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Organized by



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THE EUROPEAN ASSOCIATION
FOR COMPUTER GRAPHICS



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Preface

This issue of the Computer Graphics Forum contains the technical full papers program of the Eurographics Association 43rd annual conference, held in Reims, France from 25–29 April 2022. The Eurographics annual venue presents a unique opportunity to present outstanding technical contributions in computer graphics. The full papers selected for publication in the Computer Graphics Forum journal are arguably the most prestigious feature of the conference.

The technical paper selection process involved a group of 65 experts forming the International Program Committee (IPC). We invited experts without more than three consecutive years of participation in the IPC, so that the committee can be regularly renewed. We received a total of 119 full submissions. A sorting committee, consisting of the two Chairs and five advisory board members (Theodore Kim, Rachel McDonnell, Sylvain Paris, Ivan Viola, Michael Wimmer), subsequently assigned each paper to two IPC members, as either primary or secondary reviewer, up to five papers, respecting to their preferences, expertise, conflicts, and automatically computed matching scores between IPC members and submitted papers. The primary and secondary reviewers in turn invite three additional tertiary reviewers on each submission.

After the initial five reviews per submission were collected, the authors had five days to consult these reviews and write a 1000-word rebuttal, addressing key questions and potential misinterpretations. Four submissions were withdrawn by their authors who decided to forgo the rebuttal. Finally, all reviewers assigned to a paper read the rebuttal and all reviews and together reached an initial decision.

This year, following an established tradition that started in 2012 and improved continuously through the years, we replaced the traditional in-person IPC meeting with a one-week virtual asynchronous meeting, where the discussions between the IPC members leading to the final decisions were performed off-line by a bulletin board and other means of personal communication. This led to extensive discussions where papers and reviews were debated extensively involving other IPC members as extra readers when needed. Each paper had a public discussion board, and each and every IPC member contributed to discussions where they felt competent.

All papers conditionally accepted with minor revisions went through a short second review cycle, with evaluations from the primary reviewer, and sometimes the secondary reviewer, before being finally accepted. In the end, 40 papers out of the 119 full submissions were accepted with minor revisions for a 33.6 % acceptance rate, while 11 were recommended to a fast-track review process with major revisions to be considered for publication in a future issue of Computer Graphics Forum. This year we had papers on a diverse range of topics including machine learning, generative modeling, computational photography, geometry, meshes, appearance and shading, texture, rendering, 3D scans analysis, physical simulation, visualization, human animation and motion capture, simulation of clothes and crowds, editing, 3D printing, fabrication.

All accepted full papers are published as open-access Computer Graphics Journal papers. It is worth noting that for all submissions conflict-of-interest was managed on all levels, from reviewers, committee, advisory board, best paper committee, up to the chairs. The review process was double-blind and in case the original set of reviewers did not conclude with a decision, additional reviewers were invited to perform a full review and assist the decision process. Best papers were selected by a dedicated awards committee who selected among the top 12 papers based on overall review scores.

We would like to thank everyone who made this possible. First and foremost, we are grateful to all the members of the IPC who dedicated a remarkable amount of their time to finding tertiaries, reviewing and discussing papers, and subsequently shepherded the accepted papers undergoing the minor revision cycle. We wish to thank all the reviewers, who provided 618 high-quality and thoughtful reviews and, of course, all the authors for their efforts in preparing and revising the submitted papers. We are especially grateful to Michael Wimmer who shared with us the insights from previous years and was indefatigable with his help and assistance. We would like to express strong appreciation to the advisory board for their support with paper sorting. Last but not least, we would like to thank Stefanie Behnke from Eurographics Publishing for her outstanding support with SRM functionality for her responsiveness which was the key to the successful outcome of the paper selection process. Regarding the onsite conference in Reims, we were delighted that a large part of the computer graphics community can once again meet face-to-face, even if there are still travel restrictions in some countries. We know that it was not easy for the organizing team who had to constantly demonstrate their flexibility in this time of pandemic.

We are very happy to present the full paper proceedings of Eurographics 2022. We believe that these papers reflect the extraordinary variety of computer graphics research and its best contributions. It was both an honor and a pleasure for us to lead this selection process and we hope that you will find both the papers and the entire conference thought-provoking and inspiring of your future endeavors.

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Eurographics Distinguished Career Award 2022: Marie-Paule Cani



Marie-Paule Cani is a linguist for shapes, animation, and virtual worlds. As language allows people to exchange ideas and collaborate, Cani's work enables computer artists, engineers, scientists, and the public to communicate geometry and motion using intelligent systems and computational tools.

Marie-Paule Cani is a Professor of Computer Science at Ecole Polytechnique, where she leads the Modeling, Simulation and Learning group at LIX, CNRS/Ecole Polytechnique. She received her M.Sc. from Ecole Normale Supérieure and University Paris XI, and her Ph.D. from University Paris XI in 1990. Her research interests include shape modelling and computer animation, where she has made multiple pioneering contributions.

From implicit surfaces to the animation of deformable bodies, Cani has proposed impactful models for representing shape and motion. She introduced novel ideas for modeling and animation of hair and garments, as well as natural phenomena; from lava flows to ocean waves to clouds. She is one of the pioneers of sketch-based

modeling, applied to a variety of shapes such as garments, trees and developable surfaces. She consistently and continually suggested innovative methods for interaction and modeling, such as constant-volume sweeps for virtual clay deformation and crowd sculpting for modeling virtual environments.

In addition to her role at Ecole Polytechnique, Prof. Cani is the president of the scientific council of the French CS Society. Furthermore, she has served on multiple roles in the Computer Graphics Community, both at Eurographics and ACM SIGGRAPH. She was the president of the Eurographics Association between 2017 and 2018, was the director at large in the executive committee of ACM SIGGRAPH from 2007 to 2011 and was a member of the ACM Publication board from 2011 to 2014. Cani served as technical paper chair of SIGGRAPH 2017, was on the steering committees of SCA, SBIM and SMI, and on the editorial board of ACM TOG, Computer Graphics Forum, IEEE TVCG, Graphical Models and Computers and Graphics.

Cani has received several prestigious awards, including the Eurographics Outstanding Technical Contributions Award in 2011 and a Silver medal from CNRS in 2012. She was awarded the ERC advanced grant EXPRESSIVE (2012-2017), was elected for the Academia Europaea in 2013, for the ACM Siggraph Academy in 2019, and for the French Academy of Science in 2020.

Our mind is boundless in its ability to visualize and design. Her work has created conduits for communicating visual ideas, used by a generation of researchers and practitioners. Thus, her research has enabled collaboration between creators, scientists, and engineers, and significantly advanced the field of computer graphics.

EUROGRAPHICS is extremely pleased to recognize Marie-Paule Cani with the 2022 Distinguished Career Award.

Eurographics Outstanding Technical Contributions Award 2022: Diego Gutierrez



Diego Gutierrez is a Professor at the Universidad de Zaragoza, Spain, where he founded and leads the Graphics and Imaging Lab.

His main areas of interest include several research areas: physically-based simulation of light transport, virtual reality, and computational imaging. His work is distinguished by his deep interest in pushing the boundaries in simulating light transport, for example by including the time dimension or targeting novel display technologies, and his quest to understand how state of the art computer graphics techniques relate to human perception.

Among his many contributions, he greatly advanced methods for global illumination and light transport simulation, in particular in rendering participating media and transient rendering. In his work on transient light transport, he addressed the fundamental problem of enabling effective simulation and analysis of light transport when the speed of light is no longer considered infinite. Diego proposed novel techniques for non-line of sight (NLOS) 3D reconstruction that were up to a thousand times faster than previous work. Most notably, in a breakthrough paper published in the journal *Nature*, Diego and his team showed that NLOS imaging can also be formulated using diffractive wave propagation. This approach yields a new class of imaging algorithms that mimic the capabilities of line-of-sight cameras, enabling applications that are not restricted to laboratory conditions.

He is also recognized for his work on modeling and representation of materials, material perception, and research on percep-

tion in computer graphics more broadly. The latter include: how stylization affects perceived realism; a novel similarity measure of illustration style; real-time perceptual rendering of human skin; a perceptual study and analysis of image retargeting techniques; and work on high-dynamic range imaging, tone mapping, and modeling contrast sensitivity. Diego also made fundamental contributions to research in virtual reality and light fields. For his work on intuitive editing of visual appearance, Diego also received an ERC Consolidator Grant in 2016.

In addition to his technical contributions, Diego is highly respected for his success in fostering thriving research communities. This includes not only his leadership of the Graphics and Imaging Lab at the University of Zaragoza, which has become a leading research group, but also his service to the broader community. Among many other roles, he served as the Editor in Chief of ACM TAP, as an associate editor for ACM TOG and Computer Graphics Forum, or as program chair for several international conferences.

In summary, Diego is a role model in the field by showing a breadth of research topics while maintaining a deep technical focus and making pioneering contributions to many areas, and by inspiring young researchers to continue pushing forward the state of the art in computer graphics.

EUROGRAPHICS is pleased to recognize Diego Gutierrez with the 2022 Outstanding Technical Contributions Award.

Eurographics Young Researcher Award 2022: Jürgen Bernard



Jürgen Bernard receives the EUROGRAPHICS Young Researcher Award 2022 for his outstanding and multi-faceted contribution to the visualization and visual analytics community.

Jürgen Bernard is an Assistant Professor of Computer Science at the University of Zurich (UZH), Switzerland, where he is leading the Interactive Visual Data Analysis Group. Bernard studied Computer Sciences with focus on Computer Graphics and Biotechnology at the Technical University of Darmstadt. He received his PhD Degree in 2015, when he was with Fraunhofer IGD, with a thesis on “Exploratory Search in Time-Oriented Primary Data”. In 2016, Jürgen Bernard started as a Post-doc researcher at TU Darmstadt, leading the Visual-Interactive Machine Learning Group. In 2019, he became a postdoctoral research fellow at the University of British Columbia, Vancouver, Canada. He was also awarded the EuroVis Young Researcher Award in 2021.

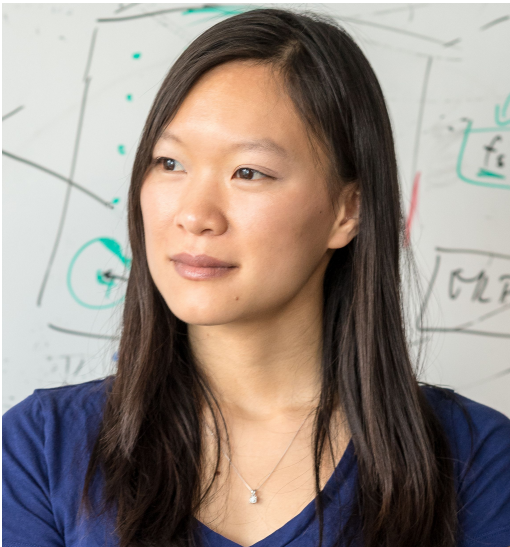
Bernard’s primary research includes the characterization, design, and evaluation of visual-interactive interfaces to combine the strengths of both humans and algorithms in interactive machine learning and data science applications. He mainly focuses on time series data and multivariate data, and develops unique interactive machine learning techniques for cluster analysis, dimensionality reduction, active learning, regression analysis, and classification. His work supports exploratory data analysis, i.e., sense-making,

decision-making, and hypotheses-building processes. His human and problem-driven work finds its use in a range of important and impactful application domains including climate and earth observation, service and energy network analysis, political decision-making, as well as healthcare and patient-related research.

In his area of research Jürgen Bernard has produced a number of outstanding contributions, which is evidenced by several best paper awards from conferences such as IEEE VIS and EuroVA, the Hugo-Geiger Preis in 2016, and the Dirk Bartz Prize in 2017.

EUROGRAPHICS is pleased to recognize Jürgen Bernard with the 2022 Young Researcher Award.

Eurographics Young Researcher Award 2022: Angela Dai



ics and AR/VR but is also paramount for the design of intelligent systems that need to understand the world they interact with.

The work of Angela Dai is published in the top tier conferences and journals of computer graphics and computer vision, and has been widely cited.

EUROGRAPHICS is pleased to recognize Angela Dai with the 2022 Young Researcher Award.

Angela Dai receives the EUROGRAPHICS Young Researcher Award 2022. Angela obtained her Bachelor degree from Princeton University, and a PhD in Computer Science from Stanford University, where she was advised by Pat Hanrahan. She is now an Assistant Professor at the Technical University of Munich where she leads the 3D AI lab.

Angela has done methodically deep and widely recognized work at the intersection of computer graphics, computer vision and machine learning. She is known for her cutting-edge research on capturing and reconstructing high-quality and semantically informed models of the 3D world from sensor data. As an example, she has done pioneering work on 3D scene reconstruction from handheld RGB-D cameras, an example being the widely used and widely cited BundleFusion algorithm. She has also done pioneering work in the area of semantic scene understanding, where she not only proposed very original new algorithms but also contributed widely used reference datasets to the community (ScanNet).

Angela Dai's work is significantly advancing a striving field of research at the intersection of computer graphics, computer vision and artificial intelligence. Her work contributes to better ways to reconstruct and semantically understand, and synthesize models of the real world. It is not only of great relevance to computer graph-

An Invitation to Borrow Ideas from Other Domains

Sylvain Paris

Adobe Research



the editorial boards of journals like *Transactions on Graphics* and *Transactions on Computational Imaging*. In 2021, he chaired the Technical Papers program of SIGGRAPH. Before joining Adobe in 2007, he worked with François Sillion at INRIA to prepare his PhD that he received from Université Joseph Fourier in Grenoble in 2004, and he then did a post-doc at MIT with Frédo Durand.

Abstract

Interdisciplinary research is common in Graphics. We often borrow ideas from other communities or combine algorithms developed in other contexts to create something new. Some pairings have become classics like computer vision & image editing, and numerical optimization & simulation. In this presentation, I will go over a few recent interdisciplinary trends that I had the chance to witness and that have impacted my work. We will talk about compilers, music, natural language, and, of course, AI. I will use these examples to illustrate a few of the powerful techniques developed in these other fields. I will also show how they found their way into real-world applications. I will conclude by sharing my experience being part of some of these projects. I hope that this discussion will encourage everyone to continue to borrow ideas from other fields to create the next wave of exciting research.

Biography

Sylvain Paris is a Fellow and a Lab Director at Adobe Research. His personal research interests are about photo editing and related topics. His team covers various aspects of machine learning, computer graphics, computer vision, cognitive science, programming languages, and audio. Several of their research contributions have become popular features in products like Photoshop, Lightroom, and Premiere. Sylvain served several times on the program committee of conferences like SIGGRAPH, Eurographics, and CVPR, and on

Perceiving Humans Using AI

Jan Kautz

Nvidia



für Informatik (2003), and worked as a post-doctoral researcher at the Massachusetts Institute of Technology (2003-2006).

Abstract

Perceiving humans, such as their pose, gaze, etc., of great interest for many practical applications, including human-machine interaction, activity recognition, video analytics, visual effects, gaming, and any other application involving humans in the scenes. We will present our work focusing on a detailed understanding of the human body from monocular RGB images. Specifically, we will present deep learning methods for body pose estimation, mesh articulation from videos, global pose recovery, and hand pose estimation. We will show how deep learning models can be made robust to face challenges posed by real-world scenarios and address the problem of data scarcity for training these methods.

Biography

Jan Kautz is VP of Learning and Perception Research at NVIDIA. Jan and his team pursue fundamental research in the areas of computer vision and deep learning, including visual perception, geometric vision, generative models, and efficient deep learning. Their work has been awarded various awards and has been regularly featured in the media. Before joining NVIDIA in 2013, Jan was a tenured faculty member at University College London. He holds an undergraduate degree in Computer Science from the University of Erlangen-Nürnberg (1999), an MMath from the University of Waterloo (1999), received his PhD from the Max-Planck-Institut

Mesh Analysis for Archaeology

Ayellet Tal

Technion



She chaired several conferences on shape modeling and computer graphics and has been an Associate Editor of a number of professional journals.

Abstract

Shape analysis has numerous applications, both within graphics and in a variety of other fields. We concentrate on archaeology not only because cultural heritage has been acknowledged worldwide as an important goal, but also because the archaeological domain exposes the limits of current computer graphics techniques. Archaeological artifacts are not nicely-behaved; rather they are broken, noisy, stained and abraded, after laying underground for thousands of years. Developing algorithms that can handle such objects will therefore benefit not only archaeology, but also computer graphics. This talk will describe our ongoing work in this area.

Biography

Ayellet Tal is a professor and the Alfred and Marion Bär Chair in Engineering at the Technion's Andrew and Erna Viterbi Department of Electrical Engineering at the Technion. She holds a Ph.D. in Computer Science from Princeton University and a bachelor degree (Summa cum Laude) in Mathematics and Computer Science from Tel-Aviv University. Her research interests include computer graphics and computer vision. Among Prof. Tal's accomplishments are the Rechler Prize for Excellence in Research, the Henry Taub Prize for Academic Excellence, the Google Research Award, and the Milton and Lillian Edwards Academic Lectureship. Prof. Tal regularly serves on the program committees of all the leading international conferences in Computer Graphics and Computer Vision.

Going against the Flow of Fluid Animation

Mathieu Desbrun

Inria / Caltech



at Caltech in the CS department in 2003, where he started the Applied Geometry lab and was awarded the ACM SIGGRAPH New Researcher award. He then became the Carl F. Braun Professor at Caltech, before receiving an International Chair from France's Inria, and being Technical Papers Chair for ACM SIGGRAPH 2018. More recently, he spent a sabbatical year at ShanghaiTech, was elected ACM Fellow, and became a member of the ACM SIGGRAPH Academy. He is now working in France as both a researcher at Inria Saclay, and a Professor at Ecole Polytechnique.

Abstract

While Computer Graphics (CG) has often been inspired by Computational Fluid Dynamics (CFD), its most commonly used algorithmic solutions to incompressible fluid animation remain limited in scope — they can only handle rather viscous fluids and/or low density ratios when simulating two-phase flows — and in scalability. As a consequence, they have found little to no industrial applications aside from special effects in movies and games. In this talk, I will discuss the Lattice Boltzmann Method (LBM) and its recent advances. Despite early works exhibiting underwhelming results, LBM solvers are now offering a promising, massively-parallel way to bridge the gap between CG and CFD for both incompressible single-phase and multi-phase fluid simulation using an atypical discretization of phase space. I will then review how hybridizing LBM with machine-learning based space-time upsampling of coarse simulations provides a rich computational framework for realistic and detailed smoke and fluid animation.

Biography

After obtaining a PhD in computer graphics in France, Desbrun joined Caltech as a postdoctoral fellow in 1998, and the CS department at the University of Southern California as an Assistant Professor in January 2000, where he remained for four years in charge of the GRAIL lab. He then became an Associate Professor