Title	Accumulated and Aggregated Shifting of Intensity for Defect Detection in Uniform Background Regions [an abstract of dissertation and a summary of dissertation review]
Author(s)	Yan, Yaping
Citation	北海道大学. 博士(工学) 甲第14145号
Issue Date	2020-03-25
Doc URL	http://hdl.handle.net/2115/78533
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	theses (doctoral - abstract and summary of review)
Additional Information	There are other files related to this item in HUSCAP. Check the above URL.
File Information	Yan_Yaping_abstract.pdf (論文内容の要旨)

学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（工学）　　氏名　Yan Yaping

学　位　論　文　題　名

Accumulated and Aggregated Shifting of Intensity for Defect Detection in Uniform Background Regions
（一様背景領域における欠陥検出のための凝集累積型明度遷移アルゴリズム）

Quality control is one of the most important procedure in in modern industrial manufacturing. Product surface inspection is an important step in quality control to guarantee that the products show good impressions to consumers. In the past decades, product surface inspection was usually performed by human beings. Manually inspection is reliable for small number of products. However, it is impossible for human beings to inspect large number of products one-by-one. On one hand, it is too slow for human beings to do such kind of huge work. On the other hand, it is very expensive to hire workers for inspecting huge amount of products. Therefore, automatic product surface inspection is highly desirable. Computer vision based automatic product surface inspection is cheap and reliable, because even micro and low-contrast defects can be captured by cameras. The most important and challenging problem in building computer vision based automatic product surface inspection system is to design accurate and robust algorithms which detects defect from images taken from product surfaces.
Conventional defect detection algorithms can be classified into two categories: hand crafted features based ones and data-driven features based ones. Handcrafted-features-based approaches can be further classified into four categories: statistical methods, structure description and analysis, domain transformation, and data separation model based methods. Data-driven features based methods are generally based on deep learning techniques. These two kinds of algorithms have their own merits and demerits. Handcrafted-features-based methods are usually have clear algorithmic meanings. For different application scenarios, suitable features can be designed for the unique goals. Handcrafted-features-based methods are usually efficient, because they do not rely on learning from huge amount of data. Data-driven methods design some learnable parameters in a model and then train the model with data. The training data usually contains both of images and corresponding annotations manually marked by human beings. Although data-driven methods show high accuracy and high generalization ability, they need huge learning data and manual annotations. The training process also need huge computational recourses and time.
This dissertation focuses on defection of low-contrast defects on micro 3D textured surfaces and defection of defects on curved and highly-reflective surfaces. To achieve this goal, an accumulated and aggregated shifting of intensity (AASI) has been proposed for detecting defects on micro 3D textured surfaces and an improved AASI approach with golden template picture (AASI-GTP) has been proposed for detecting defects on curved and highly-reflective surfaces. About AASI, two novel features, named absolute intensity deviation and local intensity aggregation, which are associated with the probability of abnormality, are designed to measure the saliency at pixel level. By considering the dynamic

property during iteration and the salient features from initial image, AASI can iteratively shift the intensity of each pixel depending on its saliency, i.e., defect probability. The AASI output sequence along iterations of defective pixels follows an exponential function, while that of defect-free pixels can be formalized as a linear function. So the detection process can be regarded as a problem of fitting to two statistical models. About AASI-GTP, a multiple-pairwise reflective observation system is first introduced. Multiple-pairwise cameras and diffused lights are fixed in specific positions and angles to capture all defects on the whole curved surfaces while avoiding shadows and highlights. Then a golden template picture (GTP) is introduced to represent the pixel-wise brightness of the defect-free background. By replacing mode intensity in AASI with GTP, the AASI-GTP is constructed for detecting defects on curved and highly-reflective surfaces.

The overall dissertation is organized as follows.

Chapter 1 introduces the importance of product quality control, the background of defect detection, conventional defect detection methods, challenges in defect detection, and contributions of this dissertation.

Chapter 2 introduces the proposed accumulated and aggregated shifting of intensity (AASI) to solve the problem of detecting defects on micro 3D textured surfaces. Two salient features which measure the saliency in pixel-level are introduced. These two features are further used to construct an iterative pixel-level enhancement procedure, which can iteratively shift intensity of each pixel according with its defective probability. And then, an original fitting-based classification rule was proposed. Two statistical models are utilized to judge whether each pixel in the given image is defective or not. Finally, the parameter setting was discussed.

Chapter 3 introduces the improved AASI with golden template picture (AASI-GTP) for defect detection on curved and highly-reflective surfaces. Firstly, the reflection property of highly specular surfaces is analyzed. And then, a multiple-pairwise reflective observation system is introduced. Multiple-pairwise cameras and diffused lights are fixed in specific positions and angles to capture all defects on the whole curved surfaces while avoiding shadows and highlights. Finally, the golden template picture (GTP) is introduced to replace the mode intensity in AASI, so that the AASI-GTP to be effective for curved surfaces with reflectance.

Chapter 4 introduces the dataset, experimental setting, experimental results and analyses. Experimental results show that our method generally outperforms state-of-the-art unsupervised defect detection methods in terms of Precision and F-measure. AASI performs well even for low-contrast defects and small-sized defects with 3×3 pixels, and is robust to uniform illumination variations. The AASI-GTP exhibits satisfied performance on curved and highly-reflective surfaces. Finally, the computation time is discussed.

Chapter 5 concludes the whole dissertation and introduces future works.