International Journal of Innovative
Computing, Information and Control
Volume **5**, Number **1**, January **2009**

ICIC International ©2009 ISSN 1349-4198
pp. **201–213**

SPACE INVARIANT BLUR ESTIMATION AND NOISELESS KALMAN FILTER-BASED IMAGE DECONVOLUTION

Wikky Fawwaz Al Maki, Takuya Shimahashi, Takanori Kitagawa and Sueo Sugimoto

Department of Electrical and Electronic Engineering
Ritsumeikan University
1-1-1, Noji-Higashi, Kusatsu City, Shiga, 525-8577, Japan
{ gr045058; re004024; re004032; sugimoto } @se.ritsumei.ac.jp

Received March 2008; revised July 2008

Abstract. *In this paper, we present a blind image deconvolution technique for space invariant blurred images, especially to the linear motion blurred images. The technique consists of blur estimation and image deconvolution. The blur estimation is performed by observing the zeros in the frequency spectrum of the blurred images. The power cepstrum analysis and a line detection algorithm are employed to obtain parameters of the motion blur. To obtain the sharp images, we derive and propose the noiseless Kalman filter as an image deconvolution method. The noiseless Kalman filter is derived based on the dynamic linear modeling (DLM) where the image process is expressed as a first-order Markov process. Finally, experimental results show our proposed idea.*
Keywords: Image deconvolution, Noiseless Kalman filter, Linear motion blur, Dynamic linear model, Spectral zeros

1. **Introduction.** The linear motion blur is a space invariant degradation process caused by a relative motion between the camera and the captured object. Many researchers tried to solve this problem. Slepian [1] and Sondhi [2] initialized the research of linear motion blurred image restoration. Sondhi assumed that the motion blur happens in horizontal direction [3]. However, such assumption is not practical in the real situation.

The point spread function (PSF) is often unknown in the practical situation. Therefore, it must be estimated to obtain a sharp image from the linear motion blurred image. For the linear motion blur case, to obtain the PSF, it is sufficient to estimate its parameters, namely blur direction and blur length. Accuracy of parameter estimation of the PSF plays an important role in the blind image deconvolution. Many researchers applied different techniques to estimate the PSF parameters. In [4] and [5], bispectrum was used in blur estimation. Estimation of PSF parameters by using the cepstral analysis was discussed in [6], [7], and [8].

In this paper, we propose a blind image deconvolution algorithm which consists of motion blur estimation and noiseless Kalman filtering. The blur estimation is performed by observing the frequency spectrum of the blurred image. The parallel lines, which are obvious in the spectrum of the blurred image, are identified by using a line detection algorithm. The Hough transform or the Radon transform can be used to detect the parallel lines and to estimate the direction of the lines. Here, the Radon transform is used to estimate the blur direction.

As periodic spectral zeros appear in the frequency domain of the linear motion blurred image, their location can be detected using a quefrency analysis. By applying the 2-D power cepstrum analysis, the periodicity is shown by a large negative value. This