Image Reconstruction From Projections

This book contains a selection of communications presented at the Third International Meeting on Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine, held 4-6 July 1995 at Domaine d' Aix-Marlioz, Aix-Ies-Bains, France. This nice resort provided an inspiring environment to hold discussions and presentations on new and developing issues. Roentgen discovered X-ray radiation in 1895 and Becquerel found natural radioactivity in 1896 : a hundred years later, this conference was focused on the applications of such radiations to explore the human body. If the physics is now fully understood, 3D imaging techniques based on ionising radiations are still progressing. These techniques include 3D Radiology, 3D X-ray Computed Tomography (3D-CT), Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET). Radiology is dedicated to morphological imaging, using transmitted radiations from an external X-ray source, and nuclear medicine to functional imaging, using radiations emitted from an internal radioactive tracer. In both cases, new 3D tomographic systems will tend to use 2D detectors in order to improve the radiation detection efficiency. Taking a set of 2D acquisitions around the patient, 3D acquisitions are obtained. Then, fully 3D image reconstruction algorithms are required to recover the 3D image of the body from these projection measurements.
This book is a collection of several tutorials from the EUROGRAPHICS '90 conference in Montreux. The conference was held under the motto "IMAGES: Synthesis, Analysis and Interaction", and the tutorials, partly presented in this volume, reflect the conference theme. As such, this volume provides a unique collection of advanced texts on 'traditional' com puter graphics as well as of tutorials on image processing and image reconstruction. As with all the volumes of the series "Advances in Computer Graphics", the contributors are leading experts in their respective fields. The chapter Design and Display of Solid Models provides an extended introduction to interactive graphics techniques for design, fast display, and high-quality rendering of solid models. The text focuses on techniques for Constructive Solid Geometry (CSG). The follow ing topics are treated in depth: interactive design techniques (specification of curves, surfaces and solids; graphical user interfaces; procedural languages and direct manipulation) and display techniques (depth-buffer, scan-line and ray-tracing techniques; CSG classification techniques; efficiency-improving methods; software and hardware implementations).
Special issue on linear algebra in image reconstruction from projections
Computer Assisted Tomography and Image Reconstruction from Projections
Snark 77
Medical Image Reconstruction
Maximum Entropy Type Algorithms for Image Reconstruction from Projections

PET and SPECT are two of today ’ s most important medical-imaging methods, providing images that reveal subtle information about physiological processes in humans and animals. Emission Tomography: The Fundamentals of PET and SPECT explains the physics and engineering principles of these important functional-imaging methods. The technology of emission tomography is covered in detail, including historical origins, scientific and mathematical foundations, imaging systems and their components, image reconstruction and analysis, simulation techniques, and clinical and laboratory applications. The book describes the state of the art of emission tomography, including all facets of conventional SPECT and PET, as well as contemporary topics such as iterative image reconstruction, small-animal imaging, and PET/CT systems. This book is intended as a textbook and reference

resource for graduate students, researchers, medical physicists, biomedical engineers, and professional engineers and physicists in the medical-imaging industry. Thorough tutorials of fundamental and advanced topics are presented by dozens of the leading researchers in PET and SPECT. SPECT has long been a mainstay of clinical imaging, and PET is now one of the world ' s fastest growing medical imaging techniques, owing to its dramatic contributions to cancer imaging and other applications. Emission Tomography: The Fundamentals of PET and SPECT is an essential resource for understanding the technology of SPECT and PET, the most widely used forms of molecular imaging. *Contains thorough tutorial treatments, coupled with coverage of advanced topics *Three of the four holders of the prestigious Institute of Electrical and Electronics Engineers Medical Imaging Scientist Award are chapter contributors *Include color artwork

"Medical Image Reconstruction: A Conceptual Tutorial" introduces the classical and modern image reconstruction technologies, such as two-dimensional (2D) parallel-beam and fan-beam imaging, three-dimensional (3D) parallel ray, parallel plane, and cone-beam imaging. This book presents both analytical and iterative methods of these technologies and their applications in X-ray CT (computed tomography), SPECT (single photon emission computed tomography), PET (positron emission tomography), and MRI (magnetic resonance imaging). Contemporary research results in exact region-of-interest (ROI) reconstruction with truncated projections, Katsevich's cone-beam filtered backprojection algorithm, and reconstruction with highly undersampled data with l0-minimization are also included. This book is written for engineers and researchers in the field of biomedical engineering specializing in medical imaging and image processing with image reconstruction. Gengsheng Lawrence Zeng is an expert in the development of medical image reconstruction algorithms and is a professor at the Department of Radiology, University of Utah, Salt Lake City, Utah, USA.

The Effects of Finite Sampling and Additive Noise on Image Reconstruction from the Radon Transform

Theory and Practice in Medicine and the Physical Sciences : Post-deadline Papers

Practical Utilization of Discrete Fourier Transforms for Image Reconstruction from Projections

Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine

A System of Programs for Image Reconstruction from Projections Using a Mini-computer

Focusing on mathematical methods in computer tomography, Image Processing: Tensor Transform and Discrete Tomography with MATLAB® introduces novel approaches to help in solving the problem of image reconstruction on the Cartesian lattice. Specifically, it discusses methods of image processing along parallel rays to more quickly and accurately reconstruct images from a finite number of projections, thereby avoiding overradiation of the body during a computed tomography (CT) scan. The book presents several new ideas, concepts, and methods, many of which have not been published elsewhere. New concepts include methods of transferring the geometry of rays from the plane to the Cartesian lattice, the point map of projections, the particle and its field

function, and the statistical model of averaging. The authors supply numerous examples, MATLAB®-based programs, end-of-chapter problems, and experimental results of implementation. The main approach for image reconstruction proposed by the authors differs from existing methods of back-projection, iterative reconstruction, and Fourier and Radon filtering. In this book, the authors explain how to process each projection by a system of linear equations, or linear convolutions, to calculate the corresponding part of the 2-D tensor or paired transform of the discrete image. They then describe how to calculate the inverse transform to obtain the reconstruction. The proposed models for image reconstruction from projections are simple and result in more accurate reconstructions. Introducing a new theory and methods of image reconstruction, this book provides a solid grounding for those interested in further research and in obtaining new results. It encourages readers to develop effective applications of these methods in CT.

This revised and updated second edition – now with two new chapters - is the only book to give a comprehensive overview of computer algorithms for image reconstruction. It covers the fundamentals of computerized tomography, including all the computational and mathematical procedures underlying data collection, image reconstruction and image display. Among the new topics covered are: spiral CT, fully 3D positron emission tomography, the linogram mode of backprojection, and state of the art 3D imaging results. It also includes two new chapters on comparative statistical evaluation of the 2D reconstruction algorithms and alternative approaches to image reconstruction.

The Fundamentals of PET and SPECT

Fundamentals of Computerized Tomography

On Some Optimization Techniques in Image Reconstruction from Projections

Image Processing

Images: Synthesis, Analysis, and Interaction

Fundamentals of Computerized TomographyImage Reconstruction from ProjectionsSpringer

Methods of the Fourier transform are widely used for practical applications of image reconstruction from projections, such as the computerized tomography. We mention the well known methods of back-projection and methods based on the Fourier slice theorem, which requires a crude interpolation when transforming the Fourier projections from the polar grid to the traditional Cartesian grid. The solution of this complex problem is very important in medical diagnoses, where projections data for reconstructing two- and three-dimensional images are obtained by means of the roentgen radiation with

an investigated part of the body. In this work, we analyze solutions of the problem of reconstruction of the discrete image on the Cartesian grid from projections of the image on the spatial domain, which are based on the concept of the two-dimensional discrete tensor transformation. In the framework of the constructed model, we show a way of using the line-integrals of the image, or real projections data for exact reconstructing the discrete image. The model of image reconstruction proposed in this research is described for the cases, when the size of the Cartesian grid are primes and power of two. The problem we focus on is formulated as follows. For a given image f(x, y) on the bounded region (such as the square [0, 1] × [0, 1]) and the N × N Cartesian grid placed on the region, reconstruct exactly the discrete image fn,m from the line-integrals of the image f(x, y) calculated in a finite number of projections. The solution of this problem is based on the new approach proposed by Grigoryan, which allows to transfer uniquely the geometry of the projections from the image plane to the geometry of projections onto the Cartesian grid. This transformation allows calculating the tensor representation of the discrete image, where the image is described by one-dimensional splitting-signals carrying the spectral information about the image at frequency-points of different subsets covering the Cartesian lattice. When the size of the image is a power of two, these subsets are intersected and this property can be used effectively for solution of the well known problem of image reconstruction from limited angle range projections. Our preliminary results show that the proposed method of reconstruction is more accurate than the known projections onto convex sets algorithm. In addition, the simulations of our algorithm demonstrate good reconstructions when the projections are within a limited angular range. The proposed method of image reconstruction is robust relative to the additive signal-independent noise in projection data.

A Programming System for Image Reconstruction from Projections

Tensor Transform and Discrete Tomography with MATLAB ®

Mini-Snark

Image Reconstruction from Projections : Engineering 819.119, a Five Day Short Course, June 11-15, 1984 : Lecture Notes

Image reconstruction from projections. Probability and random variables. An overview of the process of CT. Physical problems associated with data collection in CT. Computer simulation of data collection in CT. Data collection and reconstruction of the head phantom under various assumptions. Basic concepts of reconstruction algorithms. Backprojection. Convolution method for parallel beams. Other transform methods for parallel beams. Convolution methods for divergent beams. The algebraic reconstruction techniques. Quadratic optimization methods. Noniterative series expansion methods. Truly three-dimensional reconstruction. Three-dimensional display of organs. Mathematical background.

This book provides readers with a superior understanding of the mathematical principles behind imaging.

Applications in Medical Sciences

SNARK77

Handbook of Image Engineering

Algorithms in Image Reconstruction from Projections

SNARK89

This book introduces the classical and modern image reconstruction technologies. It covers topics in two-dimensional (2D) parallel-beam and fan-beam imaging, three-dimensional (3D) parallel ray, parallel plane, and cone-beam imaging. Both analytical and iterative methods are presented. The applications in X-ray CT, SPECT (single photon emission computed tomography), PET (positron emission tomography), and MRI (magnetic resonance imaging) are discussed. Contemporary research results in exact region-of-interest (ROI) reconstruction with truncated projections, Katsevich's cone-beam filtered backprojection algorithm, and reconstruction with highly under-sampled data are included. The last chapter of the book is devoted to the techniques of using a fast analytical algorithm to reconstruct an image that is equivalent to an iterative reconstruction. These techniques are the author's most recent research results. This book is intended for students, engineers, and researchers who are interested in medical image reconstruction. Written in a non-mathematical way, this book provides an easy access to modern mathematical methods in medical imaging. Table of Content: Chapter 1 Basic Principles of Tomography 1.1 Tomography 1.2 Projection 1.3 Image Reconstruction 1.4 Backprojection 1.5 Mathematical Expressions Problems References Chapter 2 Parallel-Beam Image Reconstruction 2.1 Fourier Transform 2.2 Central Slice Theorem 2.3 Reconstruction Algorithms 2.4 A Computer Simulation 2.5 ROI Reconstruction with Truncated Projections 2.6 Mathematical Expressions (The Fourier Transform and Convolution , The Hilbert Transform and the Finite Hilbert Transform , Proof of the Central Slice Theorem, Derivation of the Filtered Backprojection Algorithm , Expression of the Convolution Backprojection Algorithm, Expression of the Radon Inversion Formula ,Derivation of the Backprojection-then-Filtering Algorithm Problems References Chapter 3 Fan-Beam Image Reconstruction 3.1 Fan-Beam Geometry and Point Spread Function 3.2 Parallel-Beam to Fan-Beam Algorithm Conversion 3.3 Short Scan 3.4 Mathematical Expressions (Derivation of a Filtered Backprojection Fan-Beam Algorithm, A Fan-Beam Algorithm Using the Derivative and the Hilbert Transform) Problems References Chapter 4 Transmission and Emission Tomography 4.1 X-Ray Computed Tomography 4.2 Positron Emission Tomography and Single Photon Emission Computed Tomography 4.3 Attenuation Correction for Emission Tomography 4.4 Mathematical Expressions Problems References Chapter 5 3D Image Reconstruction 5.1 Parallel Line-Integral Data 5.2 Parallel Plane-Integral Data 5.3 Cone-Beam Data (Feldkamp's Algorithm, Grangeat's Algorithm, Katsevich's Algorithm) 5.4 Mathematical Expressions (Backprojection-then-Filtering for Parallel Line-Integral Data, Filtered Backprojection Algorithm for Parallel Line-Integral Data, 3D Radon Inversion Formula, 3D Backprojection-then-Filtering Algorithm for Radon Data, Feldkamp's Algorithm, Tuy's Relationship, Grangeat's Relationship, Katsevich's Algorithm) Problems References Chapter 6 Iterative Reconstruction 6.1 Solving a System of Linear Equations 6.2 Algebraic Reconstruction Technique 6.3 Gradient Descent Algorithms 6.4 Maximum-Likelihood Expectation-Maximization Algorithms 6.5 Ordered-Subset Expectation-Maximization Algorithm 6.6 Noise Handling (Analytical Methods, Iterative Methods, Iterative Methods) 6.7 Noise Modeling as a Likelihood Function 6.8 Including Prior Knowledge 6.9 Mathematical Expressions (ART, Conjugate Gradient

Algorithm, ML-EM, OS-EM, Green's One-Step Late Algorithm, Matched and Unmatched Projector/Backprojector Pairs) 6.10 Reconstruction Using Highly Undersampled Data with l0 Minimization Problems References Chapter 7 MRI Reconstruction 7.1 The 'M' 7.2 The 'R' 7.3 The 'I'; (To Obtain z-Information, x-Information, y-Information) 7.4 Mathematical Expressions Problems References Indexing

Image techniques have been developed and implemented for various purposes, and image engineering (IE) is a rapidly evolving, integrated discipline comprising the study of all the different branches of image techniques, and encompassing mathematics, physics, biology, physiology, psychology, electrical engineering, computer science and automation. Advances in the field are also closely related to the development of telecommunications, biomedical engineering, remote sensing, surveying and mapping, as well as document processing and industrial applications. IE involves three related and partially overlapping groups of image techniques: image processing (IP) (in its narrow sense), image analysis (IA) and image understanding (IU), and the integration of these three groups makes the discipline of image engineering an important part of the modern information era. This is the first handbook on image engineering, and provides a well-structured, comprehensive overview of this new discipline. It also offers detailed information on the various image techniques. It is a valuable reference resource for R&D professional and undergraduate students involved in image-related activities.

Advances in Computer Graphics

SNARK93

An Overview with Some Experiments in Limited Angle Projection Data

Circular Harmonic Expansion

Linograms in Image Reconstruction from Projections