$, elliptical Equation (8):

$$\frac{(\mathrm{x-a})^2}{m^2} + \frac{(\mathrm{y-b})^2}{n^2} = 1 , \quad (8)$$

where m, n, a and b can be obtained by the production design specification. There are four parameters in the Equation above: $(\mathrm{a,b})$ is the centre coordinates of the ellipse, oval semi-major axis m semi-minor axis n. According to the idea of Hough Transform, there need to create a cumulative four-dimensional array $A(\mathrm{a,b,m,n})$. For each a must traverse all the possible values of b, m and n, this calculation is too large to detect in real time. So in this paper, we propose an improved method.

Using gradient information, when $dy/dx = \tan\theta$, for x do derivate, get the following equation:

$$\frac{(\mathrm{x-a})^2}{m^2} + \frac{(\mathrm{y-b})^2}{n^2}\tan\theta = 0 , \quad (9)$$

$$a = x \pm \frac{\sqrt{m^2\tan\theta}}{\sqrt{m^2\tan^2\theta + n^2}} , \quad (10)$$

$$b = y \pm \frac{n^2}{\sqrt{m^2\tan^2\theta + n^2}} . \quad (11)$$

Through comparing the Equations (10), (11) with (8) can found that the number of parameters reduced from the original four to three, so just set up two three-dimensional accumulation array $A_X(\mathrm{a,m,n})$ and $A_Y(\mathrm{b,m,n})$ can meet the requirements. Every point in the image, in turn, change m and n calculate the corresponding a and b, then respectively for m, n accumulation, after the improved algorithm it obviously reduce amount of calculation.

3.3 THE SEGMENTATION ALGORITHM OF BUBBLES INSIDE THE CAPSULE

This section is mainly to detect capsules whether containing bubbles. Because of the bubbles within the capsule have a clear boundary and its colour significantly different with the surrounding, so the bubbles boundary can be clear detected. Canny operator detects the edge of the more complete and connection degree is also very good, but the result is sensitive to noise, so this paper proposed an adaptive multi-scale Canny edge detection algorithm. Specific steps are as follows:

1) Combined with capsule medicine grain images to determine the scale collection.

If σ represent one scale of the image, then $0 \le \sigma \le \sigma_{\max}$, the scale of the image edge is always in a range, so assume medicine granule image edge contains K scale. It can use $\{\sigma_k\}_{k=0,1,\ldots,K-1}$ represent the scale collection, the collection can cover all of the image edges scale, it's element is monotonic distribution and scale difference between the two adjacent elements within the set should be less than the scale interval $\Delta\sigma$, generally $0 < \Delta\sigma < 0.5$. $\sigma_{\max}$ is the maximum edge scale. $\sigma_{\max} = 2^{n-1}\sigma$, After sampling at equal intervals on the scale space $0 \sim \sigma_{\max}$ can get the scale set.

2) Use Canny edge detection operator [11] to detect the capsules image edge information on multiple scales.

In the course of capsules edge detection, first with a Gaussian function for image smoothing, then derivative of capsules image get the original image edge information on various scales. The edge information at the scale σ_k can be expressed as

$$f_k'(r,c), k = 0,1,\ldots,k-1.$$

3) Through fusion the information of scale edge to determine the edge.

After obtaining the information of each scale on the capsule image edge, complete the synthesis of various scale edge information to get the new multi-scale image edge information. In this paper, use the weighted summation algorithm.

$$f_k'(r,c) = \sum_{k=0}^{k-1} w_k f_k'(r,c) , \tag{12}$$

where w_k represents the weight factor of each scale edge information. If ignore the noise it can use mean-weighted factor. However, due to uneven illumination bring significant noise effect to the capsule image, so the mean-weighted does not meet the requirements. The weights of different scales case determined by the following steps:

Step 1: On the scale σ_k use a Gaussian function which standard deviation is σ smooth the capsules image to reduce noise, $f_k = f \cdot G(x, y, \sigma_k)$.

Step 2: In various scales of the capsule image, calculate the difference $\Delta_k = |f - f_k|$ and variance $\Delta_k^2 = |f - f_k|^2$.

Step 3: Calculates the difference and variance of image and the weight can be determined by the ratio of the two parameters.

4) The Non-maxima Suppression method to extract the edge points.

When using non-maxima suppression to get edge, mainly in order to find the ridge of the original image from the gradient image, that is to say our target point is maximum gradient, so discarded the edge is not a maximum, set $a_1,...,a_8$ are the 3×3 neighbourhood pixels of *a*:

$$\begin{matrix} a_1 & a_2 & a_3 \\ a_4 & a & a_5 \\ a_6 & a_7 & a_8 \end{matrix}$$

If *a* satisfy one of the following conditions it could as the edge points, otherwise use $\min(a, a_1,..., a_8)$ instead of *a*.

1) $a_1 + a_4 + a_6 < a_2 + a + a_7$ and $a_2 + a + a_7 > a_3 + a_5 + a_8$, *a* is vertical ridge.

2) $a_1 + a_2 + a_3 < a_4 + a + a_5$, and $a_4 + a + a_5 > a_6 + a_7 + a_8$, *a* is horizontal ridge.

3) $a_1 + a_2 + a_4 < a_3 + a + a_6$, and $a_3 + a + a_6 > a_5 + a_7 + a_8$, *a* is 45-degree angle ridge.

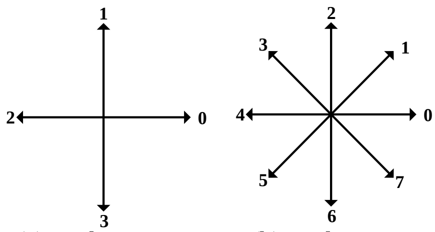
4) $a_2 + a_3 + a_5 < a_1 + a + a_8$, and $a_1 + a + a_8 > a_4 + a_6 + a_7$, *a* is 135-degree angle ridge.

4 The area calculation of the damaged tablets

Calculate the area of the damaged tablets is mainly used it quantify the damage rate. In the process of drug quality inspection need to pick out the tablet damage rate more than 3%. In this paper, the basic unit of area is pixel, by calculating the number of valid pixels in the target area to obtain the damaged area and other geometric characteristics. Since the area calculation methods all have their advantages and disadvantages and application scope. We combine with the actual situation of medicine grain of defects, proposed two methods to calculate area.

The first method: Combined chain code contour tracking algorithm [18], devised an effective multi- region contour area calculation method.

Chain code element of the contour is determined by a line segment which has both the length and direction, and each direction has a sequential number, shown in Figure 1.



(a) 4 direction (b) 8 direction

FIGURE 1 Chain code

After medicine grain image segmentation and binarization, the target region and the background region were respectively marked as 0 and 1. According to the idea of chain code contour tracing, use eight to the chain code tracking medicine grain of image boundary specific steps are as follows [19]:

1) Set the starting point b_0 as the first marked black dots of picture. Use c_0 represents b_0 neighbouring point on the left side. Figure 2b, c_0 always background points. Starting from the c_0 along the same sequence inspect b_0 eight adjacent points, find the first black adjacent points b_1 and set c_1 (background) as the point in front of the sequence of b_1. Save the location of the b_0 and c_0, in order to use in step 4.

2) Set $b = b_1$ and $c = c_1$, Figure 2c.

3) Starting from the c travels clockwise, set b eight adjacent points as $n_1, n_2,..., n_8$ respectively. Find the first n_k marked 1, set $b = n_k$ and $c = n_{k-1}$.

4) Repeat step 3, until $b = b_0$ and find the next boundary point b_1.

In Figure 2, the next point to be processed is marked in black, has been processed pixels marked grey, c is always background points in step 3, because n_k is the first point value is 1 when clockwise scanning. But the algorithm also can further improve in boundary description. After finding target area, the area is marked as grey, follow-up point may also be judged, which will be duplicate detection. Mark the point has been detected as a boundary pixel can reduce unwanted detection can further accelerate the processing speed.

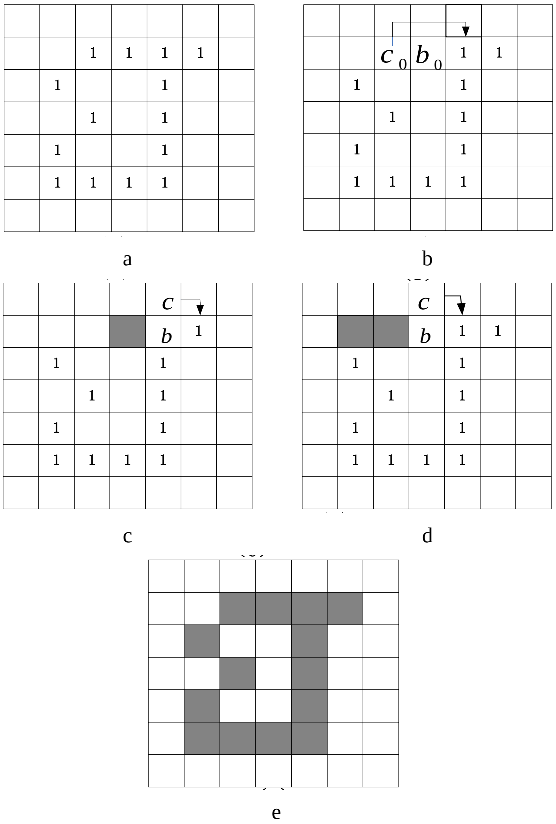


FIGURE 2 Boundary tracing algorithm description

The second method: "three point method"

"Three point method" is mainly for round tablets, because its approximate circle area after image segmentation, regional boundary has good connectivity, traverse the medicine image, and select the outermost (uppermost, lowermost, leftmost and rightmost) "point". Make straight line in the direction of maximum gradient points, it is vertical line. Calculate the intersection point of straight line, the intersection is the circular medicine circle, finally statistical the number of pixels that centre to each point (up, down, left and right edge point), calculated their average that is the drug tablet radius r, according to the area Equation $S = \pi \cdot r^2$, we can get the medicine grain area. Set four points $p_1(x_1, y_1)$, $p_2(x_2, y_2)$, $p_3(x_3, y_3)$, $p_4(x_4, y_4)$ as shown in Figure 3, after detection $p_1(x_1, y_1)$ is the rightmost edge point, but in theory, the rightmost point should be $p_1'(x_1, y_1)$. So according to the criterion, the point of $p_1(x_1, y_1)$ should be discarded. Choose the remaining three points for subsequent calculation. Determining whether the detection point is an edge point by the following criterion as in Equation (13):

$$\begin{cases} |x_2 - x_4| < c \\ |y_1 - y_3| < c \\ |y_2 - y_4 + x_3 - x_1| < 2c \\ |y_1 - y_3 + x_4 - x_2| < 2c \end{cases}, \tag{13}$$

where c is the preset threshold, it is determined whether the point is a valid edge point.

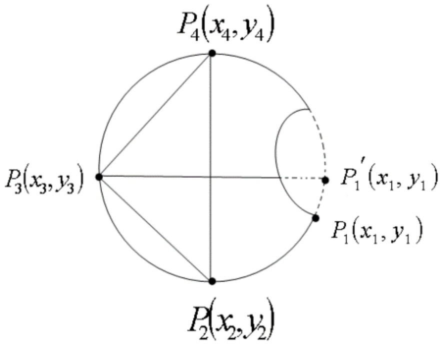


FIGURE 3 Three-point method schematic

Based on the above ideas and combined with the specific circumstances of this topic, set target pixel is white, background pixels is black. Three point method measuring area details in the following five steps:

Set P_1, P_2 are two one-dimensional arrays.

Step 1: Detecting started from the top and left of the image and gradually went on towards the down and the right, until detect the first white pixels; this point is edge point record the pixel coordinates $p_1(x, y)$.

Step 2: After obtain the first white pixel, scanning a new line and put the first met white point (the leftmost edge points) in the array P_1. At the same line when a black pixel is scanned again to put its front white pixel coordinates into the array P_2.

Step 3: When there is no white pixel to be detected in the whole row, means the end of detecting. Then the last element of the array P_2 is the most under the lowermost edge point.

Step 4: Extract the horizontal ordinate component of the each object in the array P_1, P_2 to sort. Determining the minimum and maximum of the horizontal component, thus the left-most, rightmost, uppermost, lowermost edge point coordinates are obtained.

Step 5: According to the Equation (13), determine whether the detection point is required edge point.

5 Experimental results and analysis

5.1 REGIONAL SEGMENTATION RESULTS

The improved segmentation algorithm was respectively applied to the medicine grain image, to test the effect of image segmentation and edge detection.

Figure 4 shows the damaged medicine grain region segmentation results obtained by the improved edge detection algorithm based on local greyscale difference.

Figure 4a shows the noise free image segmentation Figure 4b the image adding 3% of Gaussian noise and 2% salt and pepper noise.

Through the experimental results it can be seen that in the case of less noise, the algorithm can segment the region of medicine grain clearly. The second group is the result of edge detection after adding noise, common medicine grain image quality is much better than that situation. The improved algorithm detects the edge more complete and clear than SUSAN algorithm detected.

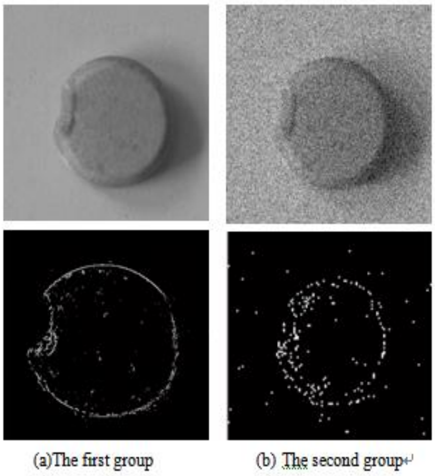


FIGURE 4 The original and add noise image region segmentation results

Figure 5 shows the irregular-shaped medicine tablets region segmentation results obtained by modified ellipse detection algorithm based on Hough transform.

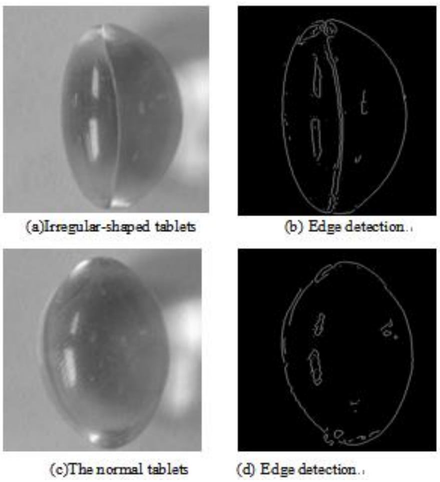


FIGURE 5 Irregular-shaped and normal tablets region segmentation results

Medicine grain qualified analysis: after dealing with the various steps above a single medicine area has to be designated. At the same time the elliptic equation is obtained by Equations (9-11), so it only needs to traverse each element of the $A_x(a,m,n)$ and $A_y(b,m,n)$, if get the value greater than 1 means that the oval medicine grain is qualified, or medicine granule irregular.

Figure 6 shows the bubble region segmentation in capsules results obtained by Multi-scale adaptive Canny edge detection algorithm.

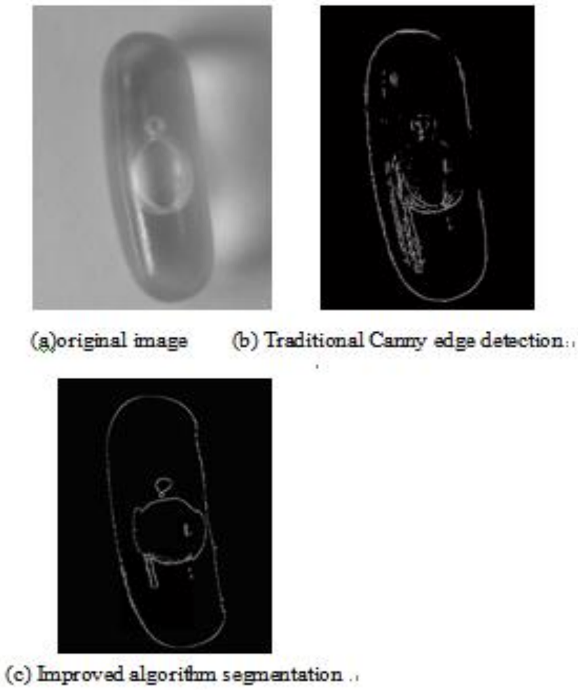


FIGURE 6 Multi-scale adaptive Canny edge detection

5.2 MEDICINE GRAIN OF DEFECT QUANTITATIVE RESULTS

First, use the Freeman chain code area algorithm processing the image, for the damage medicine grain of defect areas can be detected, quantification of the defect region, obtained theoretical defect area and actual detection area. According to the drug quality specification, damage rate more than 3% the tablet is unqualified. So that can further calculate damage rate and judge whether the drug tablets are qualified. The experimental results are shown in Table 1.

TABLE 1 Freeman chain code area algorithm of quantitative results (pixels)

No.	Theoretical area	Actual area	Damage rate	Qualified
1.	147730	137813	6.71%	no
2.	151327	147476	2.54%	yes
3.	150968	146682	2.84%	yes
4.	149978	136597	8.92%	no
5.	161468	154567	4.27%	no
6.	146798	136892	6.75%	no
…	…	…	…	…

In order to better compare the reliability and accuracy of the two algorithms, both methods deal with the same group of tablet images. The quantitative results are shown in Table 2.

TABLE 2 Three point method of quantitative results (pixels)

No.	Theoretical area	Actual area	Damage rate	Qualified
1.	153863	139867	9.09%	no
2.	157638	153433	2.67%	yes
3.	149863	145658	2.81%	yes
4.	151267	139685	7.66%	no
5.	161468	153534	3.85%	no
6.	160357	147586	7.96%	no
…	…	…	…	…

Quantitative results obtained from two algorithms can be seen: although the algorithm implementation have differences lead to concrete numerical value different, it has same results.

6 Conclusions

The experimental results show that the segmentation result satisfies the requirement of experiment, in order to quantify the damage of drug, we use the Freeman chain code area algorithm and "three point method" respectively calculated the defect area. Although the algorithm implementation have differences lead to concrete numerical value different, it has same results. But this article is just study the area of damaged medicine grains, other types without quantitative treatment, might exist misjudgments, so the algorithms also need to be improved. The system cannot achieve complete automation, there still needs a further improvement and enhancement.

References

[1] Zhu M, Zou W 2010 Application of image processing in tablets defect inspection *Computer Engineering and Design* **31**(23) 5151-4

[2] Wu H, Ji J, Zhu Y, Xi X, Fu B 2010 The design and research of capsule defect detection system *Computer Knowledge and Technology* **6**(28) 8093-4

[3] Li Z, Li H, Sun J 2012 Detection of PCB based on digital image processing *Instrument Technique and Sensor* **8** 87-9

[4] Dong W, Sun Z, Tan T 2010 Iris recognition system at a distance based on stereo vision and pan-tilt-zoom camera *Science & Technology Review* **28**(5) 35

[5] Jin L, Xia L, Yang S 2000 Histogram adaptive thresholding using index of fuzziness *Journal of Image and Graphics* **5**(5) 390-5

[6] Lixia X, Li T, Wang Z 2010 Adaptive canny edge detection algorithm *Application Research of Computers* **27**(9) 3588-90

[7] Li B, Liu D, Liang G 2002 A new algorithm for calculating the area of arbitrary enclosed shape *Journal of National University of Defense Technology* **24**(4) 61-3

[8] Yang W, Ren M, Yang J 2008 Object area algorithms based on chain code in digital image *Computer Engineering* **34**(1) 30-3

[9] Liu S, Wu G 2010 A novel method for image enhancement based on generalized histogram *Electronics Optics & Control* **17**(3) 12-4

[10] Ko S J 1991 *IEEE Transactions on Circuits and Systems* **38**(9) 984-93

[11] Lang L, He W, Lei L, Zhang W 2010 Survey on enhancement methods for non-uniform illumination image *Application Research of Computers* **27**(5) 1625-8

[12] Sun H, Shi W, Ju Y 2003 Image processing with medium value filter *Journal of Changan University* **23**(2) 104-6 (*in Chinese*)

[13] Qu C, Li H, Zhang C 2006 Wavelet package denoising method based on multiseale edge detection *Information Security and Communications Privacy* 77-8

[14] Lang Y, Zheng D 2012 An improved sobel edge detection operator *Proceedings of the 2012 Third International Conference on Mechanic Automation and Control Engineering IEEE Computer Society* 841-3

[15] Chen Q 2011 Research of image segmentation algorithm based on mathematic Morphology *Dissertation for the Master Degree in Engineering of Harbin University of Science and Technology*

[16] Lim Y W, Lee S U 1990 On the color image segmentation algorithm based on the thresholding and the fuzzy c-means techniques *Pattern Recognition* **9**(23) 935-52

[17] Zhang C 2011 Study on edge detection method *Dissertation for the Master Degree of Jiangnan University* (*in Chinese*)

[18] Chochia P A 2010 Image segmentation via contour tracking in application to the analysis of the photographs of electronic microcircuits *Journal of Communications Technology and Electronics* **55**(12) 1466-73

[19] Du Y, Shi W, Liu C 2012 Research on an efficient method of license plate location *Physics Procedia* **24**(Part C) 1990-5 (*in Chinese*)

Authors

Yueqiu Jiang, China

Current position, grades: professor in Shenyang Ligong University, China.
University study: PhD degree in Computer application technology, Northeastern University, Shenyang, China, 2004.
Research activities: network management, image processing, wireless network, pattern recognition, signal and information process.
Professional Activities and Memberships: a leader of subject direction for signal and information process.

Yujun Wang, China

Current position, grades: postgraduate student in Shenyang Ligong University, China.
University study: Graduate degree in Signal and information processing in Shenyang Ligong University in 2012.
Research activities: network management, image processing, pattern recognition, signal and information process.

Hongwei Gao, China

Current position, grades: associate professor in Shenyang Ligong University, China.
University study: PhD degree in Pattern recognition and intelligent system, Chinese Academy of Sciences (CAS), Shenyang, China, 2007.
Research activities: network management, image processing. wireless network, pattern recognition, signal and information process.
Professional Activities and Memberships: a leader of academic direction for optical and electrical detect technology and system.

Shuang Ma, China

Current position, grades: postgraduate student in Shenyang Ligong University, China.
University study: Graduate degree in Signal and information processing, Shenyang Ligong University in 2012.
Research activities: network management, image processing. pattern recognition, signal and information process.