A Novel Image Processing Algorithm of Sand-Hole Extracted for Casting Parts

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Abstract. Focusing on the detecting problem for sand-hole of casting parts, a recognition method which based on morphologically reconstructing and differently subtracting algorithms was proposed. The image of casting whose surface in somewhere occupied with sand-hole was read and denoised by median filter. Then the image was histogram equalized, enhanced image obtained with high contrast and high resolution. Following process the defect image and the qualified image through denoising, enhancing and morphologically reconstructing, respectively. Achieving the difference information through subtracting the two images, the area with the largest grayscale value was the position of the sand hole. Finally, the area, the perimeter and the circularity of the sand hole are calculated by using the relevant function, so as to better identify the defects in the future. This paper has some reference value for the development of visual detection technology.

1. Introduction
The image recognition and processing technology based on Matlab has gradually become a hot research field, which is widely used in such as the detection of internal defects of wood \cite{1}, calculation of sand grain’s roundness \cite{2}, identification of vehicle \cite{3} and image detection of coal particle \cite{4}. A new camera based machine vision system for the automatic inspection of surface defects in aluminum die casting was developed which use an image processing algorithm based on modified Laplacian of Gaussian edge detection method to detect defects with different sizes and shapes \cite{5}. X-rays image detection \cite{6} belongs to the famous non-destructive methods. However, this method is very expensive and difficult in adaptation to the conditions of production line without stopping the assembly line.

However, it is only a few research results about defects detection on the surface of the casting parts, also the detection of defects on the casting surface in the factory still depends on human eye observation. This paper acquires image processing experience from relevant literatures, and combines characteristics of Matlab image processing toolbox.

2. Methodology
The defect image acquisition is completed by image acquisition system. The working procedure of acquiring image is as below. At first the casting moves with conveyor, when the sensor detects the location information of the casting then transmit this information to the control unit of the camera. Camera control unit control camera shutter release, quickly capture the image of casting. It can obtain
several images per second. Afterwards delivery these images into image processing system. The best quality picture will be chosen.

Detection Object
1) The mass of one casting: 5kg
2) The dimension of one casting: 100X120X80(mm)
3) The material of one casting: gray iron
4) The speed of detecting: average 5s per piece
5) Camera resolution: 20 million pixel

2.1. Image Reading and Grayscale Transforming
The casting picture is in the form of JPG. The procedures read the image and transform the original image to grayscale image based on Matlab. One big hole and one small hole can be seen in the middle part of the casting.

(a) Original picture of the casting        (b) Grayscale picture of the casting

Figure 1. Image reading and grayscale transforming.

2.2. Image denoising and equalization
Image in the process of formation, transmission and process, due to the actual performance of the transmission medium and the usage of processing equipment, inevitably there are many interference existing in the image which can produce various noise[18-19]. This will result in random black and white noise points in the image, reducing the quality of the image and causing trouble for the subsequent image processing. Therefore it is necessary to reduce the noise in the image based on Matlab.

The procedures will respectively represent the median filter, the mean filter and Gaussian filter to denoise image. Two concepts of similarity and noise difference are introduced, and the simulation results are used to analyze which denoise algorithms of casting image is more reasonable.

The image effect of denoising is very close, and the method of denosing can not be determined by the naked eye. In Matlab, the similarity function $r=\text{corr}(A,B)$ can calculate correlation coefficient of the 2D image of two pictures which have the same size. If $r$ is closer to 1, that means $A$ is more similar to $B$ and vice versa. Subtract function in Matlab can calculate the difference between the two images. The discrepancy can be differentiated between the two images. Based on this principle subtract the filter denoise image of 3 different methods with gray image, the noise is less, the method is better.

After median filtering, the contrast ratio is poor, and the image is equalized to improve image quality.

2.3. Morphological reconstruction
After the above treatment, the image still has many interference, which can lead to false position. Therefore, image morphological operators are used to simplify image data and maintain the basic characteristics of image. In this paper, we make the morphological treatment of the defective image and the qualified image separately, by observation, it is to judge whether the morphological selection
algorithm is reasonable. Since the sand hole is approximately circular, we use the planar disc shape element disk when creating the morphological structures elements.

Morphological reconstruction combines the image after equalization and the post-eroded image. After the image opening operation, it can remove the isolated dots, burrs and bridges, eliminate small objects, smooth the boundary of larger objects and hardly change the area of objects at the same time.

2.4. Sand hole location
Subtract function is a processing function used to detect image changes. The qualified image is subtracted by the defective image after the processing of denoise, equalization, erode and morphological reconstruction. If the detected image doesn’t have defect, the grayscale level of each region is generally small(black). On the contrary, It can obtain the difference information between the 2 images. The grayscale level of some areas is large(white), where is the position of the sand hole.

2.5. Feature extraction
Canny operator is considered to be used for edge detection for image. The simulation results show when the threshold value T is 0.4, 0.5, 0.6, 0.7, the results of the sand hole boundary are extracted. The results of edge detection are reversed here, resulting in the background area shown as white and the border of the sand hole shown as black.

3. Results and analysis
The image processing algorithms results were as belows,

![Figure 2. Median filter image and Its edge detection.](image)

In Figure 2(a), Median filter is being adopted to process image which is the most adaptive filter in this situation according to comprehensive analysis and preparing testing.

The Figure 3 respectively presents defective image equalized, defective image eroded, defective image morphological reconstructed, defective image opening operation. The 4 operations is preparing for the next image difference which will calculate the difference between the defective image and qualified image after morphological being reconstructed.

From Figure 4 the sand hole in the middle position is greatly enlarged. This is conducive to the extraction of target characteristics. Achieving the difference information through subtracting the qualified and defective morphological images.

The grayscale level of the small white spot in the middle position of Figure 5(a) is significantly higher than the surrounding area. According to the previous analysis, the white spot in the picture is the area where the sand hole is located. Enlarge the middle area and As shown in the Figure 5(b), at this point, a larger, round and white block shape is clearly visible.

From the extraction effect of the threshold value T=0.4, 0.5, 0.6, 0.7 respectively, when the threshold value gradually increases, the number of unrelated boundaries gradually decreases.
Figure 3. The morphological processing of defective image.

Figure 4. Sand hole location.

T=0.4 has the most detected boundaries, which not only detects the boundary of the sand hole, also the boundary of other discontinuous grayscale level. T=0.7 exactly detect the boundary of sand hole, not achieving unrelated boundary. And in the following simulation, 0.7<T<1 can achieve the desired effect, therefore T=0.7 is the minimum threshold value obtaining the boundary of the sand hole.
Figure 5. The extracting results of the sand hole boundary in different threshold value.

4. Conclusion
(1) Image morphological reconstruction can simplify image data and maintain the basic features of images. The subtraction between the defective image and the qualified image can successfully locate the sand hole.

(2) Selecting the appropriate threshold value of canny algorithm can accurately divide the boundary of the sand hole. The sand hole can be detected in the simulation process by the algorithm.

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6. References
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