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REVIEW PAPER

State of the Art in Defect Detection Based on Machine Vision

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Abstract
Machine vision significantly improves the efficiency, quality, and reliability of defect detection. In visual inspection, excellent optical illumination platforms and suitable image acquisition hardware are the prerequisites for obtaining high-quality images. Image processing and analysis are key technologies in obtaining defect information, while deep learning is significantly impacting the field of image analysis. In this study, a brief history and the state of the art in optical illumination, image acquisition, image processing, and image analysis in the field of visual inspection are systematically discussed. The latest developments in industrial defect detection based on machine vision are introduced. In the further development of the field of visual inspection, the application of deep learning will play an increasingly important role. Thus, a detailed description of the application of deep learning in defect classification, localization and segmentation follows the discussion of traditional defect detection algorithms. Finally, future prospects for the development of visual inspection technology are explored.

Keywords Machine vision · Defect detection · Image processing · Deep learning

1 Introduction

Advanced industrial systems require increasingly improved product performance along with an increased need for quality control during production [1–3]. However, defects, such as scratches, spots, or holes on the surface of the product, adversely affect not only the aesthetics of the product and the comfort in using it but also its performance [4–7]. Defect detection is an effective method to reduce the adverse impact of product defects [8, 9].

Artificial visual inspection is a traditional method to perform quality control for industrial products [10]. Although in some cases, artificial visual inspection may be superior, it is inefficient and prone to fatigue. Artificial visual inspection is not feasible for some applications that have dangerous consequences in the event of a failure [11]. Because of its shortcomings, such as a low sampling rate, poor real-time performance, and low detection confidence, artificial visual inspection cannot meet the efficiency and quality requirements of modern industrial production lines [12]. Hence, more efficient and reliable visual inspection technologies need to be developed.

Machine vision is one of the key technologies used to perform intelligent manufacturing, and it has become an effective way to replace artificial visual inspection [13, 14]. Machine vision is a system that automatically receives and processes images of a real object through optical devices and noncontact sensors. Vision is one of the highest levels of human perception. Images play a very important role in human perception [15]. However, human perception is limited to the visible band of the electromagnetic spectrum. Machine vision inspection technology can cover the whole electromagnetic spectrum, ranging from gamma rays to radio waves [16]. Through powerful vision sensors, ingeniously designed optical transmission methods, and image processing algorithms, machine vision can accomplish many tasks that cannot be performed by artificial vision. With the development of computer equipment and artificial intelligence, machine vision, as a measurement and judgement technology, has been used widely in industry. Machine vision detection technology can improve the detection efficiency and degree of automation, enhance the real-time performance and accuracy of detection, and reduce manpower

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