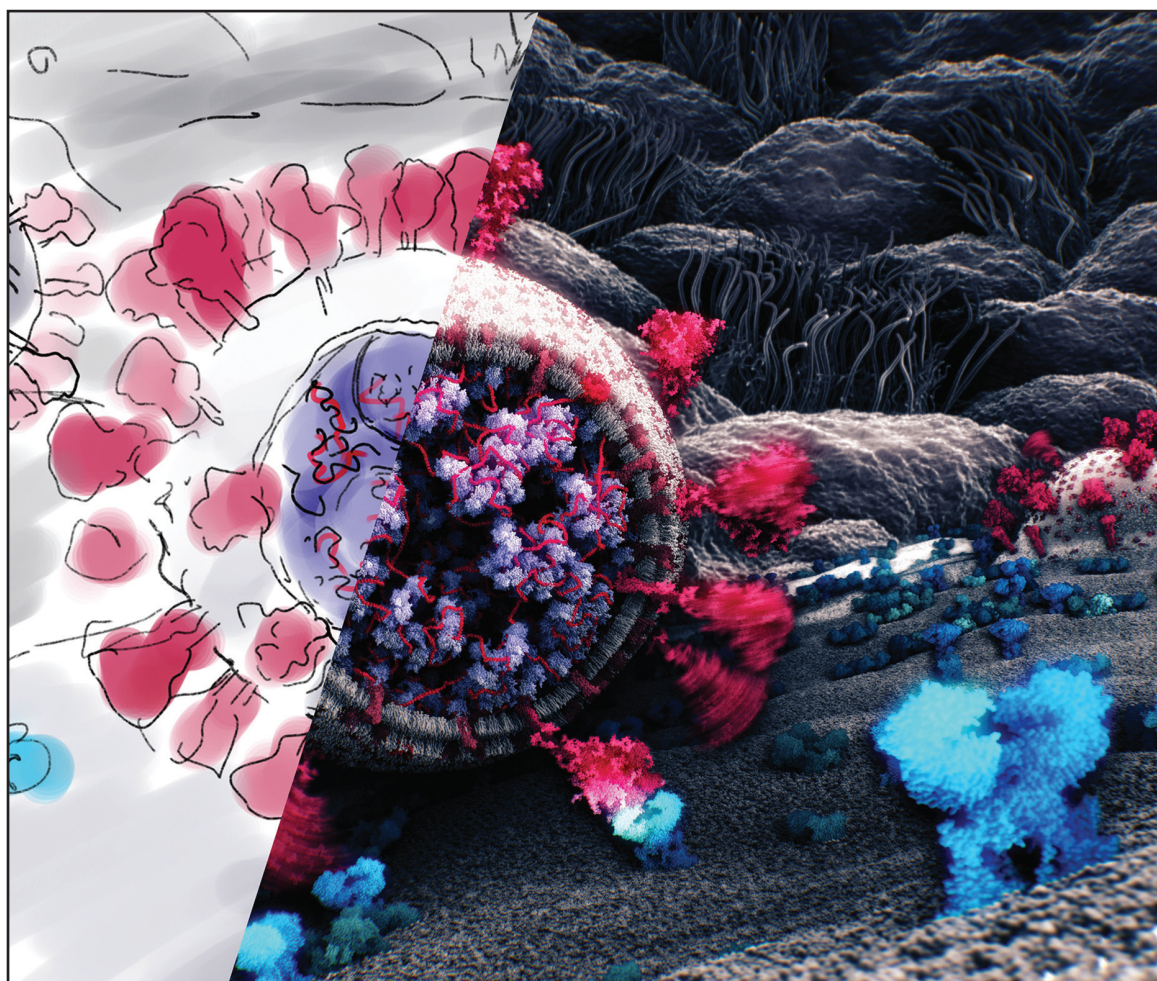


THE INTERNATIONAL JOURNAL OF THE EUROGRAPHICS ASSOCIATION

COMPUTER GRAPHICS *forum*

VOLUME 40 NUMBER 1 FEBRUARY 2021



ISSN 0167-7055



WILEY

EDITORIAL INFORMATION

Editors

Bedrich Benes
Professor of Computer Graphics Technology and Computer Science,
Purdue University
E-mail: bbenes@purdue.edu
Web: <http://hpcg.purdue.edu/bbenes/>

Helwig Hauser
Professor in Visualization, University of Bergen
E-mail: Helwig.Hauser@UiB.no
Web: vis.uib.no

Editorial Board

Wolfgang Aigner
St. Pölten University of Applied Sciences, Austria (2019-2021)
Pierre Alliez
INRIA, France (2018-2021)
J. Andreas Bærentzen
TU Denmark, Denmark (2017-2020)
Loic Barthe
University of Toulouse, France (2017-2020)
Michael Barton
Basque Center for Applied Mathematics, Spain (2019-2021)
Christopher Batty
Waterloo University, Canada (2017-2020)
Mirela Ben-Chen
Technion, Israel (2016-2019)
Jiří Bittner
Czech Technical University in Prague, Czech (2016-2019)
David Bommes
University of Bern, Switzerland (2019-2021)
Martin Cadik
Brno University of Technology, Czech (2019-2021)
Hamish Carr
Leeds University, UK (2019-2021)
Nathan Carr
Adobe, USA (2017-2020)
Yiorgos Chrysanthou
University of Cyprus, Cyprus (2017-2020)
Michael Doggett
Lund University, Sweden (2016-2019)
Eric Galin
Laboratoire LIRIS – CNRS, France (2019-2021)
Toshiya Hachisuka
University of Tokyo, Japan (2019-2021)
Peter Hall
University of Bath, UK (2016-2019)
Ying He
Nanyang Technological University, Singapore (2019-2021)
Klaus Hildebrandt
TU Delft, The Netherlands (2019-2021)

Jin Huang
Zhejiang University, China (2019-2021)
Wenzel Jakob
Ecole polytechnique fédérale de Lausanne, Switzerland (2018-2021)
Tao Ju
Washington University in St. Louis, USA (2018-2021)
Andreas Kerren
Linnaeus University, Sweden (2019-2021)
Taku Komura
University of Edinburgh, UK (2016-2019)
Yu-Kun Lai
Cardiff University, UK (2019-2021)
Bob Laramée
Swansea University, UK (2017-2020)
Rynson W. H. Lau
City University of Hong Kong, China (2017-2020)
Hao Li
University of Southern California, USA (2016-2019)
Ligang Liu
University of Science and Technology, China (2016-2019)
Marcus Magnor
TU Braunschweig, Germany (2018-2021)
Rafal Mantiuk
University of Cambridge, UK (2018-2021)
Silvia Miksch
TU Wien, Austria (2017-2020)
Niloy J. Mitra
University College London, UK (2017-2020)
Carol O'Sullivan
Trinity College Dublin, Ireland (2016-2019)
Victor Ostromoukhov
Université de Lyon, France (2016-2019)
Maks Ovsjanikov
Ecole Polytechnique, France (2016-2019)
Fabio Pellacini
Sapienza University of Rome, Italy (2016-2019)
Julien Pettre
Inria, France (2019-2021)
Soeren Pirk
Google AI, USA (2019-2021)
Huamin Qu

HK University of Science and Technology, Hong Kong, China (2018-2021)
Gerik Scheuermann
Universität Leipzig, Germany (2016-2019)
Heidrun Schumann
University of Rostock, Germany (2016-2019)
Pradeep Sen
University of California, Santa Barbara, USA (2019-2021)
Hubert Shum
Northumbria University, UK (2019-2021)
Barbara Solenthaler
ETH Zurich, Switzerland (2019-2021)
Markus Steinberger
TU Graz, Austria (2019-2021)
Daniel Sykora
Czech Technical University in Prague, Czech (2019-2021)
Shigeo Takahashi
University of Aizu, Japan (2016-2019)
Nils Thuerey
TU Munich, Germany (2018-2021)
Melanie Tory
Tableau Research, USA (2019-2021)
Anna Vilanova Bartroli
TU Delft, the Netherlands (2018-2021)
Ivan Viola
King Abdullah University of Science and Technology, Saudi (2019-2021)
Ofir Weber
Bar Ilan University, Israel (2019-2021)
Michael Wimmer
TU Wien, Austria (2016-2019)
Kai Xu
National University of Defense Technology, China (2016-2019)
Kangkang Yin
National University of Singapore, Singapore (2016-2019)
Sung-Eui Yoon
KAIST, Korea (2016-2019)
Eugene Zhang
Oregon State University, USA (2017-2020)

GENERAL INFORMATION

Computer Graphics Forum, (Print ISSN: 0167-7055; Online ISSN: 1467-8659), is an international journal reporting research, new developments and activities in all areas of computer graphics. Basic research will be covered as well as the use of computer graphics in various application areas. While scientific papers on new developments are the major area of interest, state-of-the-art surveys, algorithms, books to review and reports on current events and activities in computer graphics are also welcome. *Computer Graphics Forum* is the official journal of the Eurographics Association.

Publisher: *Computer Graphics Forum* is published by John Wiley & Sons Ltd.

Journal Customer Services: For ordering information, claims and any enquiry concerning your journal subscription please go to <https://hub.wiley.com/community/support/onlinejournal> or contact your nearest office.

Americas: Email: cs-journals@wiley.com; Tel: +1 781 388 8598 or +1 800 835 6770 (toll free in the USA & Canada).

Europe, Middle East and Africa: Email: cs-journals@wiley.com; Tel: +44 (0) 1865 778315.

Asia Pacific: Email: cs-journals@wiley.com; Tel: +65 6511 8000.

Japan: For Japanese speaking support, Email: cs-japan@wiley.com

Visit our Online Customer Help at <https://hub.wiley.com/community/support/onlinejournal>

Information for subscribers: *Computer Graphics Forum* is published in eight issues per year. Subscription prices for 2021 are:

	Europe	UK	The Americas	ROW
Premium Institutional:	€1068	£843	US \$1385	US \$1523

Prices are exclusive of tax. Asia-Pacific GST, Canadian GST and European VAT will be applied at the appropriate rates. For more information on current tax rates, please go to <https://onlinelibrary.wiley.com/library-info/products/price-lists/payment>. The price includes online access to the current and all online back files to January 1st 2017, where available. For other pricing options, including access information and terms and conditions, please visit <https://onlinelibrary.wiley.com/library-info/products/price-lists>. Terms of use can be found here: <https://onlinelibrary.wiley.com/terms-and-conditions>.

This journal is published in an online-only format.

Computer Graphics Forum accepts articles for Open Access publication. Please visit <https://authorservices.wiley.com/author-resources/Journal-Authors/open-access/onlineopen.html> for further information about OnlineOpen.

Production Editor: Amit Bansal (Email: cgf@wiley.com).

Copyright and Copying: Copyright © 2021 The Eurographics Association and John Wiley & Sons Ltd. All rights reserved. No part of this publication may be reproduced, stored or transmitted in any form or by any means without the prior permission in writing from the copyright holder. Authorization to photocopy items for internal and personal use is granted by the copyright holder for libraries and other users registered with their local Reproduction Rights Organisation (RRO), e.g. Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923, USA (www.copyright.com), provided the appropriate fee is paid directly to the RRO. This consent does not extend to other kinds of copying such as copying for general distribution, for advertising or promotional purposes, for republication, for creating new collective works or for resale. Permissions for such reuse can be obtained using the RightsLink "Request Permissions" link on Wiley Online Library. Special requests should be addressed to permissions@wiley.com

Wiley's Corporate Citizenship initiative seeks to address the environmental, social, economic, and ethical challenges faced in our business and which are important to our diverse stakeholder groups. Since launching the initiative, we have focused on sharing our content with those in need, enhancing community philanthropy, reducing our carbon impact, creating global guidelines and best practices for paper use, establishing a vendor code of ethics, and engaging our colleagues and other stakeholders in our efforts.

Follow our progress at www.wiley.com/go/citizenship

Disclaimer: The Publisher, Eurographics Association and Editors cannot be held responsible for errors or any consequences arising from the use of information contained in this journal; the views and opinions expressed do not necessarily reflect those of the Publisher, Eurographics Association and Editors, neither does the publication of advertisements constitute any endorsement by the Publisher, Eurographics Association and Editors of the products advertised.

Abstracting and Indexing Services: The Journal is indexed by Inspec; Personal Alert; The Engineering Index Monthly. For information on Abstracting and Indexing services, please go to the *Computer Graphics Forum* website at wileyonlinelibrary.com. *Computer Graphics Forum* is covered in *SciSearch*® and *Research Alert*®.

This journal is available online. Visit wileyonlinelibrary.com/journal/cgf to search the articles and register for table of contents e-mail alerts. For submission instructions, subscription and all other information visit: wileyonlinelibrary.com/journal/cgf

Cover illustration: "Life cycle of SARS-CoV-2: from sketch to visualization in atomistic resolution" by Tatjana Hirschmugl, Tobias Klein, Ondřej Strnad, Deng Luo, Ivan Viola and Peter Mindele.

CONTENTS

Editorial	5
Articles	
Temporally Dense Exploration of Moving and Deforming Shapes <i>S. Frey</i>	7
Physics-based Pathline Clustering and Exploration <i>Duong B. Nguyen, Lei Zhang, Robert S. Laramée, David Thompson, Rodolfo Ostilla Monico and Guoning Chen</i>	22
A Curvature and Density-based Generative Representation of Shapes <i>Z. Ye, N. Umetani, T. Igarashi and T. Hoffmann</i>	38
Turbulent Details Simulation for SPH Fluids via Vorticity Refinement <i>Sinuo Liu, Xiaokun Wang, Xiaojuan Ban, Yanrui Xu, Jing Zhou, Jiří Kosinka and Alexandru C. Telea</i>	54
Framework for Capturing and Editing of Anisotropic Effect Coatings <i>J. Filip, R. Vávra, F. J. Maile and M. Kolařová</i>	68
Anisotropic Spectral Manifold Wavelet Descriptor <i>Qingsong Li, Ling Hu, Shengjun Liu, Dangfu Yang and Xinru Liu</i>	81
Stochastic Volume Rendering of Multi-Phase SPH Data <i>M. Piochowiak, T. Rapp and C. Dachsbacher</i>	97
Time-Warped Foveated Rendering for Virtual Reality Headsets <i>Linus Franke, Laura Fink, Jana Martschinke, Kai Selgrad and Marc Stamminger</i>	110
Optimizing LBVH-Construction and Hierarchy-Traversal to accelerate k NN Queries on Point Clouds using the GPU <i>J. Jakob and M. Guthe</i>	124
Adaptive Compositing and Navigation of Variable Resolution Images <i>C. Licorish, N. Faraj and B. Summa</i>	138
Towards Light-Weight Portrait Matting via Parameter Sharing <i>Yutong Dai, Hao Lu and Chunhua Shen</i>	151
Wavelet-based Heat Kernel Derivatives: Towards Informative Localized Shape Analysis <i>Maxime Kirgo, Simone Melzi, Giuseppe Patanè, Emanuele Rodolà and Maks Ovsjanikov</i>	165
ECHO: Extended Convolution Histogram of Orientations for Local Surface Description <i>Thomas W. Mitchell, Szymon Rusinkiewicz, Gregory S. Chirikjian and Michael Kazhdan</i>	180
Modelling Material Microstructure Using the Perlin Noise Function <i>F. Conde-Rodríguez, Á.-L. García-Fernández and J.C. Torres</i>	195
A Modified Double Gyre with Ground Truth Hyperbolic Trajectories for Flow Visualization <i>S. Wolligandt, T. Wilde, C. Rössl and H. Theisel</i>	209
Learning Part Generation and Assembly for Sketching Man-Made Objects <i>Dong Du, Heming Zhu, Yinyu Nie, Xiaoguang Han, Shuguang Cui, Yizhou Yu and Ligang Liu</i>	222
EMU: Efficient Muscle Simulation in Deformation Space <i>V. Modi, L. Fulton, A. Jacobson, S. Sueda and D.I.W. Levin</i>	234
Structural Analogy from a Single Image Pair <i>S. Benaim, R. Mokady, A. Bermano and L. Wolf</i>	249
Primitive Object Grasping for Finger Motion Synthesis <i>Jae-Pyung Hwang, Gangrae Park, Il Hong Suh and Taesoo Kwon</i>	266
Interactive Optimization of Generative Image Modelling using Sequential Subspace Search and Content-based Guidance <i>Toby Chong, I-Chao Shen, Issei Sato and Takeo Igarashi</i>	279

The State of the Art of Spatial Interfaces for 3D Visualization <i>Lonni Besançon, Anders Ynnerman, Daniel F. Keefe, Lingyun Yu and Tobias Isenberg</i>	293
ClipFlip : Multi-view Clipart Design <i>I-Chao Shen, Kuan-Hung Liu, Li-Wen Su, Yu-Ting Wu and Bing-Yu Chen</i>	327
Functionality-Driven Musculature Retargeting <i>Hoseok Ryu, Minseok Kim, Seungwhan Lee, Moon Seok Park, Kyoungmin Lee and Jehee Lee</i>	341
Automatic Image Checkpoint Selection for Guider-Follower Pedestrian Navigation <i>K. C. Kwan and H. Fu</i>	357
Path-based Monte Carlo Denoising Using a Three-Scale Neural Network <i>Weiheng Lin, Beibei Wang, Jian Yang, Lu Wang and Ling-Qi Yan</i>	369
TopoAct: Visually Exploring the Shape of Activations in Deep Learning <i>Archit Rathore, Nithin Chalapathi, Sourabh Palande and Bei Wang</i>	382
Thin Cloud Removal for Single RGB Aerial Image <i>Chengfang Song, Chunxia Xiao, Yeting Zhang and Haigang Sui</i>	398
SketchZooms: Deep Multi-view Descriptors for Matching Line Drawings <i>Pablo Navarro, J. Ignacio Orlando, Claudio Delrieux and Emmanuel Iarussi</i>	410
Errata	
Erratum: Non-uniform subdivision surfaces with sharp features	424
Erratum: Adjustable Constrained Soft-Tissue Dynamics	425
Report	
Cover Image 2021: Life cycle of SARS-CoV-2: from sketch to visualization in atomistic resolution <i>Tatjana Hirschmugl, Tobias Klein, Ondřej Strnad, Deng Luo, Ivan Viola and Peter Mindek</i>	426

NOTES FOR AUTHORS

We welcome novel contributions from all over the world on any aspect of computer graphics. All papers are refereed, typically by three international referees, and referees' comments are passed back to the authors. It is relatively rare for a paper to be accepted without at least some changes being required. Contributors should be prepared to revise their paper accordingly.

Papers for the conference issue should be sent directly to the Programme Chairs according to the details given in the current Call for Papers. Papers of high merit which do not fit the conference programme may still be published in a regular issue; refereeing is to the same standard for all issues.

The rest of these notes are for contributors to the regular issues:

Style of presentation: Use the house style of the journal. Wherever possible, prepare your paper with our LaTeX macros, available at <https://www.eg.org/index.php/publications/guidelines>. We strongly encourage authors to use the LaTeX macros. Even if you do not want to use macros, you can obtain our Style Guide in the same way.

Try to get the layout, use of headings, etc. as close as possible to that used in the Journal. Note in particular the format used for references, both within the text and in the reference list, as references are very difficult to correct later. References should be listed in the order in which they first appear within the main text; consequently, the first citation of each paper will be in numerical order in the text.

We have no objection to your submitting material in one-column format but keep in mind that the paper will eventually be set in two columns. This is especially important when planning display material, such as program fragments, as it is difficult for the typesetter to know where to break lines. Such material must be limited to a maximum of 39 characters per line, including spaces.

Where you cannot match the style exactly, please use something that is close enough to make marking-up easy.

Language and spelling: The journal language is English. If you are not a regular or native English-speaker, it is a good idea to find such a colleague to ready your paper through to you. We use English, rather than American, spelling.

Length of contributions: The length of a full paper will typically be between 5 and 12 journal pages. Shorter papers are also accepted however, and are refereed to the same general standard as full length papers.

Title page: The first page should supply the paper title and the name, full affiliation address, and email address of each author. The affiliation(s) given should be those at which the work was performed. Present address(es), if different, should be indicated.

If the paper has been previously presented at a technical meeting, the name, date and location of the meeting and the name of the sponsoring organization should be given. However, the journal will not normally publish previously presented papers unless their distribution was limited and the material is exceptional.

Abstract: the abstract is an important component of your paper. Please include 150–200 words which faithfully reflect the content of your paper.

ACM Computing Classification System: *All papers should be classified into one or more categories of the ACM Computing Classification System (ACM CCS, found at <http://www.acm.org/class>). Please also supply a short list of **Keywords**.*

Illustrations: All illustrations should be supplied as TIFF or EPS files, at the size they are to appear in print, with clear labelling and the appropriate caption. Authors' original illustrations will be used in all cases as artwork can not be re-drawn. **Colour** illustration should be as CMYK-separated EPS files, one file for each figure. Please ensure all illustrations are referred to in the text of the paper.

Tables: Give tables a title and table number. Avoid complex tables.

Footnotes: For technical reasons we cannot include footnotes on the first page of the published paper. Avoid footnotes as much as possible. Try to incorporate footnote material into the text, e.g. parenthetically or as a "remark" or "note".

Acknowledgements: Acknowledgements of funding support may be given in a separate section at the end of paper. Any references to commercial organization or proprietary articles may also be given here, but references should not be mentioned elsewhere except when necessary to identify a specific piece of equipment, etc. Personal acknowledgements should also appear in this section.

Proof: The corresponding author will receive an e-mail alert containing a link to a website. The proof can be downloaded as a PDF file from this site. It is important to understand that this is not an opportunity to make revisions to your paper and extensive changes will be charged at a cost.

Exclusive Licence Form: Copyright of all material published resides with the Eurographics Association and John Wiley & Sons Ltd. If your paper is accepted, the author identified as the formal corresponding author for the paper will receive an email prompting them to login into Author Services; where via the Wiley Author Licensing Service (WALS) they will be able to complete the license agreement on behalf of all authors on the paper. It is the contact author's responsibility to obtain permission to use any copyright material used in the paper and to include all relevant acknowledgements.

Material under review and consideration for publication in the journal, or material that has been formally accepted, may be used elsewhere by the author except in a formal journal, periodical, book, or other copyrighted publication. If it is presented at a professional meeting or distributed as a report, it is requested that the submission to this journal and its status be acknowledged by a suitable citation or comment such as "Submitted for publication in *Computer Graphics Forum*" or "Accepted for publication in *Computer Graphics Forum*". Once the material has been prepared in publication format by the publisher, the permission of the Eurographics Association is required for any use of the material.

Submitting papers: *Computer Graphics Forum* has adopted ScholarOne Manuscripts, for online manuscript submission and peer review. This system brings with it a whole host of benefits including:

- Quick and easy submission
- Administration centralised and reduced
- Significant decrease in peer review times

All submissions to the journal must be submitted online at <http://mc.manuscriptcentral.com/cgf>. Full instructions and support are available on the site and a user ID and password can be obtained on the first visit. If you require assistance then click the **Get Help Now** link which appears at the top right of every ScholarOne Manuscripts page.

Double submission: The Chief Editors regularly exchange information about all papers in progress with the Editors of other journals. We are not prepared to consider papers which are being considered for other journals, conferences or other public output, whether the papers are the same or similar in content. The Chief Editors reserve the right to reject or to suspend consideration of any paper in this category.

Revised manuscript: When the paper has been revised in line with the referees' comments, you should send the relevant files for the paper electronically in final form, together with all associated illustration files, to the Chief Editor.

Submission of additional electronic materials: *Computer Graphics Forum* is also available electronically to EG members through the EG Digital Library at diglib.eg.org. Authors can and are therefore encouraged to submit multimedia attachments such as movies, virtual worlds, presentations, etc. that illustrate or support their contributions to the Eurographics Digital Library. Authors of accepted papers are also encouraged to optimize their papers for electronic delivery of content. For more instructions please refer to the URL <https://www.eg.org/index.php/publications/guidelines>.