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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.

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

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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

statistical modelling of natural anisotropic diffusion image quality and the latest developments in JPEG 2000 **Handbook of Image and Video Processing** Alan C. Bovik,2010-07-21 55% new material in the latest edition of this must have for students and practitioners of image video processing This Handbook is intended to serve as the basic reference point on image and video processing in the field in the research laboratory and in the classroom Each chapter has been written by carefully selected distinguished experts specializing in that topic and carefully reviewed by the Editor Al Bovik ensuring that the greatest depth of understanding be communicated to the reader Coverage includes introductory intermediate and advanced topics and as such this book serves equally well as classroom textbook as reference resource Provides practicing engineers and students with a highly accessible resource for learning and using image video processing theory and algorithms Includes a new chapter on image processing education which should prove invaluable for those developing or modifying their curricula Covers the various image and video processing standards that exist and are emerging driving today s explosive industry Offers an understanding of what images are how they are modeled and gives an introduction to how they are perceived Introduces the necessary practical background to allow engineering students to acquire and process their own digital image or video data Culminates with a diverse set of applications chapters covered in sufficient depth to serve as extensible models to the reader s own potential applications About the Editor Al Bovik is the Cullen Trust for Higher Education Endowed Professor at The University of Texas 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 1998 the IEEE Third Millennium Medal 2000 and twice was a two time Honorable Mention winner of the international Pattern Recognition Society Award He is a Fellow of the IEEE was Editor in Chief of the IEEE Transactions on Image Processing 1996 2002 has served on and continues to serve on many other professional boards and panels and was the Founding General Chairman of the IEEE International Conference on Image Processing which was held in Austin Texas in 1994 No other resource for image and video processing contains the same breadth of up to date coverage Each chapter written by one or several of the top experts working in that area Includes all essential mathematics techniques and algorithms for every type of image and video processing used by electrical engineers computer scientists internet developers bioengineers and scientists in various image intensive disciplines **Encyclopedia of Optical and Photonic Engineering (Print) - Five Volume Set** Craig Hoffman,Ronald Driggers,2015-09-22 The first edition of the Encyclopedia of Optical and Photonic Engineering provided a valuable reference concerning devices or systems that generate transmit measure or detect light and to a lesser degree the basic interaction of light and matter This Second Edition not only reflects the changes in optical and photonic engineering that have occurred since the first edition was published but also Boasts a wealth of new material expanding the encyclopedia s length by 25 percent Contains extensive

updates with significant revisions made throughout the text Features contributions from engineers and scientists leading the fields of optics and photonics today With the addition of a second editor the Encyclopedia of Optical and Photonic Engineering Second Edition offers a balanced and up to date look at the fundamentals of a diverse portfolio of technologies and discoveries in areas ranging from x ray optics to photon entanglement and beyond This edition s release corresponds nicely with the United Nations General Assembly s declaration of 2015 as the International Year of Light working in tandem to raise awareness about light s important role in the modern world Also Available Online This Taylor E mail e reference taylorandfrancis com International Tel 44 0 20 7017 6062 E mail online sales tandf co uk **Blind Image Deconvolution** Subhasis Chaudhuri,Rajbabu Velmurugan,Renu Rameshan,2014-09-22 Blind deconvolution is a classical image processing problem which has been investigated by a large number of researchers over the last four decades The purpose of this monograph is not to propose yet another method for blind image restoration Rather the basic issue of deconvolvability has been explored from a theoretical view point Some authors claim very good results while quite a few claim that blind restoration does not work The authors clearly detail when such methods are expected to work and when they will not In order to avoid the assumptions needed for convergence analysis in the Fourier domain the authors use a general method of convergence analysis used for alternate minimization based on three point and four point properties of the points in the image space The authors prove that all points in the image space satisfy the three point property and also derive the conditions under which four point property is satisfied This provides the conditions under which alternate minimization for blind deconvolution converges with a quadratic prior Since the convergence properties depend on the chosen priors one should design priors that avoid trivial solutions Hence a sparsity based solution is also provided for blind deconvolution by using image priors having a cost that increases with the amount of blur which is another way to prevent trivial solutions in joint estimation This book will be a highly useful resource to the researchers and academicians in the specific area of blind deconvolution Motion-Free Super-Resolution Subhasis Chaudhuri,Joshi Manjunath,2006-06-20 Motion Free Super Resolution is a compilation of very recent work on various methods of generating super resolution SR images from a set of low resolution images The current literature on this topic deals primarily with the use of motion cues for the purpose of generating SR images These cues have it is shown their advantages and disadvantages In contrast this book shows that cues other than motion can also be used for the same purpose and addresses both the merits and demerits of these new techniques Motion Free Super Resolution supersedes much of the lead author s previous edited volume Super Resolution Imaging and includes an up to date account of the latest research efforts in this fast moving field This sequel also features a style of presentation closer to that of a textbook with an emphasis on teaching and explanation rather than scholarly presentation **Encyclopedia of Optical Engineering: Abe-Las, pages 1-1024** Ronald G. Driggers,2003 PRINT ONLINE PRICING OPTIONS AVAILABLE UPON REQUEST ATe reference taylorandfrancis com *Scientific Computing* Gene H.

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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