

2011  
Volume 30, Number 1

# ACM Transactions on Graphics



Association for  
Computing Machinery

*Advancing Computing as a Science & Profession*

- Article 1**  
(20 pages) **A. M. Bronstein**  
**M. M. Bronstein**  
**L. J. Guibas**  
**M. Ovsjanikov** Shape Google: Geometric Words and Expressions for Invariant Shape Retrieval
- Article 2**  
(13 pages) **S.-K. Yeung**  
**C.-K. Tang**  
**M. S. Brown**  
**S. B. Kang** Matting and Compositing of Transparent and Refractive Objects
- Article 3**  
(16 pages) **H. Barki**  
**F. Denis**  
**F. Dupont** Contributing Vertices-Based Minkowski Sum of a Nonconvex–Convex Pair of Polyhedra
- Article 4**  
(10 pages) **F. Liu**  
**M. Gleicher**  
**J. Wang**  
**H. Jin**  
**A. Agarwala** Subspace Video Stabilization
- Article 5**  
(19 pages) **W. Jarosz**  
**D. Nowrouzezahrai**  
**I. Sadeghi**  
**H. W. Jensen** A Comprehensive Theory of Volumetric Radiance Estimation Using Photon Points and Beams
- Article 6**  
(14 pages) **F. Bertails-Descoubes**  
**F. Cadoux**  
**G. Daviet**  
**V. Acary** A Nonsmooth Newton Solver for Capturing Exact Coulomb Friction in Fiber Assemblies

# ACM Transactions on Graphics

ACM  
2 Penn Plaza, Suite 701  
New York, NY 10121-0701  
Tel.: (212) 869-7440  
Fax: (212) 869-0481

**TOG Home Page:** <http://tog.acm.org/>

## Editor-in-Chief

Hugues Hoppe      Microsoft Research / <http://research.microsoft.com/~hoppe/>

## Assistant to the Editor-in-Chief

Andrea Beaty      Microsoft Research / email: [abeaty@microsoft.com](mailto:abeaty@microsoft.com)

## Past Editor-in-Chief

John C. Hart      University of Illinois at Urbana-Champaign / <http://graphics.cs.uiuc.edu/~jch/papers/>

## Associate Editors

Aseem Agarwala      Adobe Systems, Inc. / email: [asagarwa@adobe.com](mailto:asagarwa@adobe.com) / <http://agarwala.org/>  
Pierre Alliez      INRIA / email: [pierre.alliez@sophia.inria.fr](mailto:pierre.alliez@sophia.inria.fr) / <http://www-sop.inria.fr/members/Pierre.Alliez>  
Nina Amenta      University of California at Davis / email: [amenta@cs.ucdavis.edu](mailto:amenta@cs.ucdavis.edu) / <http://www.cs.ucdavis.edu/~amenta/>  
Daniel Cohen-Or      Tel Aviv University / email: [dcor@tau.ac.il](mailto:dcor@tau.ac.il) / <http://www.cs.tau.ac.il/~dcor/>  
Doug DeCarlo      Rutgers University / email: [decarlo@cs.rutgers.edu](mailto:decarlo@cs.rutgers.edu) / <http://www.cs.rutgers.edu/~decarlo/>  
Julie Dorsey      Yale University / email: [dorsey@cs.yale.edu](mailto:dorsey@cs.yale.edu) / <http://graphics.cs.yale.edu/julie/>  
Philip Dutré      Katholieke Universiteit Leuven / email: [philip.dutre@cs.kuleuven.be](mailto:philip.dutre@cs.kuleuven.be) / <http://www.cs.kuleuven.be/~phil/>  
Michael Gleicher      University of Wisconsin / email: [gleicher@cs.wisc.edu](mailto:gleicher@cs.wisc.edu) / <http://www.cs.wisc.edu/~gleicher/>  
Steven Gortler      Harvard University / email: [sjg@cs.harvard.edu](mailto:sjg@cs.harvard.edu) / <http://www.eecs.harvard.edu/~sjg/>  
Cindy Grimm      Washington University / email: [cmg@wustl.edu](mailto:cmg@wustl.edu) / <http://www.cs.wustl.edu/~cmg/>  
Radek Grzeszczuk      Intel Corporation / email: [radek.grzeszczuk@nokia.com](mailto:radek.grzeszczuk@nokia.com) / [http://research.nokia.com/people/radek\\_grzeszczuk/](http://research.nokia.com/people/radek_grzeszczuk/)  
Aaron Hertzmann      University of Toronto / email: [hertzman@dgp.toronto.edu](mailto:hertzman@dgp.toronto.edu) / <http://www.dgp.toronto.edu/~hertzman/>  
Takeo Igarashi      University of Tokyo / email: [takeo@acm.org](mailto:takeo@acm.org) / <http://www-ui.is.s.u.tokyo.ac.jp/~takeo/>  
Doug James      Cornell University / email: [djames@cs.cornell.edu](mailto:djames@cs.cornell.edu) / <http://www.cs.cornell.edu/~djames>  
Henrik Wann Jensen      University of California San Diego / email: [henrik@cs.ucsd.edu](mailto:henrik@cs.ucsd.edu) / <http://graphics.ucsd.edu/~henrik/>  
Dani Lischinski      Hebrew University of Jerusalem / email: [danix@cs.huji.ac.il](mailto:danix@cs.huji.ac.il) / <http://www.cs.huji.ac.il/~danix/>  
Dinesh Manocha      UNC Chapel Hill / email: [dm@cs.unc.edu](mailto:dm@cs.unc.edu) / <http://www.cs.unc.edu/~dm>  
Nelson Max      University of California at Davis / email: [max@cs.ucdavis.edu](mailto:max@cs.ucdavis.edu) / <http://www.cs.ucdavis.edu/people/faculty/max.html>  
Jorg Peters      University of Florida / email: [jorg@cise.ufl.edu](mailto:jorg@cise.ufl.edu) / <http://www.cise.ufl.edu/~jorg/>  
Hanspeter Pfister      Harvard University / email: [pfister@seas.harvard.edu](mailto:pfister@seas.harvard.edu) / <http://gvi.seas.harvard.edu/pfister/>  
Zoran Popović      University of Washington / email: [zoran@cs.washington.edu](mailto:zoran@cs.washington.edu) / <http://www.cs.washington.edu/homes/zoran/>  
Ravi Ramamoorthi      UC Berkeley / email: [ravir@cs.berkeley.edu](mailto:ravir@cs.berkeley.edu) / <http://www.cs.berkeley.edu/~ravir/>  
Ramesh Raskar      Massachusetts Institute of Technology / email: [raskar@media.mit.edu](mailto:raskar@media.mit.edu) / <http://web.media.mit.edu/~raskar/>  
Thomas Sederberg      Brigham Young University / email: [tom@cs.byu.edu](mailto:tom@cs.byu.edu) / <http://tom.cs.byu.edu/~tom/>  
François Sillion      INRIA / email: [francois.sillion@imag.fr](mailto:francois.sillion@imag.fr) / <http://artis.inrialpes.fr/Membres/Francois.Sillion/>  
John Snyder      Microsoft Research / email: [johnsny@microsoft.com](mailto:johnsny@microsoft.com) / <http://research.microsoft.com/~johnsny/>  
Jos Stam      Autodesk Inc. / email: [jos.stam@autodesk.com](mailto:jos.stam@autodesk.com) / <http://www.dgp.toronto.edu/~stam/>  
Joe Warren      Rice University / email: [jwarren@cs.rice.edu](mailto:jwarren@cs.rice.edu) / <http://www.cs.rice.edu/~jwarren/>  
Kun Zhou      Zhejiang University / email: [kunzhou@acm.org](mailto:kunzhou@acm.org) / <http://www.kunzhou.net/>  
Denis Zorin      New York University / email: [dzorin@mrl.nyu.edu](mailto:dzorin@mrl.nyu.edu) / <http://www.mrl.nyu.edu/~dzorin/>

## Headquarters Staff

Jono Hardjowirogo      Publisher, Associate Director of Publications  
Irma Strolia      Editorial Assistant  
Media Content Marketing      Production

*ACM Transactions on Graphics* (ISSN: 0730-0301) is published quarterly in Spring, Summer, Fall, and Winter by the Association for Computing Machinery (ACM), 2 Penn Plaza, Suite 701, New York, NY 10121-0701. Periodicals class postage paid at New York, NY 10011, and at additional mailing offices. Printed in the U.S.A. POSTMASTER: Send address changes to *ACM Transactions on Graphics*, ACM, 2 Penn Plaza, Suite 701, New York, NY 10121-0701.

**For manuscript submissions, subscription, and change of address information, see inside backcover.**

Copyright © 2011 by the Association for Computing Machinery (ACM). Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists, requires prior specific permission and/or a fee. Request permission to republish from: Publications Department, ACM, Inc. Fax +1 212-869-0481 or email [permissions@acm.org](mailto:permissions@acm.org).



**Association for  
Computing Machinery**

*Advancing Computing as a Science & Profession*

For other copying of articles that carry a code at the bottom of the first or last page or screen display, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

**Cover images from “Shape Google: Geometric Words and Expressions for Invariant Shape Retrieval,” by A. M. Bronstein, M. M. Bronstein, L. J. Guibas, and M. Ovsjanikov, in this issue.**

## ACM Transactions on Graphics

<http://tog.acm.org/>

*ACM Transactions on Graphics* publishes papers of significant and lasting value in all the subfields of computer graphics.

### Guide to Manuscript Submission

Submission to the *ACM Transactions on Graphics* is done electronically through <http://acm.manuscriptcentral.com>. Once you are at that site, you can create an account and password with which you can enter the ACM Manuscript Central manuscript review tracking system. From a drop-down list of journals, choose *ACM Transactions on Graphics* and proceed to the Author Center to submit your manuscript and your accompanying files.

You will be asked to create an abstract that will be used throughout the system as a synopsis of your paper. You will also be asked to classify your submission using the ACM Computing Classification System through a link provided at the Author Center. For completeness, please select at least one primary-level classification followed by two secondary-level classifications. To make the process easier, you may cut and paste from the list. Remember, you, the author, know best which area and sub-areas are covered by your paper; in addition to clarifying the area where your paper belongs, classification often helps in quickly identifying suitable reviewers for your paper. So it is important that you provide as thorough a classification of your paper as possible.

The ACM Production Department prefers that your manuscript be prepared in either LaTeX or Ms Word format. Style files for manuscript preparation can be obtained at the following location: <http://www.acm.org/pubs/submissions/submission.htm>. For editorial review, the manuscript should be submitted as a PDF or Postscript file. Accompanying material can be in any number of text or image formats, as well as software/documentation bundles in zip or tar-gzipped formats.

Questions regarding editorial review process should be directed to the Editor-in-Chief. Questions regarding the post-acceptance production process should be addressed to the Publisher, Jono Hardjowirogo, at [jono@hq.acm.org](mailto:jono@hq.acm.org).

### Subscription, Single Copy, and Membership Information.

#### Send orders to:

ACM  
P.O. Box 12114  
Church Street Station  
New York, NY 10257

#### For information, contact:

**Mail:** ACM Member Services Dept.  
2 Penn Plaza, Suite 701  
New York, NY 10121-0701  
**Phone:** +1-212-626-0500  
**Fax:** +1-212-944-1318  
**Email:** [acmhelp@acm.org](mailto:acmhelp@acm.org)  
**Catalog:** <http://www.acm.org/catalog>

Subscription rates for *ACM Transactions on Graphics* are \$44 per year for ACM members, \$39 for students, and \$165 for non-members. Single copies are \$18 each for ACM members and \$40 for nonmembers. Your subscription expiration date is coded in four digits at the top of your mailing label; the first two digits show the year, the last two show the month of expiration.

**About ACM.** ACM is the world's largest educational and scientific computing society, uniting educators, researchers and professionals to inspire dialogue, share resources and address the field's challenges. ACM strengthens the computing profession's collective voice through strong leadership, promotion of the highest standards, and recognition of technical excellence. ACM supports the professional growth of its members by providing opportunities for life-long learning, career development, and professional networking.

**Visit ACM's Web site:** <http://www.acm.org>.

**Change of Address Notification.** To notify ACM of a change of address, use the addresses above or send an email to [coa@acm.org](mailto:coa@acm.org).

Please allow 6–8 weeks for new membership or change of name and address to become effective. Send your old label with your new address notification. To avoid interruption of service, notify your local post office before change of residence. For a fee, the post office will forward 2nd- and 3rd-class periodicals.