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ITERATIVE IDENTIFICATION AND RESTORATION OF IMAGES

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ABSTRACT

In order to restore distorted images, the unknown blurs have to be identified from the blurred images themselves. We formulate the blur identification problem as a constrained maximum likelihood problem. The constraints directly incorporate a priori known relations between the blur (and image model) coefficients, such as symmetry properties, into the identification procedure. The resulting nonlinear minimization problem is solved iteratively, yielding a very general identification algorithm. An example of blur identification on synthetic data is given.

1. INTRODUCTION

The first step towards the restoration of degraded images is the identification of the kind of degradation the image has suffered. Modeling a blurred image as the output of a 2-dimensional linear system, the identification problem is the problem of estimating the unknown characterizing point-spread function (PSF) of this system. One approach to blur identification is to obtain a model of the blurring system from the physical nature of the problem. Unfortunately, one has hardly ever enough a priori knowledge to determine the PSF in this way. Therefore, the information about the blurring process has to be determined from the blurred image itself.

The earliest work on blur identification concentrated on identifying PSFs that have zeros only on the unit z -circle [1]. One of the shortcomings of this method is that PSFs which do not satisfy this requirement, such as a properly truncated Gaussian PSF, cannot be identified. In more recent work [2,3] the original image is first modeled as a 2-D autoregressive (AR) process. Then, if the observed blurred image is assumed noiseless, the image and blur model identification problem is specified as a 2-D autoregressive moving-average (ARMA) identification problem, where the AR coefficients are related only to the image model, and the MA coefficients only to the blur model (PSF).

Tetaly et al. [2] derived maximum likelihood estimates for these ARMA parameters, and computed them by first decomposing the PSF into four (separable) quarterplane convolutional factors, each of

which is stable in its direction of recursion, and next identifying each of these factors recursively. This approach assumes that the unknown PSF is real, symmetric (i.e. zero phase) and has a positive Fourier transform. Siemond et al. [3] showed that the 2-D ARMA identification can be done in parallel, where each of the parallel channels requires the identification of a 1-D complex ARMA process. An intermediate high-order AR approximation step is used to compute these ARMA coefficients.

In this paper we formulate the blur identification problem as a constrained maximum likelihood (ML) problem. The linear constraints incorporated in the formulation represent a priori known relations between the blur (or image model) coefficients. The resulting nonlinear minimization problem is solved by employing an iterative gradient based minimization procedure. It is conceptually advantageous to use iterative methods, since they offer the possibility of incorporating a priori knowledge about the original blur and image model into the identification procedure. Furthermore, since they act upon one complete image they are free from the causality restrictions imposed by recursive techniques.

In Section II we describe the mathematical (probabilistic) models for the image and degradation. Next, in Section III, we formulate the identification problem as a ML problem. In this section we also describe the iterative algorithm for minimizing the resulting ML index. Some preliminary experimental results are presented in Section IV. Finally, Section V summarizes relevant conclusions and discusses areas of further research.

II. IMAGE AND DEGRADATION MODELS

Basic Model Development

It is assumed that the original image $f(i,j)$ (of the size $M \times N$ pixels) can be represented by the output of a 2-D AR system

$$f(i,j) = \sum_{k,l \in W_A} a(k,l) f(i-k,j-l) + v(i,j), \quad (1)$$

where $a(k,l)$ are the image model coefficients, and W_A the support of the image model, which is not necessarily causal.

By lexicographically ordering of the image data [5] we can use the more compact matrix-vector notation

$$f = Af + v, \quad (2)$$

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Iterative Identification And Restoration Of Images

KJ Lindholm-Leary



Iterative Identification And Restoration Of Images:

Iterative Identification and Restoration of Images Reginald L. Lagendijk, Jan Biemond, 2011-09-15 One of the most intriguing questions in image processing is the problem of recovering the desired or perfect image from a degraded version. In many instances one has the feeling that the degradations in the image are such that relevant information is close to being recognizable if only the image could be sharpened just a little. This monograph discusses the two essential steps by which this can be achieved, namely the topics of image identification and restoration. More specifically, the goal of image identification is to estimate the properties of the imperfect imaging system (blur) from the observed degraded image together with some statistical characteristics of the noise and the original uncorrupted image. On the basis of these properties, the image restoration process computes an estimate of the original image. Although there are many textbooks addressing the image identification and restoration problem in a general image processing setting, there are hardly any texts which give an in-depth treatment of the state of the art in this field. This monograph discusses iterative procedures for identifying and restoring images which have been degraded by a linear spatially invariant blur and additive white observation noise. As opposed to non-iterative methods, iterative schemes are able to solve the image restoration problem when formulated as a constrained and spatially variant optimization problem. In this way, restoration results can be obtained which outperform the less results of conventional restoration filters.

Iterative Identification and Restoration of Images Reginald Leendert Lagendijk, 1990
The Essential Guide to Image Processing Alan C. Bovik, 2009-07-08 A complete introduction to the basic and intermediate concepts of image processing from the leading people in the field. Up-to-date content including statistical modeling of natural anisotropic diffusion, image quality and the latest developments in JPEG 2000. This comprehensive and state-of-the-art approach to image processing gives engineers and students a thorough introduction and includes full coverage of key applications: image watermarking, fingerprint recognition, face recognition, and iris recognition and medical imaging. This book combines basic image processing techniques with some of the most advanced procedures. Introductory chapters dedicated to general principles are presented alongside detailed application-oriented ones. As a result, it is suitably adapted for different classes of readers ranging from Master to PhD students and beyond. Prof. Jean-Philippe Thiran, EPFL, Lausanne, Switzerland. Al Bovik's compendium proceeds systematically from fundamentals to today's research frontiers. Professor Bovik himself, a highly respected leader in the field, has invited an all-star team of contributors. Students, researchers, and practitioners of image processing alike should benefit from the Essential Guide. Prof. Bernd Girod, Stanford University, USA. This book is informative, easy to read, with plenty of examples, and allows great flexibility in tailoring a course on image processing or analysis. Prof. Pamela Cosman, University of California, San Diego, USA. A complete and modern introduction to the basic and intermediate concepts of image processing, edited and written by the leading people in the field. An essential reference for all types of engineers working on image processing applications. Up-to-date content including statistical modelling of natural

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 at Austin where he is the Director of the Laboratory for Image and Video Engineering LIVE He has published over 400
 technical articles in the general area of image and video processing and holds two U S patents Dr Bovik was Distinguished
 Lecturer of the IEEE Signal Processing Society 2000 received the IEEE Signal Processing Society Meritorious Service Award
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 Processing 1996 2002 has served on and continues to serve on many other professional boards and panels and was the
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This book concerns modern methods in scientific computing and linear algebra relevant to image and signal processing For these applications it is important to consider ingredients such as 1 sophisticated mathematical models of the problems including a priori knowledge 2 rigorous mathematical theories to understand the difficulties of solving problems which are ill posed and 3 fast algorithms for either real time or data massive computations Such are the topics brought into focus by these proceedings of the Workshop on Scientific Computing held in Hong Kong on March 10 12 1997 the sixth in such series of Workshops held in Hong Kong since 1990 where the major themes were on numerical linear algebra signal processing and image processing *Selected Papers on Digital Image Restoration* M. Ibrahim Sezan,1992 *Digital Image Recovery and Synthesis* ,1993 **Visual Communications and Image Processing '94** Aggelos Konstantinos Katsaggelos,1994

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Digital Image Processing ,1996 *Image Processing Algorithms and Techniques III* James R. Sullivan,Majid Rabbani,Benjamin M. Dawson,Society of Photo-optical Instrumentation Engineers,IS & T--the Society for Imaging Science and Technology,1992 **Maximum Likelihood Iterative Image Identification and Restoration** Kuen-Tsair Lay,1991
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Unveiling the Magic of Words: A Overview of "**Iterative Identification And Restoration Of Images**"

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