Defect Detection in Texture Images using Filter-Based Methods and Segmentation Techniques

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Since quality control is one of the important phases of steel production industry, designing a system for automatic inspection of steel abnormalities is so desirable. Such a system can replace man inspection and leads to high quality production. This system ought to be able to detect boundaries of defective and abnormal areas, with an acceptable accuracy, near to the ideal man-based recognition level. The first step in pattern recognition process is feature extraction. Steel image surfaces are usually texture images that their feature extraction can be performed using different techniques of texture analysis. One of the major categories of those techniques is filter-based approaches, which are common and popular in texture analysis applications, and has been used in current research, as well. Two different filter-based techniques named «Principal Component Analysis» or PCA, and «Gabor Filter Banks», are used in particular. Since Principal Component Analysis is the reference method in this research, the results of Gabor Filter Banks that is designed to represent textural characteristics of input image by selecting proper directions and frequencies of filters, is used to be compared with PCA results. PCA technique that extracts and represents spatial statistics of image, even though it is a simple technique, has shown promising performance in different applications including texture analysis.

After feature extraction phase, obtained feature vectors of pixels are fed to K-means clustering algorithm to be classified as defective or normal. The obtained results, both mathematical and visual, show that PCA outperforms Gabor in this particular application. Another part of this study is devoted to introduction of two different variance-based techniques for reducing the number of Eigenpictures, in order to increase the accuracy and decrease the time complexity of the PCA-based algorithm. In these two methods called «Variance-Based Component Analysis» or VBCA, and «Optimal Variance-Based Principal Component Analysis» or OVBPCA, after feature extraction phase, there is a feature selection phase (Eigenpicture Selection) that uses techniques based on variance of Eigenpictures to select less scattered Eigenpictures for being used in segmentation phase. In these two methods, instead of using classifier in segmentation phase, Thresholding and Pre-processing are used for segmentation. Also, in order to improve the results, PCA technique has been replaced with two different PCA-based techniques, namely 2DPCA and (2D)^2PCA, and the results are compared. It is shown that even though these methods have outperformed PCA in some other applications like face recognition and retrieval, they don’t show better performance than PCA in texture defect detection. The best mathematical result belongs to OVBPCA algorithm with classification accuracy of 97.58%, amongst all suggested algorithms.

Keywords: Defect Detection, Texture Analysis, Texture Segmentation, Filter-Based Methods, Principal Component Analysis, Gabor Filter Bank, K-Means Clustering, Variance Based Principal Component Analysis.