A Novel Detection Method of Paper Defects Based on Visual Attention Mechanism

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ABSTRACT

In this paper, an improved paper defects detection method based on visual attention mechanism computation model is presented. First, multi-scale feature maps are extracted by linear filtering. Second, the comparative maps are obtained by carrying out center-surround difference operator. Third, the saliency map is obtained by combining conspicuity maps, which is gained by combining the multi-scale comparative maps. Last, the seed point of watershed segmentation is determined by competition among salient points in the saliency map and the defect regions are segmented from the background. Experimental results show the efficiency of the approach for paper defects detection.

Keywords: Defect Detection, Paper Defects, Saliency Map, Visual Attention Mechanism, Watershed Segmentation

1. INTRODUCTION

Inefficiencies in industrial process are costly in terms of time, money and consumer satisfaction. The global economic pressures have gradually led business to ask more of it in order to become more competitive. As a result, automated industrial inspection systems (Tani-moto, 1996; Gregor, 2001) based on hardware and/or software tools have been very successful in applications to on-line quality control applications by virtue of their ability to make repetitive measurements accurately, fast, and objectively. One of the industry fields where automated visual inspection systems are mostly needed is paper manufacturing. Typical characteristics of paper manufacturing are the large values of web width and production speed. The web width of a modern paper machine makes about $3 \times 10^8 \text{ mm}^2$ of paper each second, it is impossible to use human eyes to inspect the web. Thus, automated visual inspection systems play an important role in ensuring the quality of paper products. Inspection systems based on CCD technology adopt the CCD camera as the sensor unit, take a snapshot of running paper web, and transmit the images to computer. And then with advanced image pro-

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cessing technologies, inspection systems can locate the position of paper defect and classify the type of it.

The research on defect detection technique is now focused on the intelligent on-line measurement, whose purpose is to develop a machine vision system to realize exact detection and localization of defects with a fast and effective algorithm. Existing methods (Newman, 1995; Sezgin & Sankur, 2004; Iivarinen, Heikkinen, Rauhamaa, Vuorimaa, & Visa, 2000; Iivarinen, 2000; Brzakovic, Vujovic, & Liakopoulos, 1995) mainly fall into three types: thresholding method, morphological method and grey level statistics method. The threshold method sets up different thresholds to different paper defects. Morphological method defects the edge of paper defects with eroded and expanded edge detector. Grey level statistics method detects paper defects with the statistical characteristics of the image of paper defects. From the fewer reports of modern web inspection systems, one can concludes that thresholding method is the main algorithm in paper defect detection system.

Thresholding methods, which are mainly associated with uniform web materials, is to separate the defect regions from the uniform background by using the segmentation threshold. The segmentation threshold takes an important role in the process, which is usually selected on the basis of statistics to the background with the application domain. An important assumption in this process is that the statistics of defect-free regions are stationary, and these regions extend over a significant portion of inspection images. In real applications, the paper products usually have different texture structure (Tsai & Huang, 2003) such as uniform structure, random structure and patterned structure. Therefore, the segmentation threshold needs to be re-determined because of the difference of texture structures, which has great limitation to the defect detection system in real applications.

Usually, it is the defect regions (e.g., holes, stains) not the texture attracts the attention firstly when we observe it because the defect regions are more conspicuity or saliency than the background. Therefore, how to find these attractive regions and separate them from the defect-free background accurately and rapidly is the key problem for paper manufacturing, which can help to ensure the high quality of paper and improve the producing efficiency of the factories. In this paper, we presented a new segmentation method based on visual attention mechanism (Desimone & Duncan, 1995; Kastner & Ungerleider, 2000) to separate the defect regions from the background. The aim of the study presented in this paper is to achieve robust detection of paper defects by using visual attention mechanism. The emphasis of our work is to make the visual inspection system detect defects rapidly, accurately and robustly.

2. THE PROPOSED METHOD DESCRIPTION

Psychophysical and physiological evidence indicates that primates and humans have a remarkable ability to interpret complex scenes in real time, despite the limited speed of the neuronal hardware available for such tasks. A number of studies concerning the detection, localization, and recognition of objects in the visual field have suggested a two-stage theory of human visual perception. The first stage is the “pre-attentive” mode, in which simple features are processed rapidly and in parallel over the entire visual field. In the second mode, “attentive” mode, a specialized processing focus, usually called FOA, is directed to particular locations in the visual field. This processing mechanism of human visual system is called visual attention mechanism (Desimone & Duncan, 1995; Kastner & Ungerleider, 2000). Inspired by the research results on the human visual system, Tsotsos, Culhane, Wai, Lai, Davis, and Nuflow (1995), Niebour and Koch (1998), Koch and Ullman (1995), and Itti, Koch, and Niebour (1998), etc., have proposed some calculation models by simulating the HVS, which are called bottom-up visual attention mechanism (BUVAM).
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