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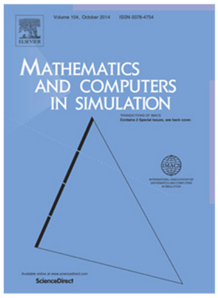

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Blind image deconvolution via Hankel based method for computing the GCD of polynomials

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Abstract

In this paper we present an algorithm, that is based on computing approximate greatest common divisors (GCD) of polynomials, for solving the problem of blind image deconvolution. Specifically, we design a specialized algorithm for computing the GCD of bivariate polynomials corresponding to z-transforms of blurred images to recover the original image. The new algorithm is based on the fast GCD algorithm for univariate polynomials in which the successive transformation matrices are upper triangular Toeplitz matrices. The complexity of our algorithm is $O(n^2 \log(n))$ where the size of blurred images is $n \times n$. All algorithms have been implemented in Matlab and experimental results with synthetically blurred images are included to illustrate the effectiveness of our approach.

Keywords: Approximate GCD, Hankel matrix, Bézout matrix, Triangular Toeplitz inversion, Fast Fourier transform, Blind image deconvolution
2000 MSC: 65F05, 65F30, 65Y20, 15A09

1. Introduction

Blind image deconvolution, which appears in a wide range of applications, such as astronomical imaging [26, 38], remote sensing [11], light microscopy [21], medical imaging [30], optics [32, 36], photography [40, 43], super resolution imaging [39], and motion tracking [16], among others, is a classical inverse problem in image processing. During acquisition as data pass through the sensing, transmission, and recording processes, images can be distorted. A degradation can be also observed as a result of noise and blurring, which is typically modeled by convolution with some blurring kernel called the Point Spread Function (PSF).

A grey level image can be represented by a matrix whose dimensions are equal to the size of the image and whose entries are the intensities, and a color image can be represented by three matrices which represent the intensities of the Red, Green and Blue intensities. We have the following relation between the original image matrix P and the distorted image matrix F: $F = P * U + N$ where U is the blurring matrix and N is the additive noise matrix.

In [20], Ghiglia, Romero and Mastin have gave a (2D) systematic approach to the problem of blind image deconvolution. Their algorithm is very sensitive to noise, and has a computational complexity of $O(n^8)$ operations for an image of size $n \times n$. Kaltofen, Yang and Zhi [24] have proposed an algorithm based on the Sylvester matrix of size $2n^2 \times 2n^2$ and the SVD technique with a reduced complexity of $O(n^6)$ operations. This method was improved by Pillai and Ben Liang [35] with a substantial saving of complexity which is $O(n^4)$ operations.