Application of printing defects detection based on visual saliency

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Abstract. Visual saliency means that when humans observe a certain area, humans automatically process the area of interest and selectively ignore the uninterested area. This local area is called the saliency area. In recent years, people have introduced image processing and pattern recognition detection methods based on visual saliency to simulate the biological visual attention mechanism, and achieved good results. This paper focuses on the process of printed product defect detection, analyzes the application of visual saliency in printed product detection in recent years, summarizes and compares the advantages and disadvantages of various printed product detection methods, and discusses future development trends.

1. Introduction

With the continuous development of society and science, traditional manual inspection methods are far from being able to meet the needs of modern production and work due to low efficiency, high cost, and high labor intensity. Print defect detection technology can improve the technical level and automation of printing. To ensure product quality, reduce costs and reduce labor intensity of workers, it is an inevitable trend to use machine vision technology to replace human labor to detect defects in printed materials.

At present, a large number of researches have been carried out on the detection methods of printed matter defects in China, and they are still under development, but the overall process is roughly the same. First of all, the collected images are preprocessed, such as edge detection, image denoising and image segmentation, and then the preprocessed images are registered. Finally, the salient features of the registered images are extracted and recognized.

2. Image preprocessing

The purpose of image preprocessing is to remove obstacles in the image that hinder computer recognition and judgment, such as uneven illumination, interference sources, noise, etc. The quality of preprocessing is directly related to the efficiency of the later algorithm.
2.1. Image filtering
The detection of printed product defects, median filtering [1] is generally used to remove noise. It is a nonlinear signal processing technology based on ranking statistical theory. Its advantage is that it has a good noise reduction effect on salt and pepper noise, and The detailed feature information of the image can also be maintained. The process is shown in formula (1).

\[ g(x,y) = \text{Med}\{f(t-x,r-y),(t,r) \in W}\]  

(1)

2.2. Image segmentation
Literature [2] uses Otsu threshold segmentation algorithm to separate background and foreground images. It uses two evaluation functions, namely the maximum between-class variance and the minimum within-class variance as the basis, and obtains the maximum threshold of the between-class variance, which is the optimal segmentation threshold. Therefore, it is a light, applied, and extensive automatic threshold calculation method. The effect is poor when the image is unevenly lit.

Literature [3] uses local dynamic threshold segmentation. The biggest difference from global threshold segmentation is that the algorithm calculates a threshold for each pixel \((x, y)\) in an image, rather than a threshold for the entire image. When an image contains noise and non-uniform illumination, the effect of full threshold segmentation is worse than that of local dynamic threshold segmentation.

2.3. Edge detection
The edge generally contains a large amount of image information and is an important basis for image discrimination. Therefore, edge detection algorithms have always been a hot spot in image processing research. In the detection of printed product defects, the Canny operator is often used to detect images. The Canny operator can weaken the influence of noise and is more accurate in edge detection accuracy, so it is suitable for defect detection of printed products. Literature [4] both adopt the canny algorithm to extract the edges of the image. The basic idea is: firstly select a Gaussian filter to smooth the image, then the edge detection is finally completed by suppressing the isolated weak edges, and then apply double threshold detection to determine the true and potential edges, and finally complete the edge detection by suppressing isolated weak edges.

3. Image registration
The so-called image registration is to take multiple images of the same target at different times, different angles or different imaging modes, and perform spatial transformation processing on these images, so that each image is optimally consistent in spatial position[5]. At present, image registration in the field of print defect detection is mainly divided into template-based image registration and image feature-based registration algorithms.

The commonly used method of template matching is the square difference matching [3] method, that is, the square difference is used for matching, and the best matching is 0. The worse the matching, the larger the matching value[3]. Although the registration method based on template matching is efficient and accurate, different printed matter inspection objects need to formulate specific template images, so the steps are cumbersome and cannot be universal in practical applications.

Reference [6] improved the template matching proposed above, and proposed a registration based on SIFT corner matching method, which is to find the position relationship of the corresponding feature point pixels between the standard sample and the sample to be inspected, thereby obtaining the affine transformation parameters. Realize the registration of the sample to be inspected and the standard sample. Its advantage is that it has a certain degree of stability to rotation, scale transformation, and brightness retention. However, the ability to extract feature points of smooth-edge targets is weak and the real-time performance is not high.

Literature [5] use the SURF feature-based image registration method. The SURF algorithm is a robust local feature point detection and description algorithm, which is formed on the basis of the improvement of the SIFT algorithm. In addition to the advantages of the SIFT algorithm, its execution
efficiency is significantly improved, and it meets the real-time requirements. The flowchart is shown in Figure 1.

Figure 1. SURF registration process

4. Research and analysis of salient features

Image saliency detection has been applied in various fields of vision and image related, such as image segmentation, target detection and so on. The saliency detection can be divided into saliency detection based on traditional model and saliency detection based on machine learning. Commonly used traditional saliency algorithms include HC algorithm, LC algorithm, SR algorithm, ITTI, RC algorithm.

4.1. Saliency detection based on traditional model

Zhai [12] et al. proposed a global contrast saliency detection algorithm LC algorithm characterized by brightness. In order to reduce the huge computational cost caused by the excessive number of colors in the Lab color space, the algorithm only uses the brightness feature to reduce the number of colors, so that the feature value is quantized at [0,255], and then the histogram is used to classify the pixels by feature. Calculate the characteristic distance between various pixels and other pixels, use the distance as the characteristic value of each pixel, and finally obtain the saliency map.

The above method only considers brightness as a salient feature, while the HC salient detection algorithm [11] is a global color contrast algorithm proposed by Mr. Mingming Chen from Tsinghua University. The salient value of an image pixel is determined by the color contrast difference between this pixel and all other pixels. It is decided that the larger the difference, the more significant the saliency value of the pixel in the figure is calculated as shown in equation (2).

\[ S(I_k) = D(I_k, I_1) + D(I_k, I_2) + \ldots + D(I_k, I_n) \]  

In the formula, \( D(I_k, I_n) \) represents the distance between the pixel points \( I_k \) and \( I_i \) in the Lab color space.

The SR algorithm is a saliency detection model proposed by Hou [10] and others based on the frequency domain residual spectrum. This method uses the spectral residual model for saliency detection. This method considers that the image information is contained in the image amplitude spectrum information Therefore, the amplitude spectrum of the prior knowledge is subtracted from the amplitude spectrum of the image, and the rest is the amplitude spectrum of the salient part, and then the salient area is obtained. However, the algorithm not only suppresses the insignificant background information in the image, but also treats salient targets. Suppression is produced, and some details of the image cannot be fully expressed.

In the detection of printed product defects, for the above three traditional saliency detection algorithms, the SR algorithm and the HC algorithm cannot separate the background and defect information well for the printed product defect image, and the edge extraction is fuzzy, while the LC algorithm can better extract the defect. Therefore, it is more suitable for printing defects detection.

4.2. Saliency detection based on traditional model

Literature [7] and Literature [8] proposed an adaptive superpixel image segmentation algorithm based on spectral residuals. The algorithm first calculates the saliency map of the image using the SR algorithm,
and then performs superpixel segmentation on the image and adapts the feature information in the defect area. Finally, the visual saliency map and the adaptive superpixel segmentation result data are combined to mark the defect area, which greatly improves the edge blur of the SR algorithm.

Literature [9] proposed a novel saliency object detection algorithm based on dense matching. The algorithm is based on abstract visual saliency features and quickly establishes dense correspondence with existing displayed images based on abstract visual saliency features. Infer the salient object area of a given image. Compared with the existing traditional salient object detection algorithm, this algorithm has better results.

5. Conclusion
At present, there are more and more researches on visually significant print defect detection. This article makes a comparative analysis of its current research results. The specific implementation of the algorithm can refer to the corresponding references in the article. From the above analysis, it can be seen that the defect detection of printed products will show more and more amazing capabilities in the field of product visual saliency. At the same time, this will also enhance another new indicator of industry competitiveness, regarding visual saliency. There is still much room for development in the research of defect detection.

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