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The Performance Evaluation of Classic ICA Algorithms for Blind Separation of Fabric Defects

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Abstract

Independent Component Analysis (ICA) is a blind source separation technique that has been broadly used in signal and image separation. In order to verify the feasibility of ICA algorithms which will be used for the detection of fabric defect, four kinds of classic ICA algorithms have been chosen and compared in terms of their algorithm performances. The results of simulation experiments show that the separation performances of these algorithms are different and FastICA algorithm has the best separation performance than others.

Keywords: ICA Algorithm; Signal and Image Separation; Performance Evaluation; Fabric Defect

1 Introduction

In production and manufacture of fabric and garment, quality control usually is a crucial aspect to improve enterprises' economic benefit and level of management. Inspection of fabric defect is an important process in fabric quality control. Defect inspection, a process of subjective, tedious, and time-consuming work, is usually carried out by human operators. With the development of machine vision and compute technology, Automated Image-based Inspection System (AIIS) offers an attractive alternative to human inspection. In image recognition, finding the shape of object or component is a rather general problem and various solutions are available, depending on the nature of data. Blind Sources Separation (BSS), which does not depend on any prior knowledge of source signals, is the process of estimating unknown source signals from observed signals. Usually BSS take an algorithm of ICA to accomplish source separation. The goal of ICA algorithm is to find a linear representation of non-Gaussian data so that the components are statistically independent.

Currently ICA has an extensive application in communication signal processing, speech signal separation, biomedical signal processing, financial data analysis, array signal processing and general signal analysis ect [1]. As so many domestic and foreign scholars studied ICA algorithms,

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the application of ICA algorithms in image processing aspect is becoming more and more popular. At present, the applications of ICA algorithms in image processing are mainly focused on image feature extraction [2, 3], face recognition and detection [4], image separation, medical image processing [5], image watermarking [6], image retrieval, character recognition, remote sensing image processing [7] ect. A few studies have also been reported with the use of ICA for texture analysis. Serzer [8] et al presented a new method for texture classification, using ICA extracts feature of texture image from non-overlapping window and classifying a subwindows as defective or non-defective based on the Euclidean distance. Tsai Du-Ming [9] et al proposed a constrained version of the ICA model for detecting defect in low-contrast surface images. In recent years, researchers have proposed various methods on fabric defects, such as Fourier transform, wavelet analysis and neural network [10]. In this paper, we introduced ICA as a computation technique for use in fabric defects detection.

2 ICA Algorithm

2.1 Preprocessing for ICA

To simplify the solution of ICA the observed data should be preprocessed appropriately to make it better meet the basic assumptions of ICA. So before applying an ICA algorithm on the data, it usually undergoes preprocessing [1]. In this section we discuss some preprocessing techniques, such as centering, whitening, that make the problem of ICA estimation simpler and better conditioned. Sometimes PCA may also be used to remove the second-order correlation.

2.1.1 Centering

Centralization is the most basic and necessary preprocessing which is used to center the observed signal. Supposed observation vector set as X and the mean of X is m = E(X), the center can expressed as X' = X−m, X'→X. After estimating centered data, E(X) = E(X') = E(X−m) = E(X)−m = 0. From the basic ICA model: X = AS, we can obtain E(X) = E(AS) = AE(S), then E(S) = A^{-1}E(X) = A^{-1}m, where m is the mean that was subtracted in the preprocessing.

2.1.2 Whitening

Another useful preprocessing strategy in ICA is whitening the observed data. Applying a linear transformation to make any multidimensional signal into a whited signal process called whitening, which is also known as sphering. One popular method for whitening is to use the eigenvalue decomposition (EVD) of the covariance matrix $E(XX^T) = EDE^T$, where E is the orthogonal matrix of eigenvalues of $E(XX^T)$ and D is the diagonal matrix of its eigenvectors. The corresponding matrix is called whitening matrix $Q = D^{-1/2}E^T$. We can solve half of the problem by whitening.

2.1.3 PCA

Traditional Principal Component Analysis (PCA) can be used as the preprocessing method of ICA to remove the second order redundancy information. PCA is a kind of orthogonal transformation,