

Measuring, Modeling, and Reproducing Material Appearance 2015

**Maria V. Ortiz Segovia
Philipp Urban
Francisco H. Imai**
Editors

**9–10 February 2015
San Francisco, California, United States**

Sponsored by
IS&T—The Society for Imaging Science and Technology
SPIE

Cosponsored by
Océ Print Logic Technologies (Netherlands)
Canon (United States)

Published by
SPIE

Volume 9398

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publishers are not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Measuring, Modeling, and Reproducing Material Appearance 2015*, edited by Maria V. Ortiz Segovia, Philipp Urban, Francisco H. Imai, Proceedings of SPIE-IS&T Electronic Imaging, SPIE Vol. 9398, Article CID Number (2015)

ISSN: 0277-786X

ISBN: 9781628414882

Copublished by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

and

IS&T—The Society for Imaging Science and Technology

7003 Kilworth Lane, Springfield, Virginia, 22151 USA

Telephone +1 703 642 9090 (Eastern Time) · Fax +1 703 642 9094

imaging.org

Copyright © 2015, Society of Photo-Optical Instrumentation Engineers and The Society for Imaging Science and Technology.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by the publishers subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/15/\$18.00.

Printed in the United States of America.

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

Contents

- v *Authors*
- vii *Conference Committee*
- ix *Introduction*

SESSION 1 RENDERING AND MODELING

- 9398 03 **Imaging artwork in a studio environment for computer graphics rendering** [9398-2]
- 9398 04 **Predictive rendering of composite materials: a multi-scale approach** [9398-3]
- 9398 05 **Estimating reflectance property from multi-focus images by light field camera and its application** [9398-4]
- 9398 06 **Experiments with a low-cost system for computer graphics material model acquisition (Invited Paper)** [9398-5]
- 9398 07 **BTF Potts compound texture model** [9398-6]
- 9398 08 **Statistical analysis of bidirectional reflectance distribution functions** [9398-7]
- 9398 09 **Principal component analysis for surface reflection components and structure in the facial image and synthesis of the facial image in various ages** [9398-8]
- 9398 0A **Extrapolation of bidirectional texture functions using texture synthesis guided by photometric normals** [9398-9]

SESSION 2 MEASURING

- 9398 0D **Metrological issues related to BRDF measurements around the specular direction in the particular case of glossy surfaces** [9398-12]
- 9398 0E **Upgrade of goniospectrophotometer GEFE for near-field scattering and fluorescence radiance measurements** [9398-13]
- 9398 0F **Multiplexed acquisition of bidirectional texture functions for materials (Best Student Paper Award)** [9398-14]
- 9398 0G **An abridged goniometer for material appearance measurements** [9398-15]
- 9398 0H **New generation of Fourier optics instruments for fast multispectral BRDF characterization** [9398-16]

- 9398 OI **Color calibration of an RGB digital camera for the microscopic observation of highly specular materials** [9398-17]
- 9398 OJ **An image-based multi-directional reflectance measurement setup for flexible objects** [9398-18]

SESSION 3 PERCEPTION OF TEXTURE, GLOSS, AND COLOR IN MATERIALS: JOINT SESSION WITH CONFERENCES 9394 AND 9398

- 9398 OK **Extended visual appearance texture features** [9398-20]
- 9398 OL **Gonochromatic difference between effect coatings: Is the whole more than the sum of its parts?** [9398-21]
- 9398 OM **Visual comparison testing of automotive paint simulation** [9398-22]

SESSION 4 APPEARANCE

- 9398 ON **Goniometric and colorimetric properties of paints and varnish** [9398-23]
- 9398 OO **Gonochromatic and sparkle properties of effect pigmented samples in multidimensional configuration** [9398-24]
- 9398 OP **Anisotropic materials appearance analysis using ellipsoidal mirror** [9398-25]
- 9398 OQ **Changing the color of textiles with realistic visual rendering** [9398-26]

SESSION 5 REPRODUCTION

- 9398 OR **3D printed glass: surface finish and bulk properties as a function of the printing process (Invited Paper)** [9398-27]
- 9398 OS **Color-managed 3D printing with highly translucent printing materials** [9398-28]
- 9398 OT **Towards gloss control in fine art reproduction** [9398-29]
- 9398 OU **Exploring the bronzing effect at the surface of ink layers** [9398-30]
- 9398 OV **Controlling colour-printed gloss by varnish-halftones** [9398-31]
- 9398 OW **Reproducing oil paint gloss in print for the purpose of creating reproductions of Old Masters** [9398-32]
- 9398 OX **3D printing awareness: the future of making things** [9398-33]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Arikan, Can Ates, 0S
Audenaert, Jan, 0D
Avery, Michael P., 0R
Baar, Teun, 0T, 0V, 0W
Baba, Kaori, 05
Barbier, Justine, 0Q
Barla, Pascal, 08
Bartlett, Paul, 0R
Belcour, Laurent, 08
Bernad, Berta, 0E
Berns, Roy S., 03
Besbes, Mondher, 0U
Bignon, Thibault, 0H
Blahová, Jana, 0L, 0V
Boher, Pierre, 0H
Bosch, Carles, 08
Brettel, Hans, 0T
Brunton, Alan, 0S
Callet, P., 04
Campos, Joaquín, 0E
Cartwright, Luke, 06
Cazier, Anthony, 0Q, 0U
Chavel, Pierre, 0U
Collomb-Patton, Véronique, 0H
Cox, Brittany D., 03
da Graça, F., 04
Deboos, Alexis, 0U
Dekker, Niels, 0L
den Brok, Dennis, 0A, 0F
Désage, Simon-Frédéric, 0K
Dik, Joris, 0W
Elkhuizen, Willemijn S., 0W
Evey, Curtis, 0M
Fairchild, Mark D., 0G
Fan, Hua-Tzu, 0M
Farup, Ivar, 0J
Favrelière, Hugues, 0K
Ferrero, Alejandro, 0E
Filip, Jiří, 0P
Fores, Adria, 0G
Frei, Regina, 0R
Frelin, Fabrice, 0K
Ged, Guillaume, 0D
Geraedts, Jo M. P., 0W
Haindl, Michal, 07
Hauer, Kai-Olaf, 0O
Havlíček, Vojtěch, 07
Hébert, Mathieu, 0I, 0Q, 0U
Henckens, Lambert, 0Q
Hernanz, M. Luisa, 0E
Hirose, Misa, 09
Hoarau, R., 04
Höpe, Andreas, 0O
Huertas, Rafael, 0L
Hugonin, Jean-Paul, 0U
Hullin, Matthias B., 0A, 0F
Hünerhoff, Dirk, 0O
Iacomussi, P., 0N
Kirchner, Eric, 0L
Klein, Reinhard, 0A, 0F
Klein, Susanne, 0R
Kuang, Deng-Feng, 0U
Le Goïc, Gaëtan, 0K
Leboulleux, Lucie, 0Q
Leloup, Frederic B., 0D
Lenseigne, Boris A. J., 0W
Leroux, Thierry, 0H
Lockerman, Yitzhak, 06
Lucassen, Marcel, 0L
Maire, Jean-Luc, 0K
Mallet, Maxime, 0U
Martín, Rodrigo, 0A
Martínez-García, Juan, 0I
Meseth, Jan, 0M
Meyer, Gary, 0M
Muller, T., 04
Muñoz, Adolfo, 08
Njo, Lan, 0L
Obein, Gael, 0D
Ogawa-Ochiai, Keiko, 09
Ojima, Nobutoshi, 09
Ortiz Segovia, Maria V., 0T, 0V
Page, Marine, 0Q
Paljic, A., 04
Pillet, Maurice, 0K
Pitard, Gilles, 0K
Pitera, David, 06
Pons, Alicia, 0E
Porral, P., 04
Radis, M., 0N
Remès, Václav, 07
Richardson, Robert, 0R
Rossi, G., 0N
Roujas, Lucie, 0Q
Rushmeier, Holly, 06
Samadzadegan, Sepideh, 0V
Sambongi, Masao, 05
Samper, Serge, 0K

Schnackenberg, Ryan, 0M
Seubert, Christopher, 0M
Simske, Steven, 0R
Sole, Aditya S., 0J
Steinhausen, Heinz C., 0A, 0F
Strothkämper, Christian, 0O
Tanksale, Tejas Madan, 0S
Tastl, Ingeborg, 0G
Teichert, Sven, 0O
Tempelman, Erik, 0W
Tominaga, Shoji, 0J
Toyota, Saori, 09
Trémeau, Alain, 0I
Tsumura, Norimichi, 05, 09
Urban, Philipp, 0L, 0S, 0V
Valpreda, F., 0X
van der Lans, Ivo, 0L
Vávra, Radomír, 0P
Verhofstad, Wim, 0W
Yamamoto, Shoji, 05
Zubiaga, Carlos J., 08

Conference Committee

Symposium Chair

Sheila S. Hemami, Northeastern University (United States)

Symposium Co-chair

Choon-Woo Kim, Inha University (Korea, Republic of)

Conference Chairs

Maria V. Ortiz Segovia, Océ Print Logic Technologies S.A. (France)

Philipp Urban, Fraunhofer-Institut für Graphische Datenverarbeitung
(Germany)

Francisco H. Imai, Canon U.S.A., Inc. (United States)

Conference Program Committee

Jan P. Allebach, Purdue University (United States)

Susan P. Farnand, Rochester Institute of Technology (United States)

James A. Ferwerda, Rochester Institute of Technology (United States)

Jon Yngve Hardeberg, Gjøvik University College (Norway)

Andreas Hoepe, Physikalisch-Technische Bundesanstalt (Germany)

Matthias B. Hullin, Universität Bonn (Germany)

Gael Obein, Conservatoire National des Arts et Métiers (France)

Carinna E. Parraman, University of the West of England
(United Kingdom)

Sabine Süsstrunk, École Polytechnique Fédérale de Lausanne
(Switzerland)

Ingeborg Tastl, Hewlett-Packard Laboratories (United States)

Greg Ward, Dolby Laboratories, Inc. (United States)

Session Chairs

Keynote Session

Maria V. Ortiz Segovia, Océ Print Logic Technologies S.A. (France)

1 Rendering and Modeling

Maria V. Ortiz Segovia, Océ Print Logic Technologies S.A. (France)

Greg Ward, Dolby Laboratories, Inc. (United States)

- 2 Measuring
Francisco H. Imai, Canon U.S.A., Inc. (United States)
Gael Obein, Conservatoire National des Arts et Métiers (France)
- 3 Perception of Texture, Gloss, and Color in Materials: Joint Session with
Conferences 9394 and 9398
Bernice E. Rogowitz, Visual Perspectives Research and Consulting
(United States)
Maria V. Ortiz Segovia, Océ Print Logic Technologies S.A. (France)
Andreas Hoepe, Physikalisch-Technische Bundesanstalt (Germany)
- 4 Appearance
Francisco H. Imai, Canon U.S.A., Inc. (United States)
- 5 Reproduction
Philipp Urban, Fraunhofer-Institut für Graphische Datenverarbeitung
(Germany)
Ingeborg Tastl, Hewlett-Packard Laboratories (United States)

Introduction

The rapid and continuous development of rendering devices, such as displays and printers, offers interesting challenges related to how materials are understood. Over the years, researchers from different disciplines have studied the interaction of incident light with the texture and surface geometry of a given object, as well as the optical properties of distinct materials. Thanks to those efforts, we have been able to render with high accuracy 2.5D and 3D objects and scenes. But given the day-to-day technological improvements of materials and devices, along with the advances in the areas of visual and tactile perception, modeling how light interacts with materials, and techniques for measuring material properties, the field of material appearance is in constant evolution. This conference offers the possibility to share research results and establish new collaborations among academic and industrial researchers from these related fields.

The main topics encountered on the papers of this document correspond to any of the following categories:

- **Methods for measuring material properties:** measurement of Bidirectional Reflectance Distribution Functions (BRDF), Bidirectional Texture Functions (BTF), and Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF); estimation of material difference perception; evaluation of metallic coatings/inks; measurement of glossiness; estimation of texture perception; and data acquisition methods for different types of materials.
- **Models for distinct characteristics of materials:** modeling of Bidirectional Reflectance Distribution Functions (BRDF), Bidirectional Texture Functions (BTF), and Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF); modeling material difference perception; appearance modeling of glossiness and texture; modeling of varnish and special effects inks; and soft-proofing methods for 2.5D and 3D printing
- **Material reproduction aspects:** quality evaluation of 2.5D and 3D soft- and hard-copy reproductions (display and printing); estimation of effects of environmental aspects in material perception (lighting, observers' position, printing media); estimation of sensory input (visual, touch, audio) effect in material perception; evaluation of aesthetic aspects of 2.5D and 3D soft- and hard-copy reproductions (display and printing); saliency of 2.5D and 3D soft- and hard-copy reproductions (display and printing); imaging and perception of metallic and effect coatings/inks; saliency, quality, and aesthetics in appearance reproduction; and spectral reproduction

Maria V. Ortiz Segovia
Philipp Urban
Francisco H. Imai

