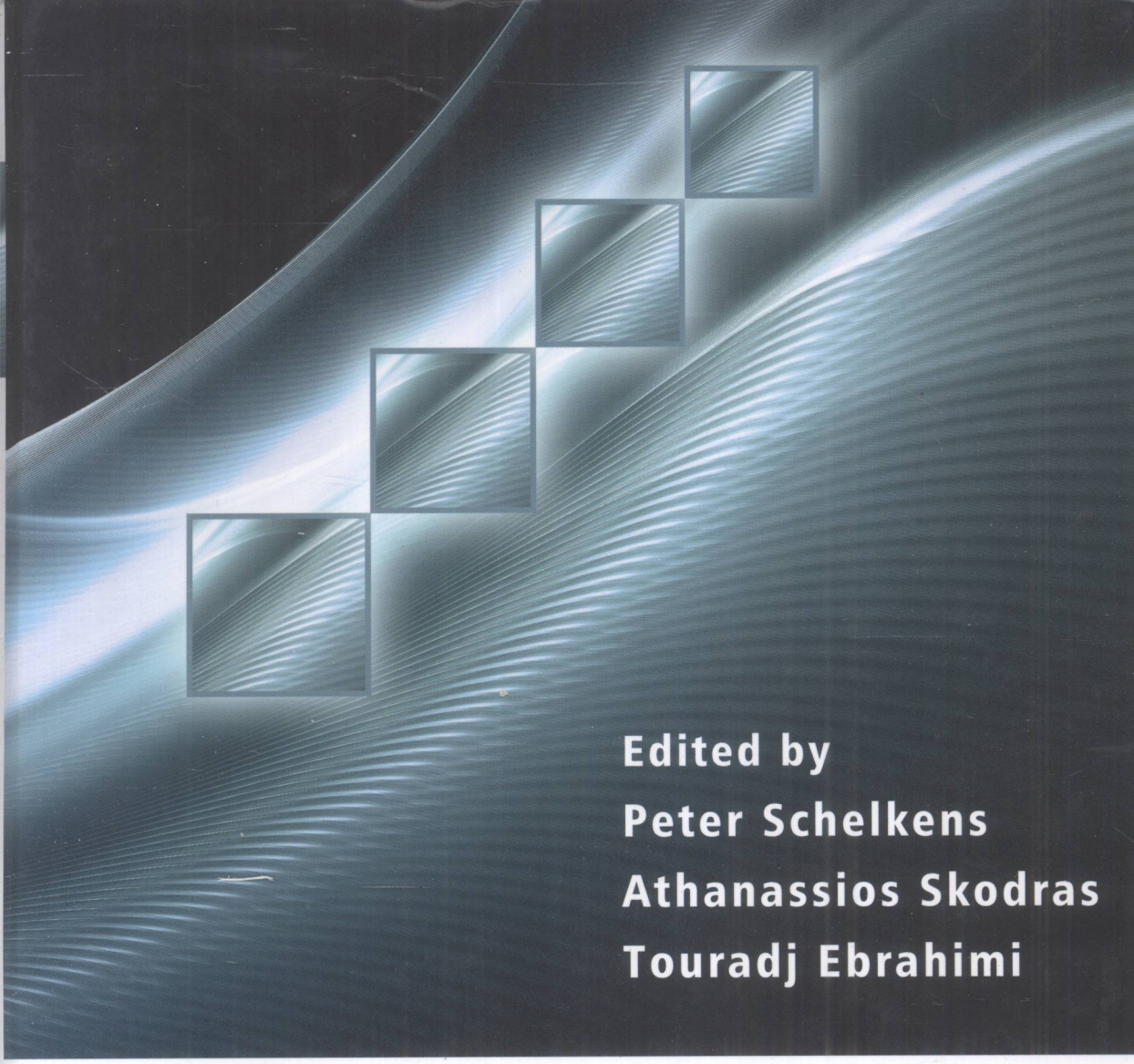

Edited by
Peter Schelkens
Athanassios Skodras
Touradj Ebrahimi

The JPEG 2000 Suite

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John Apostolopoulos is part of Hewlett-Packard Laboratories, Palo Alto, CA, where he is currently a Distinguished Technologist and Lab Director for the Multimedia Communications and Networking Lab. He is also a Consulting Associate Professor of EE at Stanford University. While at graduate school he contributed to the US Digital TV standard. In collaboration with Susie Wee, he developed an approach for media transcoding in the middle of a network while preserving end-to-end security (secure transcoding) which was adopted by the JPEG 2000 Security (JPSEC) standard. His research interests include improving the reliability, fidelity, scalability, and security of multimedia communications over wired and wireless packet networks. He received his BS, MS, and PhD degrees in EECS from MIT.

Joeri Barbarien obtained the degree of Master in Electrical Engineering in 2000 and the degree of Dr in Engineering Sciences in 2006, both from Vrije Universiteit Brussel, Belgium. Since October 2000, he has been a member of the Department of Electronics and Informatics, Vrije Universiteit Brussel, Belgium, where he is currently working as a postdoctoral researcher and part-time professor. He is also actively involved as a project coordinator in the Interdisciplinary Institute for Broadband Technology (IBBT). His research interests include scalable video and still-image coding and implementation aspects thereof. In 2007, he was the co-recipient of the Most Cited Paper Award

2007 (period 2004–2006) given by Elsevier for the paper 'In-band motion compensated temporal filtering,' published in *Signal Processing: Image Communication*.

Bernard Brower is ITT Technology Fellow of the ITT Space Systems Division. Mr Brower has over 20 years of experience in the development, optimization, and operation of remote sensing systems. He was the lead engineer in the development, optimization, and implementation of the downlink compression for ITT's commercial remote sensing systems (IKONOS, QuickBird, WorldView-1, OrbView-1), and is currently serving as the Head of the US Delegation to the ISO/IEC SC 29/JTC 1 WG 1 (JPEG) committee and the Chairman of the International Committee for Technology Standards (INCITS) L3.2 (Still Image Coding). Mr Brower has a Master of Science/Bachelor of Science from the Rochester Institute of Technology, Center for Imaging Science (1993).

Tim Bruylants graduated as a Master of Science in 2001 at the University of Antwerp. He started out working for a small private company as a systems designer and programmer, creating document publishing software. In 2005, he participated as a member of the Forms Working Group (W3C). In 2006, Tim Bruylants became a PhD student at the Vrije Universiteit Brussel, Belgium. The main topic of his research is the compression of volumetric data sets, using wavelet and geometric transforms. Since 2005, Tim Bruylants has also been an active member of the JPEG committee. He is co-editor of the JPEG 2000 Part 10 (JP3D) specification.

Robert Buckley is a Research Fellow with the Xerox Research Center Webster in Webster, NY. He has been with Xerox since 1981, when he joined the Xerox Palo Alto Research Center after receiving a PhD in Electrical Engineering from MIT. He also has an MA in Psychology and Physiology from the University of Oxford, which he attended as a Rhodes Scholar, and a BSc in Electrical Engineering from the University of New Brunswick. During his career at Xerox, he has held research management and project leadership positions in color imaging and systems and has worked on color printing, image processing, enterprise coherence, and standards for color documents and images. He is the Xerox representative on the US JPEG 2000 committee and was the Project Editor for Part 6 of the JPEG 2000 standard, which defines the JPEG 2000 file format for compound and document images. He currently chairs the CIE Technical Committee on Archival Color Imaging and was founding co-chair of the IS&T Archiving Conference. He is a Fellow of the Society for Imaging Science anad Technology (IS&T) and Past President of the Inter-Society Color Council.

Greg Colyer graduated in Physics & Theoretical Physics from the University of Cambridge and went on to research electrodynamics and quantum mechanics at the University of Sussex. From 1996 to 2004 he worked for Elysium Ltd in Crowborough, UK. He helped to create the Pandora JPEG 2000 demonstrator produced by the MIGRATOR 2000 project and the open-source C implementation of a JPIP proxy server produced by the 2KAN project. As a UK delegate to the JPEG committee, Greg worked on the design of the JPEG 2000 file format and the JPIP network protocol, co-editing ISO/IEC 15444-5/Amd.1 and ISO/IEC 15444-9. With Richard Clark he wrote PD 6777, *Guide to the practical implementation of JPEG 2000*, published by the British Standards Institution. From 2005 to

2007 he lectured in computing and physics, and since 2006 has been a systems analyst, at the University of Guelph, Ontario, Canada.

Eric Delfosse received the MS degree of the Civil Electrotechnical Engineer in Telecommunications from the Free University of Brussels (VUB), Brussels, Belgium, in 1999. From 1999 to 2001, he was a Researcher at the VUB's Telecommunication Research Group. In 2001, he joined the Multimedia Research group of the IMEC Research Center, Leuven, Belgium. He is currently Multimedia Activity Leader at IMEC. His current research interests include wavelet-based image coding algorithms, 3-D graphics, and quality of service. Since December 2001, he has been an active contributor to the ISO/IEC MPEG Standardization Committee, focusing on MPEG-4 Animated Framework eXtension (ISO/IEC 14 496-16) and MPEG-21 Digital Item Adaptation (ISO/IEC 21000-7).

Frédéric Dufaux received his MSc in Physics and PhD in Electrical Engineering from the Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland, in 1990 and 1994 respectively. From 1990 to 1994, he was a research assistant at the Signal Processing Laboratory at EPFL. In 1994 and 1995, he was a Postdoctoral Fellow at the Media Laboratory of the Massachusetts Institute of Technology. From 1995 till 2001, he was a senior member of research staff at the Cambridge Research Laboratory of Compaq Computer Corporation. In 2001, he joined Genimedia SA as a principal solutions architect. He is currently on the research staff at EPFL. His research interests include image and video coding, motion estimation, image and video analysis, media search and retrieval, archival of media content, media security, media transmission over wireless, and computer vision. He has been involved in the standardization of digital video and imaging technologies in the MPEG and JPEG committees. He is the author or co-author of more than 70 research publications and holds 10 patents in the field of media technologies.

Touradj Ebrahimi received his MSc and PhD, both in Electrical Engineering, from the Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland, in 1989 and 1992 respectively. He is currently Professor at EPFL heading its Multimedia Signal Processing Group. He is also adjunct Professor with the Center of Quantifiable Quality of Service at Norwegian University of Science and Technology (NTNU). Professor Ebrahimi has been the recipient of various distinctions and awards, such as the IEEE and Swiss national ASE award, the SNF-PROFILE grant for advanced researchers, Four ISO-Certificates for key contributions to MPEG-4 and JPEG 2000, and the best paper award of *IEEE Transactions on Consumer Electronics*. He became a Fellow of the International Society for Optical Engineering (SPIE) in 2003. Professor Ebrahimi has initiated more than two dozen National, European, and International cooperation projects with leading companies and research institutes around the world. He is also the head of the Swiss delegation to MPEG, JPEG, and SC29, and acts as the Chairman of Advisory Group on Management in SC29. He is a co-founder of Genista SA, a high-tech start-up company in the field of multimedia quality metrics. In 2002, he founded Emitall SA, a start-up active in the area of media security and surveillance. In 2005, he founded EMITALL Surveillance SA, a start-up active in the field of privacy and protection. He is or has been associate Editor with various IEEE, SPIE, and EURASIP journals, such as *IEEE Signal Processing Magazine, IEEE Transactions on Image Processing, IEEE Transactions on Multimedia,*

EURASIP Image Communication Journal, EURASIP Journal of Applied Signal Processing, and *SPIE Optical Engineering Magazine*. His research interests include still, moving, and 3-D image processing and coding, visual information security (rights protection, watermarking, authentication, data integrity, steganography), new media, and human computer interfaces (smart vision, brain computer interface). He is the author or the co-author of more than 200 research publications and holds 14 patents. Professor Ebrahimi is a member of IEEE, SPIE, ACM, and IS&T. Email: Touradj.Ebrahimi@epfl.ch.

Robert Fiete is Chief Technologist at the ITT Space Systems Division. Dr Fiete received his BS in Physics and Math from Iowa State University and his MS and PhD in Optical Sciences from the University of Arizona. In 1987 he joined Eastman Kodak's Federal Systems Division as a senior project engineer and later became manager of the Imaging Systems Analysis group. During this time he developed a digital image simulation process for designing remote sensing systems by mathematically modeling the image formation process of the entire imaging chain and generating image simulations to assess the resulting image quality. This process has been used to assess and develop many of the compression algorithms in use today. He has authored over 30 technical papers, received 9 patents, and was awarded the Rudolf Kingslake Medal by SPIE, the International Society of Optical Engineering.

Siegfried Fößel, born in 1964, received his Diploma degree (MS) in Electronic Engineering from the University of Erlangen, Germany, in 1989. He started his professional career as a scientist at the Fraunhofer Institute IIS in Erlangen. He was team leader and project manager for several projects in the field process automation, image processing systems, and digital camera design. In 2000 he received his PhD degree. Since 2001 he has been head of the digital cinema group within the Fraunhofer IIS. He was responsible for projects like ARRI D20, DCI certification plan, JPEG 2000 standardization for Digital Cinema or field recorder Megacine, and coordinated several funded projects like WorldScreen. Siegfried is a member of the ISO SC29/JPEG and TC36 group. Within the JPEG group he is chairing the ad hoc group for Digital Cinema and Motion JPEG 2000. In addition he is a member of SMPTE, FKTG, ISDCF, and DIN. Within the EDCF (European Digital Cinema Forum) he is a member of the technical board.

Ron Gut received a BS in Electrical Engineering from the Massachusetts Institute of Technology in 1992. Until 2007 he was employed at Aware, Inc. in Bedford, MA, where he participated in and led the development of several image compression software products, including spending eight years leading Aware's JPEG 2000 software development team. He was a member of the JPEG standards body, and authored or co-authored several papers and technical reports on image compression.

Hans Hoffman is currently program manager at the European Broadcast Union (EBU). Previously, he was member of the research staff at the Institut für Rundfunktechnik (IRT) in Germany. In 2007, Hans Hoffman obtained his PhD degree at Brunel University (UK) on the subject 'Image quality considerations for HDTV formats in the flat panel display environments.' He is SMPTE Governor for Europe, the Middle East, Africa, Central and South America Region for a Two-Year Term, 2008–2009, and Co-chairman of the Joint

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J. Scott Houchin is an Engineering Specialist at The Aerospace Corporation and was previously a Research Associate at The Eastman Kodak Company. Throughout the JPEG 2000 standardization process, he chaired the file format ad hoc group and was responsible for leading the development of the JP2 and JPX file formats and the metadata transfer capability of the JPEG 2000 internet protocol. Before JPEG 2000, Mr Houchin served as the chief architect of the Flashpix™ digital image format and was a major contributor to the Professional Extensions to the Photo CD system. He has written several papers on the JPEG 2000 file formats and other digital image file format technologies. Mr Houchin is a recipient of a 2006 INCITS Technical Excellence Award for his work on the JPEG 2000 family of standards.

Paul W. Jones is currently Vice President and Director of Research and Development of Certifi Media Inc. and has 24 years of technical experience in the areas of digital image and video processing, image compression, image security, and image quality. He has a proven record of innovation and currently holds 29 US patents and has eight US patent applications. As a Senior Principal Scientist at the Eastman Kodak Company, he made significant contributions to a diverse range of digital imaging applications, including consumer and professional photography, document imaging, medical imaging, and motion picture imaging. Paul was also a co-recipient of the 2005 CEK Mees Award (Kodak's highest research honor) for his work on digital image watermarking. He holds BS and MS degrees in Imaging Science from Rochester Institute of Technology and an MS degree in Electrical Engineering from Rensselaer Polytechnic Institute. He is co-author of the textbook *Digital Image Compression Techniques*, currently in its seventh printing, and has co-authored three book chapters on image compression. He has taught numerous seminars on image compression and has presented new technical contributions at a variety of conferences and forums and in journal articles. He was a co-recipient of the 2007 Journal Award for the best paper of the Society of Motion Picture and Television Engineers (SMPTE).

Rajan L. Joshi received his Bachelor of Technology degree in Electrical Engineering and Masters of Technology degree in Communications Engineering from the Indian Institute of Technology, Mumbai, in 1988 and 1990, respectively. He received his PhD degree in Electrical Engineering from Washington State University, Pullman, in 1996. Presently, he is a Senior Member of Technical Staff at Thomson Corporate Research, Burbank, CA. From 1996 to 2006 he was a Principal Scientist at Kodak Research Laboratories, Rochester, NY. His research interests include image and video compression, information theory, wavelet analysis, and image processing. He has co-authored a book chapter and tutorial in the area of wavelet image compression and JPEG 2000. He holds 12 US patents.

James Kasner received a BS degree in Electrical Engineering from the University of Akron, Akron, OH, in 1987, an MS degree in Electro-optics from the University of Dayton, Dayton, OH, in 1990, and a PhD degree in Electrical Engineering from the

University of Arizona, Tucson, AZ, in 1995. From 1995 to 1999, he was with Optivision, Inc., Palo Alto, CA, where he developed JPEG and wavelet-based image compression algorithms. Thereafter, he was with The Aerospace Corporation, Chantilly, VA, where he conducted research on multi- and hyperspectral image compression, and with Eastman Kodak Corporation. Currently, he is employed at ITT Corporation. Since 1995 he has been active in the ISO JPEG group and has participated in several standards efforts, including the development of the emerging JPEG 2000 standard. He is editor of ISO/IEC 15444-2 and editor of the Multiple Component Transform (MCT) framework Annex J.

Adi Kouadio obtained his MSc degree in communication systems in 2007 from the Ecole Polytechique Fédérale de Lausanne, Switzerland. Since 2007, he has been working as project manager at the European Broadcast Union (EBU) in Geneva, Switzerland. He is chairman of the EBU Correspondence Group on 1080P Picture Format for HDTV (D/1080P). This group reports on the state-of-the-art and industry developments concerning 1080p, monitors development in the standardization bodies, and recommends actions when necessary to ensure open and interoperable systems.

Gauthier Lafruit was a Research Scientist with the Belgian National Foundation for Scientific Research from 1989 to 1994, being mainly active in the area of wavelet image compression implementations. Subsequently, he was a Research Assistant with the Vrije Universiteit Brussel (VUB), Brussels, Belgium. In 1996, he became the recipient of the Scientific Barco Award and joined IMEC, where he was involved as a Senior Scientist with the design of low-power VLSI for combined JPEG/wavelet compression engines. He is currently the Principal Scientist in the Digital Components Unit of the Department on Smart Systems and Energy Technology at IMEC. His main interests include progressive transmission in still image, video, and 3-D object coding, as well as scalability and resource monitoring for advanced, scalable video, and 3-D coding applications. He is the author or co-author of a significant amount of scientific publications, MPEG standardization contributions, and patents (applications) and has participated (and been appointed as evaluator) in several national and international projects. Since 2008, he is also associate editor of *IEEE Transactions on Circuits and Systems for Video Technology*.

Daniel T. Lee is a seasoned technology executive with over 25 years of management experience in the high-tech industry. He is the General Manager of eBay Global Development Centers, with development centers in Shanghai, China, and Chennai, India. Prior to eBay, he was the CTO of Yahoo! Asia, and before that he was with HP, where he held a number of management positions at HP Labs as Manager of Imaging Technology and at HP Internet Imaging Operation where he led the development of OpenPix imaging software and a photo hosting service. He also worked at IBM Research where he worked on image compression. In standardization, he serves as the Convener of ISO/IEC JTC1 SC29/WG1 – JPEG Standards Committee, a position he has held since 1996. As Convener, he works with over 100 experts from 16 countries in developing the highly successful JPEG 2000 family of imaging standards that has been adopted by many groups in the imaging industry. Dr Lee received a BS degree from Cornell University and MS and PhD degrees from Stanford University. He completed the Executive Development Program at Kellogg School of Management, Northwestern University. He has published

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Margaret Lepley is a principal scientist at the MITRE Corporation with 25 years of experience and related educational background in mathematical analysis, image compression, spatial and spectral feature analysis, and scientific programming. As an active member of the JPEG committee, she helped develop Parts 1 and 2 of the JPEG 2000 image compression standard. Margaret has applied her knowledge of JPEG 2000 and wavelet compression in general in the fields of remote sensing and fingerprint imaging.

Simon McPartlin works as a software engineer for a think-cell at Software GmbH in Berlin, Germany. He studied Computer Science at the University of Edinburgh and his interests include digital image processing and still image compression. He is co-editor of the JPEG 2000 Part 6 ISO standard and developed the first commercial JPM implementation for LuraTech GmbH.

Michael Marcellin holds the title of Regents Professor of Electrical and Computer Engineering at the University of Arizona. Dr Marcellin was a major contributor to JPEG 2000. Throughout the standardization process, he chaired the JPEG 2000 Verification Model ad hoc group. He is co-author of the book, *JPEG 2000: Image Compression Fundamentals, Standards and Practice*, Kluwer Academic Publishers. Dr Marcellin served as a consultant to Digital Cinema Initiatives (DCI) on the development of the JPEG 2000 profiles for digital cinema. Professor Marcellin is a Fellow of the IEEE and is a member of Tau Beta Pi, Eta Kappa Nu, and Phi Kappa Phi. He is a 1992 recipient of the National Science Foundation Young Investigator Award, and a co-recipient of the 1993 IEEE Signal Processing Society Senior (Best Paper) Award.

Joerg Mohr studied Electrotechnical Engineering at the Friedrich-Alexander University in Erlangen, Germany, where he graduated in 1999. He started working as research engineer at the Fraunhofer Institute for Integrated Circuits IIS, Germany. After his participation in several projects of camera and imaging device development, Joerg Mohr focused on video compression and Digital Cinema technology. He was responsible for JPEG 2000 hardware and software development and participated at various public and private founded research projects. As a member of the JPEG 2000 standardization committee he contributed mainly to Motion JPEG 2000 and Digital Cinema activities. Since 2008 he is head of R&D at KERN electronic GmbH, a Germany-based manufacturer of professional wireless video transmission equipment.

Luk Overmeire obtained his MSc degree of Electrotechnical Engineering at the University of Ghent, Belgium. After his studies he joined Alcatel Bell Antwerp where he designed software-based services and digital filters for ADSL. In 2002, he joined the R&D department of VRT, where he did research on metadata-based video coding and bit-rate control. Currently, he is leading a competence group on media production and processing of audiovisual data. He is a member of the EBU working group on P/TVFile (MXF), AMWA (Advanced Media Workflow Association) and SMPTE's W25. Luk Overmeire is the co-author of several scientific publications and patents.

Robert Prandolini graduated in Electrical and Electronics Engineering from the Queensland University of Technology (QUT) in 1986. While on the academic staff of QUT (1987–1992), he was a consultant in electronic forensics. This led to his PhD studies (QUT) in nonlinear spread-spectrum, which he graduated from in 1996. In 1995 he joined the Australian Federal Police (AFP) as an expert in forensic electronic recording. He moved to the Defence Science and Technology Organisation in 1999 to work on image coding and management, including JPEG 2000 for military applications. He was the chair and co-editor for Part 9 of the JPEG 2000 standard. Over the past few years Dr Prandolini has been working on future imagery and geospatial information systems, was the lead for the ground environment technical implementation team in the Australian 2006 North-West Shelf UAV Trial, and is presently advising Defence on agile dissemination technology for UAVs.

Majid Rabbani received his MS and PhD degrees in electrical engineering from the University of Wisconsin in Madison in 1980 and 1983, and joined Eastman Kodak in the same year. He is a Kodak Distinguished Research Fellow and project manager of video processing at Eastman Kodak. Rabbani is the recipient of the 1988 Kodak C. E. K. Mees Award, and co-recipient of two Engineering Emmy Awards in 1990 and 1997, respectively. He has been actively involved in organizing technical conferences and panels and teaching short courses, both internal and external to Kodak. His current research interests span the various aspects of digital imaging, where he has published many technical articles, four book chapters, and holds more than 30 issued patents. Majid Rabbani was actively involved in the JPEG 2000 standardization process. He is a Fellow of IEEE, a Fellow of SPIE, and a Kodak Distinguished Inventor. He is the co-author of the book *Digital Image Compression Techniques* published by SPIE Press in 1991 and the Editor of the SPIE Milestone Series on *Image Coding and Compression*, published in 1992.

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Louis Sharpe is President of Picture Elements Inc., which develops algorithms, boards, chips, sensors, and software for document scanners. He has been actively involved in JPEG 2000 standardization and is co-editor of Part 6 of the standard and of the color amendment to JBIG2. He has been involved in document imaging and scanner design since the early 1980s. He was a co-author of the SCSI scanner command set, which is still used in USB scanners. He has consulted with the Library of Congress, the Federal Reserve Banks, and the US Patent Office to develop high-quality approaches to imaging documents. He holds a degree in Physics from the University of Colorado Boulder.

Roddy Shuler is Senior Staff Engineer of Image Science Products at the ITT Space Systems Division. Mr Shuler has extensive experience in applying and optimizing JPEG 2000 and JPIP technology to GIS and remote sensing applications. He has been a key software developer for several JPEG 2000 projects, including ITT's Image Access Solutions (IAS) product line, and was the lead image scientist for the development of ITT's JPEG 2000 compression hardware. He has also contributed to the success of the ITT downlink compression algorithm used on the WorldView-1 and GeoEye-1 satellites. He is currently the lead engineer for ITT's airborne compression and dissemination solutions based on JPEG 2000 and JPIP. Mr Shuler holds a Master of Science Degree in Electrical Engineering from Stanford University (1993).

Athanassios Skodras studied Physics at the Aristotle University of Thessaloniki, Greece, and Computer Engineering and Informatics at the University of Patras, Greece. He holds a PhD degree in Electronics from the University of Patras. Since 1986 he has held teaching and research positions at the Departments of Physics and Computer Engineering and Informatics of the University of Patras and the Research Academic Computer Technology Institute, Patras, Greece. From October 2002 he has been Professor of Digital Systems and Head of Computer Science, School of Science and Technology, Hellenic Open University, Patras, Greece. During the academic years 1988–1989 and 1996–1997 he has been a Visiting Research Scientist with the DEEE, Imperial College, London, UK. His research interests include image and video coding, digital watermarking for IPR protection, and video analysis. He has published over 100 technical papers in journals and conference proceedings, authored or co-authored four books, two book chapters, and holds two international patents on compressed domain image processing. He is the co-recipient of the first place Chester Sall Award for the best paper in the *2000 IEEE Transactions on Consumer Electronics* for the work on JPEG 2000 standards. He is a Chartered Engineer, Senior Member of the IEEE, Chair of the Greek Association of Image Processing and Digital Media, and Technical Coordinator of the WG6 on image and video coding of the Greek Organization for Standardization. Email: skodras@eap.gr.

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Frederik Temmermans studied theoretical Computer Science at the University of Brussels (Vrije Universiteit Brussel) and specialized in artificial intelligence. He graduated in 2006. Thereafter, he started a PhD at the Department of Electronics and Informatics (ETRO) of the same university. His research is mainly situated in the area of medical image retrieval. In the context of his PhD research, Frederick has been following the activities of JPSearch, a part of the JPEG committee, focusing on interoperability between image retrieval systems.

Alexis Tzannes received a BS in Electrical Engineering from the University of Central Florida in 1990, an MS in Electrical Engineering from Brown University in 1992, and a PhD in Electrical Engineering from Northeastern University in 1998. Since 1999 he has been employed at Aware, Inc. in Bedford, MA, where he has led their JPEG 2000 software development team. For the past 10 years he has also been an active participant in the JPEG standards body. He was co-editor of JPEG 2000 Part 10 (JP3D) and is Chair of the JPIP sub-group and the Medical Imaging ad hoc group. He has presented various tutorials and papers on JPEG 2000 and its applications at scientific conferences and symposiums. He was also the author of DICOM Supplement 105, which incorporated the Multi-Component Transformations of JPEG 2000 Part 2 into the DICOM standard. He is the author of several papers in the areas of image compression and point target detection and tracking.

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Foreword

Image coding is one of the most popular fields of research since the advent of digital communication in modern times. Researchers are attracted to image coding research for many reasons. It is a very stimulating field requiring firm groundings in image science, digital signal processing, information theory, and systems concepts. A larger reason is the satisfaction of being able to directly see the visual results of the images, often manifested in an interactive way where not only can one appreciate the beauty but also the innovations applied to the images in the research.

The industry also sees the attractiveness of imaging as a significant market potential. As more researchers are attracted to the field, technology coming from research has led to developments of new imaging products and services. Having attractive products, however, is not good enough to ensure market success. As the image itself is often an integral part of the product, market success of the imaging products will depend on the adoption of well-defined imaging standards to support the interoperability of features and functions among the imaging products.

A good example is the success of the consumer digital camera market, which has made the use of digital photos pervasive in recent years. The joy of sharing digital photos is a new phenomenon in human social interactions enjoyed by millions of Internet users today. A key element of this success is due to the availability of a well-adopted standard, in this case the JPEG standard, a highly successful standard that was published in 1988.

With the ubiquity of broadband networks (wired and wireless), a growing number of new applications such as high-resolution imagery, digital libraries, cultural archives, high-fidelity color imaging, Internet applications, wireless, medical imaging, digital cinemas, etc., requires additional, enhanced functionalities from a compression standard, which JPEG cannot satisfy due to some of its inherent shortcomings – design points that were beyond the scope of JPEG when it was developed in the previous decade. The shortcomings of JPEG can be seen in a number of areas: distortion and artifacts, ineffective handling of high-quality images, poor compression for lossless images, lack of effective colorspace support, and lack of resolution scaling. In the mid-1990s, the JPEG committee had an opportunity to start a *new work item* to address these issues and the result is the JPEG 2000 family of standards.

JPEG 2000 makes use of several advances in compression technology to deliver superior compression performance and provides many advanced features in scalability, flexibility, and systems functionalities that outperform its predecessor. In particular, JPEG 2000 uses the discrete wavelet transform (DWT) in place of the discrete cosine transform (DCT) of JPEG. It uses a more sophisticated coding mechanism that supports more flexible, finely embedded representation of the image so that many desirable features are provided in one