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The Algorithm of ICA Based on PCA for Fabric Defect Detection ⋆

Junfeng Jing*, Juan Zhao, Pengfei Li, Hongwei Zhang, Lei Zhang

School of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, China

Abstract

The Independent Component Analysis (ICA) algorithm based on Principal Component Analysis (PCA) is described in this paper to achieve the raw textile defect detection. In the first step, the observed matrix X is constructed from a large number of defect-free sub-images and PCA is operated to achieve dimension reduction. In the second step, the transformation matrix W and independent basis subspace s are obtained from defect-free sub-images through ICA. In the final step, feature extraction is achieved from the overlapping sub-windows of a test image. Then a sub-window is classified as defective or non-defective according to Euclidean distance. The results have been analyzed in detail and illustrated this approach has better performance in raw textile.

Keywords: Textile Defect Detection; Feature Extraction; Principal Component Analysis; Independent Component Analysis Heading; Introduction; Times New Roman; Number

1 Introduction

In order to reduce the production cost of textile industry, more and more people pay attention to how to improve the quality of the fabric inspection level. Scholars have been concerned about the automatic fabric defect detection problem and done a lot of researches on it. They have made a variety of algorithms and construction of hardware platform, successfully making the automatic fabric defect detection possible.

As the research on artificial intelligence and pattern recognition [1, 2] has become more and more popular, intelligent image recognition has become a hot topic in recent years in the field of pattern recognition which is mainly composed of image preprocessing, target segmentation, feature extraction and classification.

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*Corresponding author.
Email address: jingjunfeng0718@sina.com (Junfeng Jing).

Currently, people put forward many solutions to solve the problem of feature extraction. Methods such as Principle Component Analysis [3], Independent Component Analysis [4], Factor Analysis, Linear Discriminate Analysis [5, 6], and Local Feature Analysis (Multidimensional Scaling) are classical and widely used. As an extension of PCA, independent component analysis (ICA) focuses on the data between the higher order statistics, so that the components are independent of higher-order statistics from each other after transformation. It reflects the essential characteristics between data.

ICA gets a lot of attention in the feature extraction. Du-Ming Tsai used ICA for defect detection of solar modules and got a high recognition rate [7]. Using SVM as a classifier, Chuang proposed ICA for facial feature extraction and achieved better results in facial cell recognition [8]. At the same time, ICA plays an important role in biomedical signal processing [9], speech signal processing [10], textile analysis [11,12], seismic signal processing [13] as well as many other aspects of radar signal processing.

In this paper, we combine the Independent Component Analysis (ICA) algorithm with Principal Component Analysis (PCA) to achieve the raw textile defect detection and get ideal performance.

2 The Basic Principle of Method

2.1 PCA and PCA Dimension Reduction

Principal Component Analysis (PCA) is a technique for data analysis. The most important application of PCA is to simplify the data. PCA extracts dominant features (principal components) which retain most of the information by replacing the original features with a group of smaller and unrelated features [14]. In this paper, we use PCA to simplify the original data and reduce computational complexity.

PCA dimension reduction works as follows:

(1) For a sample with 20×100 pixel size, which contains 20 training subsamples, we calculate its covariance matrix cov_x of size 20×20.

(2) To calculate the eigenvalues and eigenvectors of covariance matrix cov_x, we keep the first five largest dimensions. These five eigenvectors would constitute a matrix of size 20×5, namely the feature matrix.

(3) To obtain the whitening matrix V_{PCA} of size 100×5 according to its eigenvalues and corresponding eigenvectors by using PCA whitening solution.

(4) After multiplying the whitening matrix by any sample of size 1×100, we will get a new sample of size 1×5 after dimension reduction.

The PCA aims to find the whitening matrix to achieve dimension reduction. The eigenvalues D and the eigenvectors E of covariance matrix corresponding to sample are calculated. Then whitening matrix V_{PCA} is defined as Eq. (1):

$$V_{PCA} = D^{-1/2}E^T \tag{1}$$

where E is the eigenvectors matrix. D is the eigenvalues matrix which has eigenvalues of the covariance matrix on its diagonal.