BOOK REVIEW

Motion Analysis and Image Sequence Processing

M. Ibrahim Sezan and Reginald L. Lagendijk, Eds., ISBN 0-7923-93295. Kluwer Academic Publishers, 101 Philip Drive, Norwell, Massachusetts 02061 (1993) $110 hardbound.

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Recent applications of video and time-varying imagery in entertainment, medicine, and science have spawned rapidly expanding research interest in video signal processing. This edited collection of papers brings together many of the most active researchers in the field of image and video processing. Each contributor reports on his or her own recent research project, addressing some specific problem in motion analysis and image sequence processing. While the contributions are not intended to survey work in the various problem areas, the editors have attempted to include a representative sampling of research activity addressing a broad spectrum of problems in motion and video processing. In making their selections, the editors distinguish between the topics of *image sequence processing* and *image sequence analysis*, with the papers in this collection concentrating on the former. Image sequence processing operates on an input sequence to produce some desired output sequence, while image sequence analysis operates on an input sequence to extract information for the purpose of interpretation or retrieval. Thus, for example, the editors chose not to include coverage of the computer vision literature addressing the extraction of 3-D structure from video sequences.

The book is divided into four parts. Part 1 consists of four contributions focusing on motion field estimation from image sequences. Part 2 contains three papers addressing sampling and resampling of video for applications such as frame-rate or format conversion. Part 3 details five distinct approaches to coding video sequences, ranging from the study of model-based compression schemes to a high-level description of a high-definition TV (HDTV) video compression system. Part 4 presents three papers covering filtering of image sequences. The following paragraphs aim at providing a flavor for the contributions in each of the four parts.

Part 1 addresses algorithms for 2-D motion estimation from image sequences. Anandan et al. describe four distinct models for motion ranging from affine flow through rigid body motion to general nonrigid flow. They propose a hierarchical computational framework for estimating model parameters for all models. Chin et al. address the estimation of optical flow from an estimation theoretic framework. They develop a near-optimum Kalman filtering algorithm for sequential estimation and propose applying multiscale probability models developed in their earlier work for deriving efficient multigrid algorithms. Dubois and Konrad adopt an estimation theoretic framework similar to that of Chin et al., but apply a more sophisticated Markov random field *a priori* motion model capable of modeling motion field discontinuities. Finally, in a quite different vein, Zakhor and Lari describe a detailed algorithm for estimating global 3-D camera motion for efficient video coding.

Part 2 addresses spatiotemporal signal representation with a focus on sampling and resampling for frame-rate or format conversion. Girod relies on a 3-D frequency characterization of motion in video sequences to analyze the visual system's response to motion and various forms of motion-compensated processing. Tubaro and Rocca discuss algorithms for motion-compensated interpolation, paying special attention to the benefits of scene segmentation for improved interpolation. Belfor, Lagendijk, and Biemond apply basic multidimensional sampling theory on lattices as the framework for analyzing motion-compensated interpolation and subsampling schemes. Their analysis focuses on nonadaptive and motion-adaptive sub-Nyquist sampling of image sequences.

Part 3 consists of five papers on video compression. Nicoulin et al. present a video compression algorithm incorporating many current popular coding themes: subband coding, motion compensation, temporal transforms, arithmetic coding, rate control, and vector quantization (VQ). Mersereau et al. summarize several extensions of VQ proposed in the literature and evaluate their performance as intraframe coders of frames from a sequence. They then describe and evaluate two approaches for coupling VQ techniques with motion compensation to exploit temporal redundancies. Buck and Diehl discuss model-based coding of image sequences, proposing to model implicitly 3-D surface shapes and object motion via mapping parameters characterizing the relationship of object regions between successive frames. Aizawa et al. present a more detailed description of a model-based coding of the human face, employing a hierarchy of facial parameterizations ranging from low-level facial model fitting to high-level modeling of facial expressions. Finally, Apostolopoulos and Lim provide a high-level discussion of advanced television coding issues, followed by a description of a digital HDTV system design.

Part 4 covers filtering of image sequences. Woods and Kim extend their previous research on 2-D reduced-update Kalman filtering (RUKF) to 3-D image sequences and propose a scheme for applying the 3-D RUKF along motion trajectories. Ozkan et al. formulate the Wiener restoration problem in the

context of image sequences, incorporating global image displacement. Finally, Viero and Neuvo describe 3-D median filter structures that simultaneously provide noise-removing temporal filtering in stationary regions and spatial median filtering in moving regions.

Each paper presents material at a level equivalent to that of a typical journal article, requiring a moderate level of sophistication in statistical signal and image processing. The presentations are independent and self-contained, so the reader should not expect unified notation or usage of terms between papers and should expect some moderate amount of overlap. While the topics covered by this collection are quite broad, certain topics of wide interest are notable omissions. In particular, the collection lacks any discussion of many interesting motion compensation and coding issues raised by the MPEG video coding standard (e.g., bidirectional motion estimation, motion compensation modes for interlaced sequences, etc.).

Most of the papers in this collection have either already appeared, or will soon appear, in similar forms in journals and proceedings. However, these works are spread over at least five IEEE transactions, two European published journals, and numerous conference and workshop proceedings. This book provides a snapshot of current work in video sequence processing that is more easily accessible than coverage provided by the technical journals. Thus, the text will serve as an excellent reference for the serious researcher seeking an overview of current activities in motion analysis and image sequence processing without conducting a thorough survey of the literature. In particular, the combined bibliographies of the 15 chapters provides a formidable reference tool for research in this field.

Michael T. Orchard received BS and MS degrees in electrical engineering from San Diego State University in 1980 and 1986, respectively, and MA and PhD degrees in electrical engineering from Princeton University in 1988 and 1990, respectively. Since August 1990, he has been with the University of Illinois at Urbana-Champaign as an assistant professor with the Department of Electrical and Computer Engineering and a research assistant professor with the Coordinated Science Laboratory and the Beckman Institute. Professor Orchard received the National Science Foundation Young Investigator Award in 1993. His industrial experience includes specification and design of passive sonar digital signal processors with the Government Products Division of Scientific Atlanta from 1982 to 1986. Since 1988, he has also been consulting with the Visual Communications Department of AT&T Bell Laboratories on problems in video coding. His research interests include image and video coding with emphasis on motion modeling, estimation, and compensation, model-based representations of images and video, image display, and fast algorithms for signal and image processing.