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Wavelet-Based 2-D Statistical Process Control for Wafer Bin Maps

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1. Introduction

As the technology of process monitoring has been advanced, machine vision system (MVS) is developed. Machine vision system is an automated inspection system by conducting 2-D monitoring to preserve the quality of products, and has an advantage that an inspection is carried out with less time and cost than visual inspection.

MVS can be applied to statistical process control (SPC) to control products and real-time manufacturing processes. After pre-processing images, the calculation of control statistics and control limits are defined with features extracted from the image to construct a control chart.

There has been multiple SPC methods based on discrete wavelet transform (DWT), one of the signal processing methods used for the feature extraction from the signal or image. It is known that wavelet-based methods show better performance than traditional approaches directly applied to raw images[1]. However, existing wavelet-based SPC requires a pre-specified distribution calculating the statistics, and the performance is sensitive to the hyperparameters.

In this paper, we suggest a wavelet spectrum-based 2-D SPC that is non-parametric and stable to provide a robust output. In section 2, we explained a suggested procedure. and the data application of the approach with previous ones was conducted in section 3.

2. Methodology

Wavelet Spectrum-based SPC is a procedure for detecting the partial faults as well as overall ones without an assumption of distribution or hyperparameters. The feature of images is derived from 2 -D DWT and wavelet spectrum analysis by calculating the fault strengths of divided windows.

The detailed procedure for wavelet spectrum-based SPC is shown as Fig. 1.

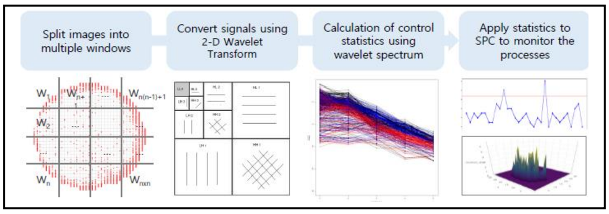

Fig. 1. Wavelet Spectrum-Based SPC Procedure

In order to obtain the spatial characteristics from a single image, it should be divided into multiple windows in order to apply 2-D DWT to each window.

After dividing the image, wavelet spectral analysis, the potential variability of signals can be captured by multi-resolution approach. Once energies are calculated for each resolution level, a linear model can be constructed so that the slope of the model is recognized as a control statistic. Computed slopes for divided windows can be constructed as the spatial control charts for a single image.

3. Data Application

We evaluated the performance of algorithm by using wafer bin maps (WBM) data, which signifies the faulty region as red points in Fig. 2.

The application result shows that the increase of faulty region leads to the greater variation of wavelet spectrum. Based on this idea, we can construct the spectrum-based spatial control chart.

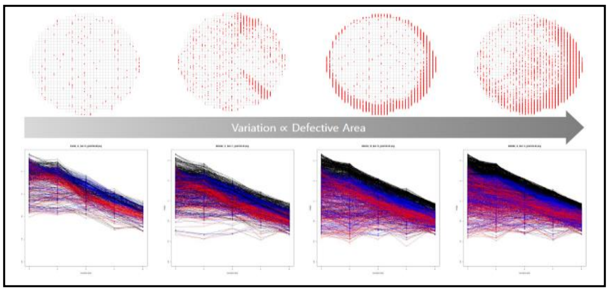

Fig. 2. Variation of Wavelet Spectrum of WBMs

The 2-D spatial control chart implemented from WBM images are shown in Fig. 3. The defective region has greater difference in terms of control statistics from the normal region. The spatial control chart in real-time data is expected to provide a stereotaxic monitoring as well as a detection of defective region effectively.

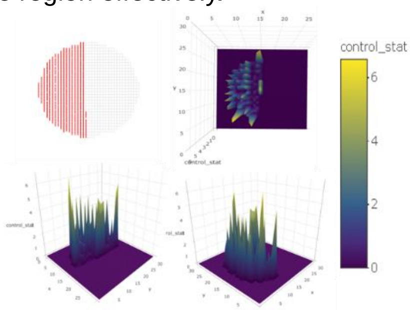

Fig 3. Spatial Control Statistics of Defective WBM

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