Research and Implementation of Partition Detection Algorithm Based on Defects of sanitary Products

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Abstract. In order to solve the problem of detecting the surface stains of the unfixed shading flexible sanitary Products, a new detection algorithm was proposed to realize the rapid and accurate detection of the unfixed shading flexible sanitary products.

In the detection algorithm, the collected sample images are first pre-processed, and then the threshold image segmentation method is used in the sample images to perform partitioning, and different mathematical morphology processes are performed according to different partition regions; Then, the segmented image processed by mathematical morphology is subjected to defect detection of its suitable algorithm according to its different regional features; Finally, the stains are extracted by using the dilation, erosion, and connectivity of the region. The algorithm is implemented by Halcon operator of MVTec company in Germany. Experiments show that the algorithm can identify edge stains, cotton pad stains and cotton core stains well. The average time overhead is 92ms and the detection accuracy is 100%. Compared with the traditional method, the method in this paper is robust and fast, and can meet the needs of industrial high-speed production.

1. Introduction

With the continuous development of China's industrialization process, people's requirements for quality of life are getting higher and higher. Sanitary products are indispensable in our daily lives, so the sanitary products industry is slowly developing towards diversification and high quality. In the actual sanitary process, many stains often appear due to improper operation. This requires us to test the quality of printed sanitary products on high-speed lines to improve the quality of the products.

At present, the detection of most flexible sanitary products still remains on the manual detection method. The manual detection method consumes a lot of time and has high labor costs. At the same time, long time repetitive work is easy to cause fatigue, resulting in the detection result is not reliable because of the strong subjective influence. In recent years, machine vision technology has been developed based on the development of cross disciplines such as digital image processing, pattern recognition and field analysis. This technology has been applied to the surface defect detection of industrial products more and more. Due to the high speed, low cost, and the reliability of results, machine vision technology has made this technology a new focus. At the same time, it has significantly improved the quality inspection performance of flexible sanitary products, as well as the quality of products.

For sanitary products production, the most important defect detection is stain detection. It’s the most difficult to detect shading-like stains on the surface of flexible sanitary products with unfixed
shading. Because the gray level of stain is similar to that of shading, it brings great trouble to the inspection of machine vision. At the same time, when produced on the assembly line, flexible printed products will cause certain deformation due to the flexible material. In this case, it is necessary to perform a good image segmentation on the acquired image in order to better perform partition detection on the product.

In this paper, a solution based on machine vision technology using Halcon platform to implement detection algorithms is proposed. This solution to a certain extent solves the problem of high error rate and long matching time when detecting defects in flexible sanitary products.

2. Algorithm overview

Aiming at the problem that the sanitary article is easy to be deformed and the shading is not fixed, a detection algorithm based on the halcon operator is proposed. The detection process of the algorithm is shown in Figure 1.

First, the collected images are image-divided into edge regions, cotton pad regions, and cotton core regions. If the image of the cotton pad area is divided into a plurality of segments due to deformation and staining of the product, it is necessary to perform morphological processing such as erosion, connection, dilation, and filling of the image after the segmentation. The segmented edge region and the cotton pad region are subjected to threshold segmentation to extract stains, and finally the morphological method is used to process the threshold segmented image to more accurately find the product stain. For the image of the cotton core area, since the unfixed shading may interfere with the detection of the stain, it is necessary to extract the unfixed shading to obtain a De-shading image, and then perform automatic threshold segmentation on the De-shading image. And morphological processing to achieve the purpose of accurately detecting stains.

![Figure 1. The basic flow of the algorithm](image)

3. Image segmentation

Image segmentation is the process of subdividing it into multiple sub-regions based on the characteristics of different regions of the image [5]. The purpose is to obtain the image sub-region related to the target to be obtained, reduce the interference of some unrelated regions during the research, thereby reducing the calculation amount and improving the operation efficiency of the algorithm. The importance of image segmentation is whether it is possible to accurately segment different regions of the image and determine whether it can be effectively detected.

3.1 Automatic Threshold Segmentation

When the image is segmented, it is found that the maximum and minimum values of the image gradation cannot be well determined due to the random fluctuation of the gray histogram. Therefore, the image must be smoothed by processing the gray value of the image with a one-dimensional Gaussian filter. Its mathematical model is as shown in equation (1), equation (2).

\[
L(x, \sigma) = G(x, \sigma) \ast I(x)
\]  

(1)
Where $I(x)$ represents the pixel value of the gray histogram in the image, and the value of $\sigma$ mainly affects the smoothness of the histogram. The larger the $\sigma$, the wider the band of the Gaussian filter and the better the smoothness.

In order to select the appropriate $\sigma$ value for the Gaussian filter, a good strategy is to gradually increase $\sigma$ and smooth the histogram until two unique maxima and a unique minimum can be obtained from the smoothed histogram. The segmented image is shown in Figure 2.

![Figure 2. Automatic Threshold Segmentation Image](image)

### 3.2 Morphological processing

Images that are segmented by automatic thresholding often contain unwanted interference from the experiment\(^{[6-9]}\). Therefore, it is necessary to adjust the shape of the divided region in order to obtain the desired result of the experiment. Mathematical morphology is defined as a theory that analyzes spatial structures. With these theories, the partitioning effect desired by the experiment can be obtained.

In mathematical morphology, dilation is the process of merging all the background points that are in contact with an object into the object, which causes the boundary to expand outward, it can be used to fill holes in the object. Its mathematical expression is shown in formula (3).

$$X \oplus S = \left\{ x \mid S[x] \cap x \neq \emptyset, x \neq s \right\}$$

The principle of the image dilation is to move the center origin of the element $S$ to the pixel $(x,y)$ of the target image, and the result of the dilation is to make the binary image larger. The dilation1 operator is used in halcon for processing.

In mathematical morphology, erosion is the process of eliminating boundary points and shrinking the boundaries to the interior. Its mathematical expression is shown in formula (4).

$$X \Theta S = \left\{ x \mid S[x] \subseteq X \right\}, x \in s$$

where, is the connected region of the target image, $S$ is a structural element, and $S[x]$ represents the result of the image $S$ being translated by $x$ pixels. The result of the erosion is to reduce the binary image. The erosion1 operator is used in halcon for processing.

First, the image with automatic threshold segmentation (Fig.2) is subjected to morphological processing such as erosion, connection, dilation, and filling of the image. Then use the select_shape operator to select an area that removes the edge, and experiment to define it as image 2, as shown in Figure 4. Then, the image 2 is subjected to automatic threshold segmentation, and the morphological processing can obtain the cotton core region and the cotton pad region desired by the experiment; Finally, image 1 and image 2 are subtracted, and processed by a difference operator in halcon to obtain an edge region. The flow of the segmentation algorithm is shown in Figure 3. The divided cotton pads, cotton cores and edge regions are shown in Figures 5, 6 and 7.

![Figure 3. Dividing process of cotton core, cotton pad and edge area](image)
4. Implementation of image detection algorithm

4.1 Cotton pad, edge area detection algorithm

For cotton pads and edge regions, the pixels do not fluctuate throughout the region because they have no shading. As shown in Figures 8 and 9, the stains for the cotton pad and the edge regions can be extracted by threshold segmentation. The image of the cotton pad and the edge region is subjected to threshold segmentation, and then subjected to morphological processing by combination of erosion, dilation, connection [10] and filling, in order to completely extract the defect region. Finally, use the select_shape operator in halcon to select the region, and select all the regions within a certain areas. If the selected areas is greater than 1, it is determined that there is stain on the cotton pad and the edge area; If the selected areas is equal to 1, the area of the cotton pad and the edge area is determined. If the area of the areas is within the appropriate threshold range, the cotton pad and the edge area are determined to be normal. If the area of the areas is not within the appropriate threshold range, the cotton pad and the edge area are determined to have wrinkles. If the selected areas is equal to 0, it means that no product has been captured.

4.2 Cotton core area image detection

The detection of the cotton core area, due to the presence of shading, the gray level of the shading and the gray value of the stain may be similar, so the stain area cannot be directly divided by the threshold segmentation method. The scheme adopted in this experiment is to first extract the shading and obtain the De-shading image; then, the De-shading image is automatically thresholded; finally, the morphological processing is performed to mark the defective area.

The stain detection process in the cotton core area is shown in Figure 10.
In this experiment, a fixed threshold range is set in the x and y directions, and each pattern of the cotton core area is sequentially sorted and labeled to find the first pattern. First, sort the labels of each pattern in the cotton core area in order, find the first pattern, and use the area_center operator to find the center coordinates of the area. Then find the next connected area and extract its center coordinates. Finally, the abscissa and ordinate values of the central coordinates of the two connected regions are subtracted. If the abscissa and the ordinate difference between the connected region and the first pattern are within a fixed threshold range, it is determined that the connected region is the second shading. And so on, until all the shading is found. See formula (5)

\[
\Delta Y = ||y_i - y_{i+1}||, \quad \Delta X = ||x_i - x_{i+1}||
\]

Judge, if \( \alpha_1 \leq \Delta X \leq \alpha_2 \land \theta_1 \leq \Delta Y \leq \theta_2 \), then determine that the connected area is the pattern of the cotton core area. \([\alpha_1, \alpha_2], [\theta_1, \theta_2]\) is the threshold range set in the x and y directions, respectively, \( \Delta X, \Delta Y \) are the absolute values of the difference between the abscissa and the ordinate value of the first pattern and the next connected region, respectively.

After extracting the complete pattern, the De-shading image can be obtained by subtracting from the cotton core area, as shown in Figure 11. Then perform automatic threshold segmentation on the De-shading image. Then the segmented image is connected, dilation, erosion and filled separately. Finally, use the select_shape operator in halcon to select the region, and select all the regions within a certain area. If the selected area is greater than 1, it is determined that there is stain in the cotton core area; if the selected area is equal to 1, it is judged that the cotton core area is normal; if the selected area is equal to 0, it means that the product is missing the cotton core area.

5. Experimental results

In order to test the detection of the algorithm in the paper, 500 BMP images of 2048*2450 were collected as the defect sample images in the industrial pipeline, and the defect detection was performed on the sample images in turn. The partial detection results are shown in Fig. 12. The results show that on a computer with 64-bit operating system, 8GB of memory, Intel® Core™ i5 processor, and 2.30GHz CPU, the accuracy of detecting 500 samples is 100%, and the average time for detecting an image is 92ms, can achieve the real-time requirements very well.
6 Conclusions
The surface defect detection algorithm of the flexible sanitary product has an accuracy of 100%, and the average time for detecting an image is 92 ms. Compared with the traditional manual detection method, the accuracy is improved, and the time overhead is also greatly reduced. Can meet the requirements of industrial high-speed testing. Because the algorithm is aimed at the sample image with the change of the shading pattern, the product detection effect of the irregular change of the shading is not ideal, so further research on this algorithm is needed to make it more suitable for the detection of various kinds of flexible sanitary products.

References
[1] Jie Shi, Yingjie Tang, Shibin Chen. Research and Implementation of Signature Detection Based on Matching Algorithm [J]. IOP Conference Series: Materials Science and Engineering, 2017, 322(7): 322-329.
[2] SAJAD KIANI, SAEID MINAEI. Potential Application of Machine Vision Technology to Saffron (Crocus Sativus L.) Quality Characterization [J]. Elsevier Journal, 2016, 212: 392-394.
[3] JURGEN BEYERER, MICHAEL HEIZMANN, THOMAS LANGLE. Machine Vision in Automation Technology [J]. De Gruyter Journal, 2017, 6(65): 367-368.
[4] Zhang Qiong, Shen Hai-hong, Shen Ming-feng. HACLON Based Image Quality Detection of Markless Prints [J]. Journal of Shantou University (Natural Science Edition), 2011, 26(2): 63-68.
[5] Chen Kun, Liu Jin-qing. MRI Segmentation Combining Watershed Algorithm and WKFCM Algorithm [J]. Journal of Electronic Measurement and Instrumentation, 2011, 25(6): 516-521.
[6] ISABELLE BLOCH, ALAIN BRETTO, AERELIE LEBORGNE. Robust Similarity between Hypergraphs Based on Valuations and Mathematical Morphology Operators [J]. Discrete Applied Mathematics, 2015, 183: 2-19.
[7] Luo Qiu-tang. Image Processing Algorithm Based on Mathematical Morphology [J]. Electronic Technology and Software Engineering, 2016, 06: 80-81.
[8] CHEN L C, KUO C C. Automatic TFT-LCD Mura Defect Inspection Using Discrete Cosine Transform- based Background Filtering and 'Just Noticeable Difference' Quantification Strategies [J]. Measurement Science and Technology, 2007, 19(1): 507—516.
[9] AGUSTINA BOUCHET, PEDRO ALONSO, JUAN IGNACIO PASTORE. Fuzzy Mathematical Morphology for Color Images Defined by Fuzzy Preference Relations [J]. Elsevier Journal, 2006, 60: 720—733.
[10] JUNGHWA BAE, JINWOO PARK. An Efficient Algorithm for Band-pass Sampling of Multiple RF Signals [J]. IEEE Signal Processing Letters, 2006, 13(4): 193—196.