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ITERATIVE IDENTIFICATION AND RESTORATION OF IMAGES

R.L. Lagendijk, A.K. Katsaggelos* and J. Biemond

Delft University of Technology, Dept. of EE, Information Theory Group, Delft, The Netherlands
*Northwestern University, Dept. of EECS, The Technological Institute, Evanston IL 60201, USA

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.

I. INTRODUCTION

The first step towards the restoration of degraded images is the identification of the kind of degradation the image has suffered. Modelling a blurred image as the output of a 2-dimensional linear system, the identification problem is the problem of estimating the unknown characterising 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 bi-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).

Tekalp et al. [2] derived maximum likelihood estimates for these ARMA parameters, and computed them by first decomposing the PSF into four (causal) quasiterplane 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. Ellwood 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 NxN pixels) can be represented by the output of a 2-D AR system

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

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 [1] we can use the more compact matrix-vector notation

$$f = Af + v. \qquad (2)$$

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Iterative Identification And Restoration Of Images

James R. Sullivan,Majid Rabbani,Benjamin M. Dawson,Society of Photo-optical Instrumentation Engineers,IS & T--the Society for Imaging Science and Technology

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 identifi cation is to estimate the properties of the imperfect imaging system blur from the observed degraded image together with some statistical char acteristics 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 indepth 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 invari ant 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 prob In this way restoration results can be obtained which outperform the lem 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 anistropic 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 orientated 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

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Golub,Lui Shui-Hong,T. Luk Franklin,Robert J. Plemmons,1998-06-01 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 **Visual Communications and Image Processing** ,1989 **Pattern Recognition and Image Processing in Physics,** Robin Antony Vaughan,1991 The Scottish Universities Summer School in Physics has been held every year since 1960 The purpose of the school is to contribute to the dissemination of advanced knowledge and the formation of contacts among scientists from different countries The lecturers at the school are all international experts in their subject Their brief is to present an up to date survey of current research in their own field in the form of a coherent series of lectures at a level suitable for students who are normally in their second or third postgraduate year With more and more sophisticated computers and computer software proving itself invaluable with its advanced pattern recognition capabilities in such areas as defence and environmental and industrial control this edited volume discusses various systems that have emerged in recent years and their potential and actual applications Necessary computer architecture and software tools are explained Image processing and analysis are discussed paying particular attention to shape and motion analysis and image enhancement Neural networks play a vital role and are discussed in some detail Specific applications of this technology are concentrated on in the final section of this work notably earth observations and geological study Signal Processing IV Jean-Louis Lacoume,1988 This was the fourth in a sequence of international conferences promoted and organized by the European Association for Signal Processing EURASIP This book in three volumes presents the proceedings of that conference EUSIPCO 88 comprised 47 separate sessions organized in 7 parallel programs Each of the 438 papers that were presented at the conference were reviewed by at least two referees from two independent institutions In addition 8 tutorials were contributed by experts in a large field of topics from Hidden Markov Fields to High Definition TV Systems The new technical potential of the DSP opening new frontiers was evidenced by the plenary session on Cheap and Powerful DSP Technologies A Challenge The contributions are grouped by topic in the contents in order to facilitate easy access The diversity of the topics as well as the extraordinary tempo at which Signal Processing has progressed since the first conference in Lausanne 1980 attest to the permanent vitality of this field of research and development Due to the extensive length of the contents only the number of papers presented per session is

listed below Signal Processing, Theories and Applications ,1988 Applications of 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 *Neural and Stochastic Methods in Image and Signal Processing* ,1993

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Table of Contents Iterative Identification And Restoration Of Images

1. Understanding the eBook Iterative Identification And Restoration Of Images
    - The Rise of Digital Reading Iterative Identification And Restoration Of Images
    - Advantages of eBooks Over Traditional Books
2. Identifying Iterative Identification And Restoration Of Images
    - Exploring Different Genres
    - Considering Fiction vs. Non-Fiction
    - Determining Your Reading Goals
3. Choosing the Right eBook Platform
    - Popular eBook Platforms
    - Features to Look for in an Iterative Identification And Restoration Of Images
    - User-Friendly Interface
4. Exploring eBook Recommendations from Iterative Identification And Restoration Of Images
    - Personalized Recommendations
    - Iterative Identification And Restoration Of Images User Reviews and Ratings
    - Iterative Identification And Restoration Of Images and Bestseller Lists
5. Accessing Iterative Identification And Restoration Of Images Free and Paid eBooks
    - Iterative Identification And Restoration Of Images Public Domain eBooks
    - Iterative Identification And Restoration Of Images eBook Subscription Services

- Iterative Identification And Restoration Of Images Budget-Friendly Options
6. Navigating Iterative Identification And Restoration Of Images eBook Formats
   - ePub, PDF, MOBI, and More
   - Iterative Identification And Restoration Of Images Compatibility with Devices
   - Iterative Identification And Restoration Of Images Enhanced eBook Features
7. Enhancing Your Reading Experience
   - Adjustable Fonts and Text Sizes of Iterative Identification And Restoration Of Images
   - Highlighting and Note-Taking Iterative Identification And Restoration Of Images
   - Interactive Elements Iterative Identification And Restoration Of Images
8. Staying Engaged with Iterative Identification And Restoration Of Images
   - Joining Online Reading Communities
   - Participating in Virtual Book Clubs
   - Following Authors and Publishers Iterative Identification And Restoration Of Images
9. Balancing eBooks and Physical Books Iterative Identification And Restoration Of Images
   - Benefits of a Digital Library
   - Creating a Diverse Reading Collection Iterative Identification And Restoration Of Images
10. Overcoming Reading Challenges
   - Dealing with Digital Eye Strain
   - Minimizing Distractions
   - Managing Screen Time
11. Cultivating a Reading Routine Iterative Identification And Restoration Of Images
   - Setting Reading Goals Iterative Identification And Restoration Of Images
   - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Iterative Identification And Restoration Of Images
   - Fact-Checking eBook Content of Iterative Identification And Restoration Of Images
   - Distinguishing Credible Sources
13. Promoting Lifelong Learning
   - Utilizing eBooks for Skill Development
   - Exploring Educational eBooks
14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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