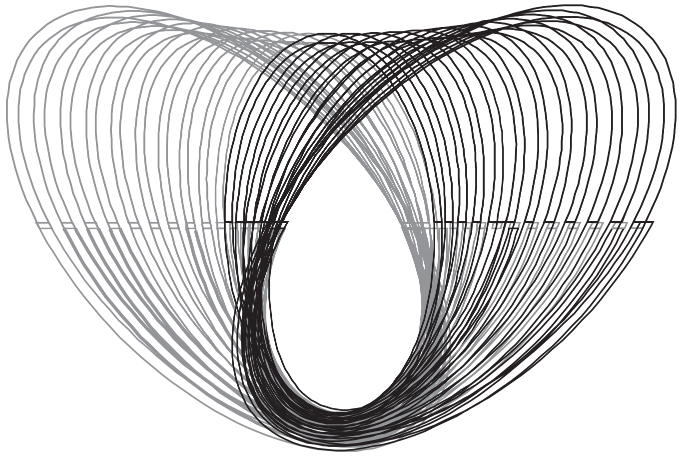
Final Program and Abstracts

SIAM Conference on Geometric & Physical Modeling (GD/SPM15)



October 12-14, 2015
Sheraton Salt Lake City Hotel
Salt Lake City, Utah, USA

acm In-Cooperation

ACMSIGGRAPH

This conference is sponsored by the SIAM Activity Group on Geometric Design, and in cooperation with ACM SIGGRAPH, incorporating the 2015 SIAM Conference on Geometric Design and the 2015 Symposium on Solid and Physical Modeling.

The SIAM Activity Group on Geometric Design is concerned with the mathematical and computational issues that arise in generating and processing geometric information for various engineering applications, such as mechanical design, process planning, and manufacturing. The scope of the group's activities encompasses a wide spectrum of scientific, technological, and other skills, ranging from rigorous mathematics to the subjective aesthetics of shape. The SIAG organizes the biennial SIAM Conference on Geometric and Physical Modeling and also maintains a website, a member directory, and an electronic mailing list. For details please visit *http://siags.siam.org/siaggd/*.

siam®

Society for Industrial and Applied Mathematics
3600 Market Street, 6th Floor
Philadelphia, PA 19104-2688 USA
Telephone: +1-215-382-9800 Fax: +1-215-386-7999
Conference E-mail: meetings@siam.org
Conference Web: www.siam.org/meetings/
Membership and Customer Service: (800) 447-7426 (US& Canada) or +1-215-382-9800 (worldwide)

www.siam.org/meetings/gdspm15

Table of Contents

General Information............................2
Program-at-a-Glance....Fold-out section
Get-togethers.......................................5
Invited Plenary Presentations...............6
Prizes and Awards................................7
Program Schedule................................9
Abstracts 23
Speaker and Organizer Index.............43
Conference Budget .....Inside Back Cover
Hotel Floor Plan..................Back Cover

Organizing Committee

General Co-Chairs

Gershon Elber
Technion – Israel Institute of Technology, Israel

Horea Ilies
University of Connecticut, USA

Program Co-chairs

Thomas Grandine
The Boeing Company, USA

Scott Schaefer
Texas A&M University, USA

Charlie C. L. Wang
The Chinese University of Hong Kong, Hong Kong

Program Committee

Nina Amenta
University of California at Davis, USA

Carolina Beccari
Università di Bologna, Italy

Dominique Bechmann
Université de Strasbourg, France

Mirela Ben-Chen
Technion, Israel

Georges-Pierre Bonneau
Grenoble Universités, France

Willem Bronsvoort
Delft University of Technology, Netherlands

Yong Chen
University of Southern California, USA

Elaine Cohen
University of Utah, USA

Frédéric Cordier
Université de Haute-Alsace, France

Chongyang Deng
Hangzhou Dianzi University, China

Jiansong Deng
University of Science and Technology of China, China

Tamal Dey
The Ohio State University, USA

Tor Dokken
SINTEF, Norway

Gershon Elber
Technion, Israel

Shuming Gao
Zhejiang University, China

Yotam Gingold
George Mason University, USA

Dan Gonsor
Boeing, USA

Cindy Grimm
Oregon State University, USA

Xiaohu Guo
University of Texas at Dallas, USA

Balan Gurumoorthy
Indian Institute of Science, India

Stefanie Hahmann
Grenoble Institute of Technology, France

John C. Hart
University of Illinois, Urbana-Champaign, USA

Ying He
Nanyang Technological University, Singapore

Martin Hering-Bertram
Hochschule Bremen University of Applied Science, Germany

Lei Hi
Microsoft, USA

Christoph Hoffmann
Purdue University, USA

Kai Hormann
Università della Svizzera Italiana, Switzerland

Shi-Min Hu
Tsinghua University, China

Zhangjin Huang
University of Science and Technology of China, China

Horea Ilies
University of Connecticut, USA

Ravi Janardan
University of Minnesota, USA

Robert Joan-Arinyo
Universitat Politècnica de Catalunya, Spain

Leo Joskowicz
The Hebrew University of Jerusalem, Israel

Tao Ju
Washington University in St. Louis, USA

Bert Jüttler
Johannes Kepler Universität Linz, Austria

John Keyser
Texas A&M University, USA

Deok-Soo Kim
Hanyang University, Korea

Myung-Soo Kim
Seoul National University, Korea

Young Kim
Ewha Womans University, Korea

Adarsh Krishnamurthy
Iowa State University, USA

Yu-Kun Lai
Cardiff University, United Kingdom

Bruno Lévy
Inria, France

Xin Li
Louisiana State University, USA

Jyh-Ming Lien
George Mason University, USA

Hongwei Lin
Zhejiang University, China

Yaron Lipman
Weizmann Institute of Science, Israel

Ligang Liu
University of Science and Technology of China, China

Yong-Jin Liu
Tsinghua University, China

Weiyin Ma
City University of Hong Kong, China

Stephen Mann
University of Waterloo, Canada

Dinesh Manocha
University of North Carolina at Chapel Hill, USA

Josiah Manson
Activision, USA

Ralph Martin
Cardiff University, United Kingdom

Sara McMains
University of California, Berkeley, USA

Saigopal Nelaturi
Xerox PARC, USA

Jorg Peters
University of Florida, USA

Tom Peters
University of Connecticut, USA

Konrad Polthier
Freie Universität Berlin, Germany

Xiaoping Qian
Illinois Institute of Technology, USA

Ewald Quak
Tallinn University of Technology, Estonia

Lucia Romani
University of Milano-Bicocca, Italy

Jarek Rossignac
Georgia Institute of Technology, USA

Nickolas Sapidis
University of Western Macedonia, Greece

Vadim Shapiro
University of Wisconsin-Madison, USA

Alla Sheffer
University of British Columbia, Canada

Tim Strotman
Siemens PLM Software, USA

Andrea Tagliasacchi
EPFL, Switzerland

Kai Tang
Hong Kong University of Science and Technology, China

Yiying Tong
Michigan State University, USA

Georg Umlauf
Hochschule Konstanz University of Applied Sciences, Germany

Jan Vandenbrande
Defense Advanced Research Projects Agency, USA

Johannes Wallner
Graz University of Technology, Austria

Jun Wang
Nanjing University of Aeronautics and Astronautics, China

Chee Yap
New York University, USA

Thomas Yu
Drexel University, USA

Yongjie (Jessica) Zhang
Carnegie Mellon University, USA

Jianmin Zheng
Nanyang Technological University, Singapore

SIAM Registration Desk

The SIAM registration desk is located in the Canyons Lobby. It is open during the following hours:

Sunday, October 11
4:00 PM - 7:00 PM

Monday, October 12
7:00 AM - 3:00 PM

Tuesday, October 13
7:30 AM - 3:00 PM

Wednesday, October 14
7:30 AM - 3:00 PM

Hotel Address

Sheraton Salt Lake City Hotel
150 West 500 South
Salt Lake City, UT 84101
USA
Phone Number: 801-401-2000
Toll Free Reservations (USA and Canada): 1-888-627-8152
Fax: 801-534-3450
Hotel web address:
http://www.sheratonsaltlakecityhotel.com/

Hotel Telephone Number

To reach an attendee or leave a message, call 801-401-2000. If the attendee is a hotel guest, the hotel operator can connect you with the attendee's room.

Hotel Check-in and Check-out Times

Check-in time is 3:00 PM.
Check-out time is 12:00 PM.

Child Care

To find local child care options in Salt Lake City, please use *https://careaboutchildcare.utah.gov/parent/search.aspx*, using the area code 84101, or *https://www.guardianangelbaby.com/home-frame.htm* to find reputable child care services.

Corporate Members and Affiliates

SIAM corporate members provide their employees with knowledge about, access to, and contacts in the applied mathematics and computational sciences community through their membership benefits. Corporate membership is more than just a bundle of tangible products and services; it is an expression of support for SIAM and its programs. SIAM is pleased to acknowledge its corporate members and sponsors. In recognition of their support, non-member attendees who are employed by the following organizations are entitled to the SIAM member registration rate.

Corporate Institutional Members

The Aerospace Corporation

Air Force Office of Scientific Research

Aramco Services Company

AT&T Laboratories - Research

Bechtel Marine Propulsion Laboratory

The Boeing Company

CEA/DAM

Department of National Defence (DND/CSEC)

DSTO- Defence Science and Technology Organisation

ExxonMobil Upstream Research

Hewlett-Packard

IBM Corporation

IDA Center for Communications Research, La Jolla

IDA Center for Communications Research, Princeton

Institute for Computational and Experimental Research in Mathematics (ICERM)

Institute for Defense Analyses, Center for Computing Sciences

Lawrence Berkeley National Laboratory

Lockheed Martin

Los Alamos National Laboratory

Max-Planck-Institute for Dynamics of Complex Technical Systems

Mentor Graphics

National Institute of Standards and Technology (NIST)

National Security Agency (DIRNSA)

Oak Ridge National Laboratory, managed by UT-Battelle for the Department of Energy

Sandia National Laboratories

Schlumberger-Doll Research

Tech X Corporation

U.S. Army Corps of Engineers, Engineer Research and Development Center

United States Department of Energy

List current August 2015.

Funding Agency

SIAM and the Conference Organizing Committee wish to extend their thanks and appreciation to the U.S. National Science Foundation for its support of this conference.

Join SIAM and save!

Leading the applied mathematics community SIAM members save up to $130 on full registration for the SIAM Conference on Geometric and Physical Modeling (GD/SPM15)! Join your peers in supporting the premier professional society for applied mathematicians and computational scientists. SIAM members receive subscriptions to *SIAM Review, SIAM News* and *SIAM Unwrapped,* and enjoy substantial discounts on SIAM books, journal subscriptions, and conference registrations.

If you are not a SIAM member and paid the *Non-Member* or *Non-Member Mini Speaker/Organizer* rate to attend the conference, you can apply the difference between what you paid and what a member would have paid ($130 for a *Non-Member* and $65 for a *Non-Member Mini Speaker/ Organizer*) towards a SIAM membership. Contact SIAM Customer Service for details or join at the conference registration desk.

If you are a SIAM member, it only costs $10 to join the SIAM Activity Group on Geometric Design (SIAG/GD). As a SIAG/GD member, you are eligible for an additional $10 discount on this conference, so if you paid the SIAM member rate to attend the conference, you are eligible for a free SIAG/GD membership.

Free Student Memberships are available to students who attend an institution that is an Academic Member of SIAM, are members of Student Chapters of SIAM, or are nominated by a Regular Member of SIAM.

Join onsite at the registration desk, go to *www.siam.org/joinsiam* to join online or download an application form, or contact SIAM Customer Service:

Telephone: +1-215-382-9800 (worldwide); or 800-447-7426 (U.S. and Canada only)

Fax: +1-215-386-7999

E-mail: membership@siam.org

Postal mail: Society for Industrial and Applied Mathematics, 3600 Market Street, 6th floor, Philadelphia, PA 19104-2688 USA

Standard Audio/Visual Set-Up in Meeting Rooms

SIAM does not provide computers for any speaker. When giving an electronic presentation, speakers must provide their own computers. SIAM is not responsible for the safety and security of speakers' computers.

The Plenary Session Room will have two (2) screens, one (1) data projector and one (1) overhead projector. The data projectors support VGA connections only. Presenters requiring an HDMI or alternate connection must provide their own adaptor.

All other concurrent/breakout rooms will have one (1) screen and one (1) data projector. The data projectors support VGA connections only. Presenters requiring an HDMI or alternate connection must provide their own adaptor.

If you have questions regarding availability of equipment in the meeting room of your presentation, please see a SIAM staff member at the registration desk.

Internet Access

Attendees booked within the SIAM room block will have complimentary wireless Internet access in their guest rooms. All conference attendees will have complimentary wireless Internet access in the meeting space and lobby area of the hotel.

SIAM will provide a limited number of email stations for attendees during registration hours.

Conference Registration Fee Includes

- Admission to all technical sessions
- Coffee breaks daily
- Room set-ups and audio/visual equipment
- SIAG/GD Business Meeting *(open to SIAG/GD members)*
- SMA Business Meeting
- Welcome Reception

Conference Dinner Banquet

(separate fee applies)

A conference dinner banquet will be held in the Wasatch Room on Tuesday, October 13, 2015 at 6:30 PM. Tickets are available for $46.50 per person and will include a three-course meal. A cash bar will be offered.

Tickets are available at the SIAM registration desk until 12:00 PM on Monday, October 12. Tickets will not be sold after this time.

Proceedings

The proceedings will be published as a journal special issue in Computer-Aided Design. Papers will be available for download during the conference from Elsevier for those who do not subscribe to the journal.

Job Postings

Please check with the SIAM registration desk regarding the availability of job postings or visit *http://jobs.siam.org*.

SIAM Books and Journals

Display copies of books and complimentary copies of journals are available on site. SIAM books are available at a discounted price during the conference. If a SIAM books representative is not available, completed order forms and payment (credit cards are preferred) may be taken to the SIAM registration desk. The books table will close at 2:30 PM on Wednesday, October 14.

Conference Sponsor

Autodesk is a sponsor of the Solid Modeling Association Best Paper Awards.

AUTODESK

Name Badges

A space for emergency contact information is provided on the back of your name badge. Help us help you in the event of an emergency!

Comments?

Comments about SIAM meetings are encouraged! Please send to:

Cynthia Phillips, SIAM Vice President for Programs (vpp@siam.org).

Get-togethers

- **Welcome Reception**
  Sunday, October 11
  5:00 PM – 7:00 PM

- **SIAG/GD Business Meeting** *(open to SIAG/GD members)*
  Tuesday, October 13
  4:45 PM - 5:30 PM
  Complimentary beer and wine will be served.

- **SMA Business Meeting**
  Tuesday, October 13
  5:30 PM - 6:00 PM

- **Conference Dinner Banquet**
  Tuesday, October 13
  6:30 PM
  (*optional fee event; ticket required*)
  See page 4 for details.

Please Note

SIAM is not responsible for the safety and security of attendees' computers. Do not leave your laptop computers unattended. Please remember to turn off your cell phones, pagers, etc. during sessions.

Recording of Presentations

Audio and video recording of presentations at SIAM meetings is prohibited without the written permission of the presenter and SIAM.

Social Media

SIAM is promoting the use of social media, such as Facebook and Twitter, in order to enhance scientific discussion at its meetings and enable attendees to connect with each other prior to, during and after conferences. If you are tweeting about a conference, please use the designated hashtag to enable other attendees to keep up with the Twitter conversation and to allow better archiving of our conference discussions. The hashtag for this meeting is #GDSPM15.

Invited Plenary Speakers

** All Invited Plenary Presentations will take place in the Canyons Room**

Monday, October 12

8:00 AM - 9:00 AM

IP1 3D Printing: Challenges and Opportunities for Geometric and Physical Modeling

Yong Chen, *University of Southern California, USA*

1:00 PM - 2:00 PM

IP2 Design to Manufacturing via Level Set Method

H. Alicia Kim, *University of Bath, United Kingdom*

Tuesday, October 13

8:00 AM - 9:00 AM

IP3 Power and Challenges of Simplicity

Jarek Rossignac, *Georgia Institute of Technology, USA*

1:00 PM - 2:00 PM

IP4 Engineering Through Abstractions

Vadim Shapiro, *University of Wisconsin, Madison, USA*

Wednesday, October 14

8:00 AM - 9:00 AM

IP5 When Solid Modeling Stopped Being Solid: Custom Materials and Additive Processes

Jan H. Vandenbrande, *Defense Advanced Research Projects Agency, USA*

1:00 PM - 2:00 PM

IP6 C^1 Isogeometric Spaces on Multipatch Geometries

Giancarlo Sangalli, *University of Pavia, Italy*

Prizes and Awards

** Prize and Awards Presentations will take place in the Canyons Room**

Pierre Bézier Award

Recipients of the 2014 and 2015 Pierre Bézier Award
will be announced during the conference.

Best Paper Awards

The Solid Modeling Association
will announce the Best Paper Awards:

Wednesday, October 14

4:45 PM - 5:00 PM

SIAM Presents

An audio-visual archive, comprised of more than 1800 presentations posted in 28 searchable topics, including:

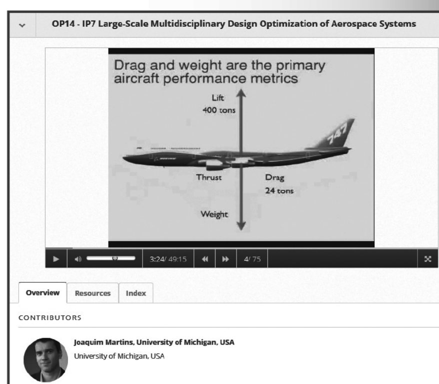
- algebraic geometry
- atmospheric and oceanographic science
- computational science
- data mining
- geophysical science
- optimization
- uncertainty quantification

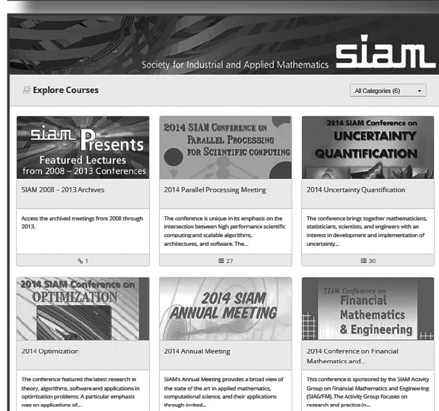
  and more…

The collection, *Featured Lectures from our Archives,* includes audio and slides from 25 conferences since 2008, including talks by invited and prize speakers, select minisymposia, and minitutorials from the 2014 Annual Meeting and four 2014 SIAG meetings.

In addition, you can view brief video clips of speaker interviews and topic overviews from sessions at Annual Meetings starting in 2010, as well as the 2013 SIAM Conference on Computational Science and Engineering and the 2014 SIAM Conference on the Life Sciences.

Plans for adding more content from SIAM meetings abound, including presentations from six meetings in 2015.





New presentations are posted every few months as the program expands with sessions from additional SIAM meetings. Users can search for presentations by category, speaker name, and/or keywords.

The audio, slide, and video presentations are part of SIAM's outreach activities to increase the public's awareness of mathematics and computational science in the real world, and to bring attention to exciting and valuable work being done in the field. Funding from SIAM, the National Science Foundation, and the Department of Energy was used to support this project.

www.siam.org/meetings/presents.php

Society for Industrial and Applied Mathematics
3600 Market Street, 6th Floor • Philadelphia, PA 19104-2688 USA
Phone: +1-215-382-9800 • Fax +1-215-386-7999 • *pao@siam.org* • *www.siam.org*

GD/SPM15 Program

SIAM Conference on

Geometric & Physical Modeling
(GD/SPM15)

October 12-14, 2015
Sheraton Salt Lake City Hotel
Salt Lake City, Utah, USA

Sunday, October 11

Registration
4:00 PM-7:00 PM

Room:Canyons Lobby

Welcome Reception
5:00 PM-7:00 PM

Room:Arches

Monday, October 12

Registration
7:00 AM-3:00 PM

Room:Canyons Lobby

Welcoming Remarks
7:45 AM-8:00 AM

Room:Canyons

IP1
3D Printing: Challenges and Opportunities for Geometric and Physical Modeling
8:00 AM-9:00 AM

Room:Canyons

Chair: Charlie C. L. Wang, The Chinese University of Hong Kong, Hong Kong

3D printing (additive manufacturing) has drastically changed the design and manufacturing landscape by enabling companies to prototype and produce products faster and cheaper. However, significant challenges remain to be addressed in order to fully realize the use of 3D printing as a direct digital manufacturing approach. This talk will discuss some unique properties of 3D printing technology and related opportunities for geometric and physical modeling. Some of our recent work on new process development and design for additive manufacturing will be presented. The talk will conclude with remarks and thoughts on future 3D printing developments and new design and manufacturing paradigms.

Yong Chen
University of Southern California, USA

Coffee Break
9:00 AM-9:30 AM

Room:Arches

Monday, October 12

MS1
Design for Composites
9:30 AM-11:30 AM

Room:Snowbird

The purpose of this symposium is to expose this community to the challenges in carbon fiber composite design, analysis and manufacturing. Composites enable fantastic new opportunities to create products with tailored material properties. Yet the tools and methods to model with composites and fully leverage their potential are still in their infancy. There are many challenges to be addressed that span the spectrum of representations, mathematics, geometry, optimization (including topology), scale, computing, analysis and simulation, and material science. This symposium intends familiarize the community with what composites are, what the current practices are and what the current challenges are.

Organizer: Jan H. Vandenbrande
Defense Advanced Research Projects Agency, USA

Organizer: Dan E. Gonsor
The Boeing Company, USA

9:30-9:55 Composite Design Primer
Agnes Blom, The Boeing Company, USA

10:00-10:25 Composite Manufacturing
Kurtis Willden, The Boeing Company, USA

10:30-10:55 Composite Analysis
Anoush Poursartip, University of British Columbia, Canada

11:00-11:25 Future Vision of Advanced Materials and Processes in Design
Jan H. Vandenbrande, Defense Advanced Research Projects Agency, USA

Monday, October 12

MS2

Representation and Isogeometric Analysis - Part I of III

9:30 AM-11:30 AM

Room:Brighton

For Part 2 see MS5

Isogeometric Analysis (IGA), introduced in 2005 by T.J.R. Hughes, replaces traditional Finite Elements by NonUniform Rational B-splines (NURBS), thus aligning FEA and CAD shape representation. While CAD-models focus on the overall shape accuracy and allow adjacent surfaces to not match exactly, FEA-models are required to have elements that match exactly with the element structure strongly influencing the quality of the analysis to be performed. The minisymposium will address state-of-the-art and identified research challenges of IGA as well as present selected research topics in more detail.

Organizer: Tor Dokken
SINTEF, Norway

Organizer: Michael Scott
Brigham Young University, USA

9:30-9:55 Bézier Projection and Applications

Michael Scott, Brigham Young University, USA

10:00-10:25 A New Basis for PHT-Splines

Falai Chen, Hongmei Kang Kang, and Jiansong Deng, University of Science and Technology of China, China

10:30-10:55 On Analysis Suitable T-Splines in Any Dimension

Rene Hiemstra, University of Texas at Austin, USA

11:00-11:25 Hybrid Volume Completion with Mixed-Order Bézier Elements

First Suqin Zeng and *Elaine Cohen*, University of Utah, USA

Monday, October 12

MS3

Geometrical Big Data Sciences

9:30 AM-11:30 AM

Room:Sundance

As computing and imaging sensors become increasingly higher performance, computational data processing, including and especially in the manipulation of geometry, needs to keep pace with an increase in innovation and efficiency. Geometric data scientists in fields such as molecular, biomedical and fluid dynamics modeling, easily end up with large high quality simulation and imaging datasets, with limited ability to process and rapidly interrogate the data with existing techniques and tools. This initial minisymposium will present four talks, outlining methods and challenges of Big Data in any dimension, with a mix of revisited and new insights in their interaction and extraction of geometric intelligence.

Organizer: Heidi E. I. Dahl
SINTEF ICT, Norway

Organizer: Chandrajt Bajaj
University of Texas at Austin, USA

9:30-9:55 Fast, Approximate and Scalable Geometric Optimization (Big Data and High Dimensional Spaces)

Chandrajt Bajaj, University of Texas at Austin, USA

10:00-10:25 Synchronous Visual Analytics on Petabytes of Molecular Simulations-Topology, Geometry and Numerics

Thomas J. Peters, University of Connecticut, USA; Kirk E. Jordan, IBM T.J. Watson Research Center, USA; Hugh Cassidy and Ji Li, LeanTaaS Inc., USA; Kevin Marinelli, University of Connecticut, USA

10:30-10:55 Geometric Processing in Statistical Shape Modeling

Xilu Wang and Yunyang Xiong, University of Wisconsin, Madison, USA; Kang Li, Illinois Institute of Technology, USA; Xiaoping Qian, University of Wisconsin, Madison, USA

11:00-11:25 Modelling Geometrical Big Data Using Locally Refined B-Splines

Heidi E. I. Dahl, SINTEF ICT, Norway

Monday, October 12

PS1

Full Paper Presentations: Applications and Splines

9:30 AM-11:35 AM

Room:Canyons

Chair: Georg Umlauf, HTWG Konstanz, Germany

9:30-9:50 Surgem: A Solid Modeling Tool for Planning and Optimizing Pediatric Heart Surgeriem

Mukul Sati, Mark Luffel, Jarek Rossignac, and Ajit P. Yoganathan, Georgia Institute of Technology, USA; Christopher Haggerty, Maria Restrepo, Timothy Slesnick, Kirk Kanter, Pedro del Nido, and Mark Fogel, Unknown

9:55-10:15 Automatic Generation of Lego Building Instructions from Multiple Photographic Images of Real Objects

Takashi Maekawa, Takuya Kozaki, and Hiroshi Tadenuma, Yokohama National University, Japan

10:20-10:40 Generalizing Bicubic Splines for Modelling and Iga with Irregular Layout

Jörg Peters, University of Florida, USA; Kestutis Karciauskas, Vilnius University, Lithuania; Thien T. Nguyen, University of Florida, USA

10:45-11:05 Geometric Characteristics of a Class of Cubic Curves with Rational Offsets

Jianmin Zheng, Nanyang Technological University, Singapore; Xing-jiang Lu, Yiyu Cai, and Gang Zhao, Unknown

11:10-11:30 Average Curve of N Smooth Planar Curves

Mukul Sati and Jarek Rossignac, Georgia Institute of Technology, USA; Raimund Seidel, Unknown; Brian Wyvill, University of Victoria, Canada; Suraj Musuvathy, University of Utah, USA

Lunch Break

11:30 AM-1:00 PM

Attendees on their own

Monday, October 12

IP2

Design to Manufacturing via Level Set Method

1:00 PM-2:00 PM

Room:Canyons

Chair: Horea T. Ilies, University of Connecticut, USA

There has been a rise of research interests in two notable areas of engineering design. One is to use more high fidelity design in conceptual design stage and the other is in design for additive manufacturing. Topology optimization is a design approach that has been identified as being able to address both of these challenges. Topology optimization is a most generalized form of structural optimization that can provide an unintuitive and potentially revolutionary design solution. Many case studies quote weight saving or performance improvement in the order of 20% - 80%. Topology optimization is traditionally formulated as material distribution problems where a finite element may or may not exist in the specified design domain. This discrete formulation produces a design that is fundamentally linked to the finite element representation and challenges in linking to a CAD or more traditional geometrical representation was a barrier to a wide adoption of topology optimization in the engineering design environment. The recent development of topology optimization uses the level set method which has a continuous geometry representation and together with its flexibility in topological changes, it can naturally integrate conceptual design to manufacturing. Our research group has been developing the level set topology optimization method to raise its maturity. We have also shown that the level set representation of a design eliminates the cumbersome post-processing typically required for manufacturing. The presentation will offer a perspective on the current research and the future trends of level set topology optimization.

H. Alicia Kim
University of Bath, United Kingdom

Coffee Break

2:00 PM-2:30 PM

Room:Arches

Monday, October 12

MS4

The Ewald Quak Forward Looking Session

2:30 PM-4:30 PM

Room:Canyons

Forward Looking Sessions and Panel Discussions were organized by Ewald Quak at the previous four conferences in San Antonio in 2007, San Francisco in 2009 and Orlando 2011 and Denver 2013. He would also have organized such a Forward Looking Session at the 2015 conference in Salt Lake City if he had not unexpectedly passed away in April 2015. The 2015 forward looking is organized in the spirt of Ewald Quak and in remembrance of Ewald Quak´s role as a driving force in SIAM Activity Group for Geometric Design. Following the presentations the subsequent panel discussion is again intended for lively discussions of future directions involving all conference participants.

Organizer: Tor Dokken
SINTEF, Norway

Organizer: Tom A. Grandine
The Boeing Company, USA

2:30-2:55 Design and Simulation in the Cloud

Tor Dokken, SINTEF, Norway

3:00-3:25 Scripted Geometry Processing for Manufacturing

Tom A. Grandine, The Boeing Company, USA

3:30-3:55 Pre- and Post- Design - The Future of Geometric Modeling?

Tim Strotman, Siemens Corporation Research, Germany

4:00-4:25 Issues and Experiences Implementing Cloud-based CAD

Bil Denker, Solid Modeling Solutions, USA

Monday, October 12

MS5

Representation and Isogeometric Analysis - Part II of III

2:30 PM-4:30 PM

Room:Brighton

For Part 1 see MS2
For Part 3 see MS8

Isogeometric Analysis (IGA), introduced in 2005 by T.J.R. Hughes, replaces traditional Finite Elements by NonUniform Rational B-splines (NURBS), thus aligning FEA and CAD shape representation. While CAD-models focus on the overall shape accuracy and allow adjacent surfaces to not match exactly, FEA-models are required to have elements that match exactly with the element structure strongly influencing the quality of the analysis to be performed. The minisymposium will address state-of-the-art and identified research challenges of IGA as well as present selected research topics in more detail.

Organizer: Tor Dokken
SINTEF, Norway

Organizer: Michael Scott
Brigham Young University, USA

2:30-2:55 Isogeometric Analysis for Wave-Body Interaction Problems

Panagiotis Kaklis, University of Strathclyde, United Kingdom; Alexandros I. Ginnis, National Technical University of Athens, Greece; Konstantinos Kostas and Costas Politis, Technological Educational Institute of Athens, Greece

3:00-3:25 Discrete Surface Uniformization, Theory and Algorithms

Xianfeng Gu, Stony Brook University, USA

3:30-3:55 Free Surface Hydrodynamics Using Isogeometric Analysis

Jens Gravesen, Technical University of Denmark, Denmark

4:00-4:25 Hierarchical Spline Quasi-Interpolation

Hendrik Speleers, University of Rome II, Tor Vergata, Italy

Monday, October 12

PS2

Full Paper Presentations: Segmentation and Meshing

2:30 PM-4:35 PM

Room:Snowbird

Chair: Wenping Wang, University of Hong Kong, Hong Kong

2:30-2:50 Secondary Laplace Operator and Generalized Giaquinta-Hildebrandt Operator with Applications on Surface Segmentation and Smoothing

Jessica Zhang, Carnegie Mellon University, USA; Xinge Li, Chinese Academy of Sciences, China; Guoliang Xu, Academia Sinica, China; Tao Liao, Carnegie Mellon University, USA

2:55-3:15 A Statistical Atlas Based Approach to Automated Subject-Specific Fe Modeling

Xiaoping Qian and Xilu Wang, University of Wisconsin, Madison, USA

3:20-3:40 Consistent Quadrangulation for Shape Collections Via Feature Line Co-Extraction

Ying He and Min Meng, Nanyang Technological University, Singapore

3:45-4:05 Isogeometric Segmentation: Construction of Auxiliary Curves

Dang-Manh Nguyen and Michael Pauley, Johannes Kepler Universität, Linz, Austria; Bert Juettler, University of Linz, Austria

4:10-4:30 Analytic Methods for Geometric Modeling Via Spherical Decomposition

Morad Behandish, University of Connecticut, Storrs, USA; Horea T. Ilies, University of Connecticut, USA

Monday, October 12

CP1

Contributed Talks

2:30 PM-4:30 PM

Room:Sundance

Chair: Bonita V. Saunders, National Institute of Standards and Technology, USA

2:30-2:45 Peicewise Bézier Surfaces over Unstructured Quadrilateral Meshes

Michel Bercovier, Hebrew University, Israel

2:50-3:05 Support Vector Machines for Knot Placement in B-Spline Surface Approximation

Pascal Laube, Hochschule Konstanz University of Applied Sciences, Germany; Georg Umlauf, HTWG Konstanz, Germany

3:10-3:25 Slices of 3D Surfaces on the Web Using Tensor Product B-Spline Grids

Bonita V. Saunders, National Institute of Standards and Technology, USA

3:30-3:45 Curves with Quadratic Logarithmic Curvature Graphs

Norimasa Yoshida, Nihon University, Japan; Takafumi Saito, Tokyo University of Agriculture and Technology, Japan

3:50-4:05 Truncated B-Splines for Non-Nested Refinement

Urska Zore, Johannes Kepler University Linz, Austria; Bert Juettler, University of Linz, Austria

4:10-4:25 Stable Simplex Spline Bases for C3 Quintics on the Powell-Sabin 12-Split

Georg Muntingh, SINTEF, Norway; Tom Lyche, University of Oslo, Norway

Intermission

4:30 PM-4:45 PM

Monday, October 12

PD1

The Ewald Quak Forward Looking Panel Discussion

4:45 PM-5:45 PM

Room:Canyons

Chair: Thomas A. Grandine, The Boeing Company, USA

Computer-Aided Geometric Design has been a thriving discipline for more than 30 years. In that time, commercial products have solidified and representation standards have emerged, including surface representation using rational tensor product splines and solid representation via representation of solid boundaries. In the meantime, important new applications are arising, including 3D printing and isogeometric analysis for which these standard representation schemes appear to be inadequate. This panel discussion will empower audience participants to challenge the panelists on the emerging technologies that they perceive will fill this and other important gaps in CAGD technology.

Panelists:

Bill Denker
Solid Modeling Solutions, USA

Tor Dokken
SINTEF, Norway

Tim Strotman
Siemens Corporation Research, Germany

Jan Vandenbrande
Defense Advanced Research Projects Agency, USA

Tuesday, October 13

Registration

7:30 AM-3:00 PM

Room:Canyons Lobby

Remarks

7:55 AM-8:00 AM

Room:Canyons

IP3

Power and Challenges of Simplicity

8:00 AM-9:00 AM

Room:Canyons

Chair: John Keyser, Texas A&M University, USA

Valuable solutions to difficult problems are often based on surprisingly simple ideas. Why then did it take us so long to discover them? Possible reasons include the lack of the proper abstractions, the obsession with full generality, and the concern that some sub-problems may be insurmountable. We will illustrate this observation using examples from the speaker's contributions: 3D GUI techniques for the realtime control of camera [miniCam] and free-form deformations [Twister, Bender]; compact representations for rendering [Vertex Clustering], processing [ECT, SOT, LR, Zipper] or transmitting [Topological Surgery, EdgeBreaker] triangle meshes; efficient algorithms for evaluating and rendering CSG models [Blister, CST, OBL]; effective formulations for constant [Grow&Shrink, Tightening] and variable [Relative Blending] radius rounding; and expressions for optimal in-betweening [Ball Morph] deformations or interpolating motions [Steady Affine Morph] defined by control shapes or affine transformations.

Jarek Rossignac
Georgia Institute of Technology, USA

Coffee Break

9:00 AM-9:30 AM

Room:Arches

Tuesday, October 13

MS6

Intrinsic Methods for Surface Meshing and Processing

9:30 AM-11:30 AM

Room:Canyons

Many geometric processing tasks, such as surface meshing and geodesic computation on surfaces, need to consider intrinsic curvature or anisotropy induced by a Riemannian metric. Their solutions go beyond existing methods based on embedding space equipped with Euclidean metric and call for new ideas and extensions. This minisymposium consists of four presentations addressing the problems of high quality anisotropic surface remeshing, intrinsic Delaunay triangulations, and novel shape signatures based on geodesic distances.

Organizer: Ying He
Nanyang Technological University, Singapore

Organizer: Wenping Wang
University of Hong Kong, Hong Kong

9:30-9:55 Computing Intrinsic Delaunay Triangulations on Polyhedral Surfaces

Yongjin Liu, Tsinghua University, P. R. China; *Ying He*, Nanyang Technological University, Singapore

10:00-10:25 A Spectral Method for Anisotropic Quad Meshing

Wenping Wang, University of Hong Kong, Hong Kong

10:30-10:55 High-Quality Anisotropic Surface Meshing

Xiaohu Guo, University of Texas, Dallas, USA

11:00-11:25 Geodesic-Based Shape Descriptors

Shi-Qing Xin, Ningbo University, China

Tuesday, October 13

MS7

Distance-related Computations on Freeform Geometric Models

9:30 AM-11:30 AM

Room:Snowbird

Distance computation plays an important role in improving the computational efficiency as well as the numerical stability of many geometric algorithms in solid and physical modeling. This minisymposium will present recent developments in the design of spatial data structures, acceleration algorithms, and applications of minimum/maximum distance computation for freefom geometric models represented with NURBS curves and surfaces. In particular, we consider topics such as bounding volume hierarchies (BVH) for freeform models, GPU-accelerated algorithms, and various applications in solid and physical models.

Organizer: Myung-Soo Kim
Seoul National University, Korea

9:30-9:55 Bounding Volume Hierarchies for Planar Freeform Curves

Myung-Soo Kim, Seoul National University, Korea

10:00-10:25 Hierarchical Data Structures for Freeform Geometric Models

Yong-Joon Kim, Technion Israel Institute of Technology, Israel

10:30-10:55 Gpu Approaches to Distance Calculations for Freeforms

Sara McMains, University of California, Berkeley, USA

11:00-11:25 Covering 2D Domains Using Random Curves

Jinesh Machchhar and Gershon Elber, Technion Israel Institute of Technology, Israel

Tuesday, October 13

MS8

Representation and Isogeometric Analysis - Part III of III

9:30 AM-12:00 PM

Room:Brighton

For Part 2 see MS5

Isogeometric Analysis (IGA), introduced in 2005 by T.J.R. Hughes, replaces traditional Finite Elements by NonUniform Rational B-splines (NURBS), thus aligning FEA and CAD shape representation. While CAD-models focus on the overall shape accuracy and allow adjacent surfaces to not match exactly, FEA-models are required to have elements that match exactly with the element structure strongly influencing the quality of the analysis to be performed. The minisymposium will address state-of-the-art and identified research challenges of IGA as well as present selected research topics in more detail.

Organizer: Tor Dokken
SINTEF, Norway

Organizer: Michael Scott
Brigham Young University, USA

9:30-9:55 Splines on Regular Triangulations in Isogeometric Analysis

Carla Manni, University of Rome II, Tor Vergata, Italy

10:00-10:25 Iga on Generalized 3-Direction Triangulations

Thien T. Nguyen, University of Florida, USA

10:30-10:55 Isogeometric Analysis and Shape Optimization on Triangulations

Xiaoping Qian, University of Wisconsin, Madison, USA

11:00-11:25 Weighted T-spline and Its Application in Isogeometric Analysis

Lei Liu, Yongjie Zhang, and Xiaodong Wei, Carnegie Mellon University, USA

11:30-11:55 A Numerical Evaluation of Convergence Properties of Unstructured T-splines in Extraordinary Regions for Isogeometric Analysis

Weiyin Ma, Xiaoyun Yuan, and Yue Ma, City University of Hong Kong, Hong Kong; Michael Scott, Brigham Young University, USA

Tuesday, October 13

CP2

Contributed Talks

9:30 AM-11:10 AM

Room:Sundance

Chair: Alexey Stepanov, University of Maryland, USA

9:30-9:45 IgA-Based Solver for Turbulence Modelling on Multipatch Geometries

Bohumir Bastl, Marek Brandner, Jiri Egermaier, Kristyna Michalkova, and Eva Turnerova, University of West Bohemia, Pilsen, Czech Republic

9:50-10:05 Nurbs Models and Volumetric Parameterizations of Water Turbines

Kristyna Michalkova and Bohumir Bastl, University of West Bohemia, Pilsen, Czech Republic

10:10-10:25 A New One-Sided Spline Filter for Discontinuous Galerkin Solutions on Domains with Boundary

Dang Manh Nguyen and Jorg Peters, University of Florida, USA

10:30-10:45 Steady-State and Dynamical Radially-Symmetric Solutions of 2D Nonlinear Viscoelasticity

Alexey Stepanov, University of Maryland, USA

10:50-11:05 Adaptively Weighted Numerical Integration in the Finite Cell Method

Vaidyanathan Thiagarajan and Vadim Shapiro, University of Wisconsin, Madison, USA

Lunch Break

11:30 AM-1:00 PM

Attendees on their own

Tuesday, October 13

IP4

Engineering Through Abstractions

1:00 PM-2:00 PM

Room:Canyons

Chair: Gershon Elber, Technion Israel Institute of Technology, Israel

Abstractions determine to a large extent how we relate to physical world, guiding the way we perceive, imagine, communicate, design and manufacture. In the context of computer-aided engineering, abstractions are formal models of physical artifacts, processes, and systems that give precise meaning to computer representations and algorithms. Familiar examples of abstractions in solid modeling include r-sets, orientable manifolds, constraint graphs, sweeps, and Euler operators. Recent emphasis on model-based engineering requires understanding, extending, and reconciling abstractions that include logical models to describe system's structure, various graph models to represent discrete and continuous behaviors, finite element models to simulate spatially distributed phenomena, and yet to be agreed upon models for materials, functions, and systems. The future of model-based engineering hinges on the ability to support the ever increasing diversity of abstractions in a systematic and computationally efficient manner. I will illustrate these challenges by specific examples and will propose some basic principles for addressing them.

Vadim Shapiro
University of Wisconsin, Madison, USA

Coffee Break

2:00 PM-2:30 PM

Room:Arches

Tuesday, October 13

MS9

Topological Methods in Geometric and Physical Modeling

2:30 PM-4:30 PM

Room:Snowbird

We wish to discuss the application of ideas and techniques from algebraic topology, differential geometry, and exterior calculus (differential and discrete) to present-day problems in geometric modeling. Our main aim is to contribute to a mathematical foundation for the integration between geometric and physical modeling, while fostering the development of versatile and efficient representations of topology and geometry, capable of unifying the treatment of images, meshes and polyhedral data.

Organizer: Antonio DiCarlo
Università degli Studi Roma Tre, Italy

Organizer: Vadim Shapiro
University of Wisconsin, Madison, USA

2:30-2:55 Smooth k-Vector Fields, k-Measures and Their Boundary

Antonio DiCarlo, Università degli Studi Roma Tre, Italy

3:00-3:25 Computing Harmonic Forms

Anil Hirani and Kaushik Kalyanaraman, University of Illinois at Urbana-Champaign, USA; Han Wang, North Carolina State University, USA; Seth Watts, University of Illinois at Urbana-Champaign, USA

3:30-3:55 LAR: a Novel Representation Scheme of Geometric-Topological Data

Antonio DiCarlo and *Alberto Paoluzzi*, Università degli Studi Roma Tre, Italy; Vadim Shapiro, University of Wisconsin, Madison, USA

4:00-4:25 Compatibility Equations of Nonlinear Elasticity for Non-Simply-Connected Bodies

Arash Yavari, Georgia Institute of Technology, USA

Tuesday, October 13

MS10

Numerical Integration Schemes for Isogeometric Discretizations

2:30 PM-4:30 PM

Room:Brighton

NURBS representations have been used extensively in computer-aided design and engineering. Recently, their use in numerical simulation has attracted special attention in the context of isogeometric analysis. It was observed that the NURBS-based discretization of partial differential equations requires techniques for high-order numerical integration in order to guarantee the desired order of accuracy. Due to the increased polynomial degree, the extended support and interaction between basis functions and the influence of the isogeometric geometry map, the computational costs associated with standard Gauss quadrature are substantially higher than for classical finite elements. This minisymposium will explore methods, approaches and current results regarding computationally efficient numerical integration schemes for isogeometric discretizations.

Organizer: Angelos Mantzaflaris
Austrian Academy of Sciences, Austria

Organizer: Bert Juettler
University of Linz, Austria

2:30-2:55 Compact Kronecker Representation of Isogeometric Matrices for Fast Integration

Angelos Mantzaflaris, RICAM, Austrian Academy of Sciences, Austria; Bert Juettler, University of Linz, Austria; Ulrich Langer, RICAM, Austrian Academy of Sciences, Austria; Boris Khoromskij, Max Planck Institut Leipzig, Germany

3:00-3:25 Efficient Quadrature Algorithm and Trimmed Geometries

Massimiliano Martinelli, IMATI-CNR, Italy; Gershon Elber, Technion Israel Institute of Technology, Israel

continued in next column

3:30-3:55 Truncated Hierarchical Catmull-Clark Subdivision with Local Refinement

Xiaodong Wei and Jessica Zhang, Carnegie Mellon University, USA; Thomas Hughes, University of Texas at Austin, USA; Michael Scott, Brigham Young University, USA

4:00-4:25 Efficient Quadrature for High Degree Isogeometric Analysis

Francesco Calabrò, Università degli studi di Cassino e del Lazio Meridionale, Italy; *Giancarlo Sangalli*, University of Pavia, Italy

Tuesday, October 13

PS3

Full Paper Presentations: Contacts and Geometry

2:30 PM-4:35 PM

Room:Canyons

Chair: Sara McMains, University of California, Berkeley, USA

2:30-2:50 Efficient Global Penetration Depth Computation for Articulated Models

Hao Tian, *Xinyu Zhang*, and Changbo Wang, East China Normal University, China; Jia Pan, Hong Kong University, Hong Kong; Dinesh Manocha, University of North Carolina, Chapel Hill, USA

2:55-3:15 Precise Contact Motion Planning for Deformable Planar Curved Shapes

Yong-Joon Kim and Gershon Elber, Technion Israel Institute of Technology, Israel; Myung-Soo Kim, Seoul National University, Korea

3:20-3:40 Effective Contact Measures

Mikola Lysenko and Vadim Shapiro, University of Wisconsin, Madison, USA

3:45-4:05 Solving the Initial Value Problem of Discrete Geodesics

Peng Cheng and Chunyan Miao, Nanyang Technological University, Singapore; Yong-Jin Liu, Tsinghua University, P. R. China; Changhe Tu, Shandong University, China; Ying He, Nanyang Technological University, Singapore

4:10-4:30 A Total Order-Based Convex Hull Algorithm for Points in the Plane

Abel Gomes, Universidade da Beira Interior Covilhã, Portugal

Tuesday, October 13

CP3

Contributed Talks

2:30 PM-4:10 PM

Room:Sundance

Chair: Erkan Gunpinar, Istanbul Technical University, Turkey

2:30-2:45 2D Packing of Large Size Non-Rectangular Quad Items into Smaller Size Polygonal Bins

Erkan Gunpinar, Istanbul Technical University, Turkey

2:50-3:05 Reconstruction and Design of Functionally Graded Material Structures

Xingchen Liu and Vadim Shapiro, University of Wisconsin, Madison, USA

3:10-3:25 Interpolation and Shape Preserving Design with Hyperbolic Spaces

Jesús M. Carnicer, *Esmeralda Mainar*, and Juan Manuel Peña, Universidad de Zaragoza, Spain

3:30-3:45 On Developable Surfaces in Dental Imaging

Marco Paluszny, Universidad Nacional de Colombia, Colombia; Cindy Gónzalez, Universite de Valenciennes et du Hainaut Cambresis, France

3:50-4:05 A Parallel Hash Map for Level-of-Detail-Aware Depth-Map Fusion

Georg Umlauf, HTWG Konstanz, Germany; Markus Friedrich, University of Konstanz, Germany; Bernd Hamann, University of California, Davis, USA

Intermission

4:30 PM-4:45 PM

Tuesday, October 13

SIAG/GD Business Meeting

4:45 PM-5:30 PM

Room:Canyons

Complimentary beer and wine will be served.

SMA Business Meeting

5:30 PM-6:00 PM

Room:Canyons

Conference Dinner Banquet (*optional fee event; ticket required*)

6:30 PM-8:30 PM

Room:Wasatch

See page 4 for additional details.

Wednesday, October 14

Registration

7:30 AM-3:00 PM

Room:Canyons Lobby

Remarks

7:55 AM-8:00 AM

Room:Canyons

IP5

When Solid Modeling Stopped Being Solid: Custom Materials and Additive Processes

8:00 AM-9:00 AM

Room:Canyons

Chair: Tom A. Grandine, The Boeing Company, USA

New fabrication processes and materials are being developed that enable products to be conceived that are well beyond anyone's imagination. However, current authoring tools and design processes are not equipped to exploit these capabilities. This talk will discuss some of the short comings with the current modeling technologies and provide the motivation for the development of a new set of foundations to fully exploit the possibilities of novel fabrication processes, such as 3D printing, and materials, including carbon fiber composites.

Jan H. Vandenbrande
Defense Advanced Research Projects Agency, USA

Coffee Break

9:00 AM-9:30 AM

Room:Arches

Wednesday, October 14

MS11

Geometric Modeling and Processing in Additive Manufacturing - Part I of II

9:30 AM-11:30 AM

Room:Snowbird

For Part 2 see MS13

Additive manufacturing, such as 3D printing and layered manufacturing, refers to a digital fabrication process that can directly fabricate a physical object with complex shape and structure from a Computer-Aided Design (CAD) model without special tools and fixtures. Direct Digital Manufacturing (DDM) based on such a process has been widely recognized as a disruptive manufacturing technology for a variety of applications. The objective of this minisymposium is to identify challenges, opportunities, and new applications; disseminate recent insights and findings by the CAD/CAM communities; define and discuss theoretical and computational issues and cutting edge techniques across multiple and diversified fields.

Organizer: Yong Chen
University of Southern California, USA

Organizer: Charlie C. L. Wang
The Chinese University of Hong Kong, Hong Kong

9:30-9:55 Representation and Analysis of Additively Manufactured Parts

Saigopal Nelatu and *Vadim Shapiro*, University of Wisconsin, Madison, USA

10:00-10:25 Designing for Am: Integrating Mesh-Based Modelling Techniques with Parametric Cad

Ryan Schmidt, Autodesk, Inc., USA

10:30-10:55 Adaptive and Robust Slicing of Scan Data for Additive Manufacturing

Xiaoping Qian, University of Wisconsin, Madison, USA

11:00-11:25 4D Printing for Freeform Surfaces: Design Optimization of Origami and Kirigami Structures

Tsz-Ho Kwok, University of Southern California, USA; Charlie C. L. Wang, The Chinese University of Hong Kong, Hong Kong; Yong Chen, University of Southern California, USA

Wednesday, October 14

MS12

Isogeometric Analysis on Complex Geometries - Part I of II

9:30 AM-11:30 AM

Room:Brighton

For Part 2 see MS14

A key feature of isogoemetric analysis is the possibility of incorporating CAD geometry parametrizations directly into the PDE solver. One of the challenges of IgA is the design of tools that can handle complex geometries in an "analysis-suitable" and efficient way. We focus on two very active areas of research: The design and study of non-tensor product spline-based spaces that allow for local h-refinement and a more flexible representation of geometries; and the construction of arbitrary-topology C1-smooth isogeometric spaces. This allows for a direct Galerkin approximation of many relevant fourth-order diferential problems, which is not possible with classical finite elements.

Organizer: Thomas Takacs
University of Pavia, Italy

Organizer: Giancarlo Sangalli
University of Pavia, Italy

9:30-9:55 Spline Manifold Spaces for Isogeometric Analysis

Giancarlo Sangalli and *Thomas Takacs*, University of Pavia, Italy; Rafael Vazquez, IMATI-CNR, Italy

10:00-10:25 Adaptive Isogeometric Analysis on Multi Patch Domains

Florian Buchegger, Johannes Kepler Universität, Linz, Austria; Bert Juettler, University of Linz, Austria; Angelos Mantzaflaris, RICAM, Austrian Academy of Sciences, Austria

10:30-10:55 Iga Across Irregularities

Jorg Peters and Thien T. Nguyen, University of Florida, USA; Kestutis Karciauskas, Vilnius University, Lithuania

11:00-11:25 C1 Assembly of Quadrilateral Patches, Some Properties Relating to their Geometry

Michel Bercovier, Hebrew University, Israel

Wednesday, October 14

PS4

Full Paper Presentations: Implicits and Constraints

9:30 AM-11:10 AM

Room:Canyons

Chair: Ying He, Nanyang Technological University, Singapore

9:30-9:50 An Improved Star Test for Implicit Polynomial Objects

Lincong Fang, Zhejiang University, China; Dominique Michelucci, Université Bourgogne Franche-Comté, France; Sebti Foufou, Qatar University, Qatar

9:55-10:15 Efficient Data-Parallel Tree-Traversal for BlobTrees

Herbert Grasberger, Jean-Luc Duprat, Brian Wyvill, and Paul Lalonde, University of Victoria, Canada; Jarek Rossignac, Georgia Institute of Technology, USA

10:20-10:40 Re-parameterization Reduces Irreducible Geometric Constraint Systems

Hichem Barki, Qatar University, Qatar; Lincong Fang, Zhejiang University, China; Dominique Michelucci, Université Bourgogne Franche-Comté, France; *Sebti Foufou*, Qatar University, Qatar

10:45-11:05 Statistical Geometric Computation on Tolerances for Dimensioning

Songgang Xu and John Keyser, Texas A&M University, USA

Wednesday, October 14

CP4

Contributed Talks

9:30 AM-11:30 AM

Room:Sundance

Chair: Alexey Sukhinin, Southern Methodist University, USA

9:30-9:45 Crystal Growth Shapes in Bond-Counting Models and Continuum Models

Tim Krumwiede, University of Tennessee, USA

9:50-10:05 Multi-Resolution Geometrical Models of Mammalian Tissues

Hernán A. Morales-Navarrete, Fabian Segovia-Miranda, Piotr Klukowski, Kirstin Meyer, Marino Zerial, and Yannis Kalaidzidis, Max Planck Institute of Molecular Cell Biology and Genetics, Germany

10:10-10:25 Blind Reconstruction of a Single-Source Signal from Its Multi-Reflected Data in a Convex Polygonal Room

Hirofumi Sasaki, Waseda University, Japan; Fumio Sasaki, Tokyo University of Science, Japan; Michio Yamada, Kyoto University, Japan

10:30-10:45 Multi-resolution Method for Co-propagating High Intensity Pulses

Alexey Sukhinin, Southern Methodist University, USA

10:50-11:05 Tree Representations of Streamline Topologies of Structurally Stable 2D Hamiltonian Vector Fields

Tomoo Yokoyama, Kyoto University of Education, Japan; Takashi Sakajo, Kyoto University, Japan

11:10-11:25 Anamorphosis Made Simple; Impossible Objects Made Possible

Javier Sánchez-Reyes and Jesús Miguel Chacón, Universidad de Castilla-La Mancha, Spain

Lunch Break

11:30 AM-1:00 PM

Attendees on their own

Wednesday, October 14

IP6

C^1 Isogeometric Spaces on Multipatch Geometries

1:00 PM-2:00 PM

Room:Canyons

Chair: Scott Schaefer, Texas A&M University, USA

One key features of isogeometric analysis is the possibility of smooth shape functions. Within each patch, smoothness up to C^{p-1} continuity is naturally achieved by p-degree splines and NURBS. However, global continuity beyond C^0 on so-called multipatch geometries poses some significant difficulties. We consider a multi-patch parametrization having G^1 continuity at the patch interfaces, and we study the behaviour of G^1 continuous isogeometric spaces under *h*-refinement. In general, these spaces have suboptimal approximation properties. The reason is that the G^1 continuity condition easily overconstrains the space that, in some cases, is in fact fully *locked* to zero at the patch interface. Optimal convergence is achieved under specific conditions on the geometry parametrization and spline regularity. We develop a mathematical framework and perform numerical tests, with the aim of understanding the possibilities and the rules to follow when constructing G^1 isogeometric aproximations over complex geometries. This work is in collaboration with Annabelle Collin and Thomas Takacs from the University of Pavia.

Giancarlo Sangalli
University of Pavia, Italy

Coffee Break

2:00 PM-2:30 PM

Room:Arches

Wednesday, October 14

MS13

Geometric Modeling and Processing in Additive Manufacturing - Part II of II

2:30 PM-4:30 PM

Room:Snowbird

For Part 1 see MS11

Additive manufacturing, such as 3D printing and layered manufacturing, refers to a digital fabrication process that can directly fabricate a physical object with complex shape and structure from a Computer-Aided Design (CAD) model without special tools and fixtures. Direct Digital Manufacturing (DDM) based on such a process has been widely recognized as a disruptive manufacturing technology for a variety of applications. The objective of this minisymposium is to identify challenges, opportunities, and new applications; disseminate recent insights and findings by the CAD/CAM communities; define and discuss theoretical and computational issues and cutting edge techniques across multiple and diversified fields.

Organizer: Charlie C. L. Wang
The Chinese University of Hong Kong, Hong Kong

Organizer: Yong Chen
University of Southern California, USA

2:30-2:55 Perceptual Models of Preference in 3D Printing Direction
Emily Whiting, Dartmouth College, USA; *Charlie C. L. Wang*, The Chinese University of Hong Kong, Hong Kong

3:00-3:25 An Interactive Beam Structure Design Method Based on Principal Stress Lines for Additive Manufacturing
Yong Chen, University of Southern California, USA

3:30-3:55 Solid Mechanics Based Design and Optimization for Support Structure Generation for Additive Manufacturing
Chi Zhou, SUNY College at Buffalo, USA

4:00-4:25 Support Slimming for Single Material Based Additive Manufacturing
Charlie C. L. Wang and *Shuo Jin*, The Chinese University of Hong Kong, Hong Kong

Wednesday, October 14

MS14

Isogeometric Analysis on Complex Geometries - Part II of II

2:30 PM-4:30 PM

Room:Brighton

For Part 1 see MS12

A key feature of isogoemetric analysis is the possibility of incorporating CAD geometry parametrizations directly into the PDE solver. One of the challenges of IgA is the design of tools that can handle complex geometries in an “analysis-suitable” and efficient way. We focus on two very active areas of research: The design and study of non-tensor product spline-based spaces that allow for local h-refinement and a more flexible representation of geometries; and the construction of arbitrary-topology C1-smooth isogeometric spaces. This allows for a direct Galerkin approximation of many relevant fourth-order diferential problems, which is not possible with classical finite elements.

Organizer: Thomas Takacs
University of Pavia, Italy

Organizer: Giancarlo Sangalli
University of Pavia, Italy

2:30-2:55 LR B-Splines and Linear Independence
Tor Dokken, SINTEF, Norway

3:00-3:25 Polycube-Based Volumetric T-spline Construction for Isogeometric Analysis
Jessica Zhang, Carnegie Mellon University, USA

3:30-3:55 Complexity of Hierachical Refinements for Strictly Admissible Mesh Configurations
Annalisa Buffa, Consiglio Nazionale delle Ricerche, Italy; *Carlotta Giannelli*, Istituto Nazionale di Alta Matematica Francesco Severi, Italy; Philipp Morgenstern and Daniel Peterseim, Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

4:00-4:25 Splines on Triangles
Tom Lyche, University of Oslo, Norway

Wednesday, October 14

MS15

Perspective Projection in Conformal Clifford Algebras

2:30 PM-4:30 PM

Room:Sundance

Clifford (geometric) algebra allows us to construct a wide variety of geometries. Versors and rotors are the primary operator in these geometries, and they are linear operators on the elements. In this minisymposium, after providing an introduction to the relevant ideas of Clifford algebra, we explore adding perspective projection into two geometric algebra models of geometry. In particular, we show how to perform perspective projection in the conformal geometry and in R(4,4). The construction is similar to that used in computer graphics: we have a sequence of linear operations followed by a single perspective projection.

Organizer: Stephen Mann
University of Waterloo, Canada

Organizer: Ron Goldman
Rice University, USA

2:30-2:55 Introduction to Clifford Algebras and Geometries
Alyn Rockwood, Retired

3:00-3:25 Perspective Projection in Homogeneous Models
Stephen Mann, University of Waterloo, Canada

3:30-3:55 Perspective in R(4,4)
Ron Goldman, Rice University, USA

4:00-4:25 Perspective in the Conformal Model and in the Standard Homogeneous Model
Juan Du, Rice University, USA

Wednesday, October 14

Intermission

4:30 PM-4:45 PM

SMA Best Paper Awards Presentation

4:45 PM-5:00 PM

Room:Canyons

Closing Remarks

5:00 PM-5:15 PM

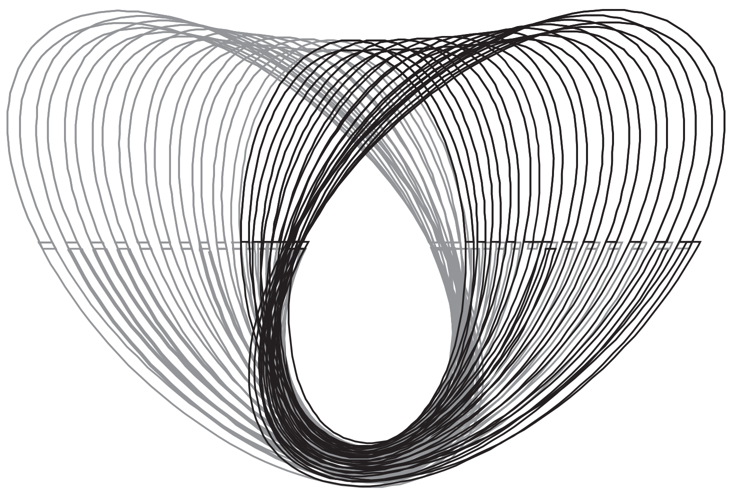
Room:Canyons

Notes

GD/SPM15 Abstracts

SIAM Conference on

Geometric & Physical Modeling (GD/SPM15)



October 12-14, 2015
Sheraton Salt Lake City Hotel
Salt Lake City, Utah, USA

Abstracts are printed as submitted by the authors.

PLEASE NOTE: PS Paper Presentation Session abstracts are included under "CPO" abstracts.

IP1

3D Printing: Challenges and Opportunities for Geometric and Physical Modeling

3D printing (additive manufacturing) has drastically changed the design and manufacturing landscape by enabling companies to prototype and produce products faster and cheaper. However, significant challenges remain to be addressed in order to fully realize the use of 3D printing as a direct digital manufacturing approach. This talk will discuss some unique properties of 3D printing technology and related opportunities for geometric and physical modeling. Some of our recent work on new process development and design for additive manufacturing will be presented. The talk will conclude with remarks and thoughts on future 3D printing developments and new design and manufacturing paradigms.

Yong Chen
University of Southern California
yongchen@usc.edu

IP2

Design to Manufacturing via Level Set Method

There has been a rise of research interests in two notable areas of engineering design. One is to use more high fidelity design in conceptual design stage and the other is in design for additive manufacturing. Topology optimization is a design approach that has been identified as being able to address both of these challenges. Topology optimization is a most generalized form of structural optimization that can provide an unintuitive and potentially revolutionary design solution. Many case studies quote weight saving or performance improvement in the order of 20%–80%. Topology optimization is traditionally formulated as material distribution problems where a finite element may or may not exist in the specified design domain. This discrete formulation produces a design that is fundamentally linked to the finite element representation and challenges in linking to a CAD or more traditional geometrical representation was a barrier to a wide adoption of topology optimization in the engineering design environment. The recent development of topology optimization uses the level set method which has a continuous geometry representation and together with its flexibility in topological changes, it can naturally integrate conceptual design to manufacturing. Our research group has been developing the level set topology optimization method to raise its maturity. We have also shown that the level set representation of a design eliminates the cumbersome post-processing typically required for manufacturing. The presentation will offer a perspective on the current research and the future trends of level set topology optimization.

H. Alicia Kim
University of Bath, United Kingdom
H.A.Kim@bath.ac.uk

IP3

Power and Challenges of Simplicity

Valuable solutions to difficult problems are often based on surprisingly simple ideas. Why then did it take us so long to discover them? Possible reasons include the lack of the proper abstractions, the obsession with full generality, and the concern that some sub-problems may be insurmountable. We will illustrate this observation using examples from the speakers contributions: 3D GUI techniques for the realtime control of camera [miniCam] and free-form deformations [Twister, Bender]; compact representations for rendering [Vertex Clustering], processing [ECT, SOT, LR, Zipper] or transmitting [Topological Surgery, EdgeBreaker] triangle meshes; efficient algorithms for evaluating and rendering CSG models [Blister, CST, OBL]; effective formulations for constant [Grow&Shrink, Tightening] and variable [Relative Blending] radius rounding; and expressions for optimal in-betweening [Ball Morph] deformations or interpolating motions [Steady Affine Morph] defined by control shapes or affine transformations.

Jarek Rossignac
Georgia Institute of Technology
jarek@cc.gatech.edu

IP4

Engineering Through Abstractions

Abstractions determine to a large extent how we relate to physical world, guiding the way we perceive, imagine, communicate, design and manufacture. In the context of computer-aided engineering, abstractions are formal models of physical artifacts, processes, and systems that give precise meaning to computer representations and algorithms. Familiar examples of abstractions in solid modeling include r-sets, orientable manifolds, constraint graphs, sweeps, and Euler operators. Recent emphasis on model-based engineering requires understanding, extending, and reconciling abstractions that include logical models to describe system's structure, various graph models to represent discrete and continuous behaviors, finite element models to simulate spatially distributed phenomena, and yet to be agreed upon models for materials, functions, and systems. The future of model-based engineering hinges on the ability to support the ever increasing diversity of abstractions in a systematic and computationally efficient manner. I will illustrate these challenges by specific examples and will propose some basic principles for addressing them.

Vadim Shapiro
University of Wisconsin - Madison
vshapiro@engr.wisc.edu

IP5

When Solid Modeling Stopped Being Solid: Custom Materials and Additive Processes

New fabrication processes and materials are being developed that enable products to be conceived that are well beyond anyones imagination. However, current authoring tools and design processes are not equipped to exploit these capabilities. This talk will discuss some of the short comings with the current modeling technologies and provide the motivation for the development of a new set of foundations to fully exploit the possibilities of novel fabrication processes, such as 3D printing, and materials, including carbon fiber composites.

Jan H. Vandenbrande
DARPA
jan.h.vandenbrande@gmail.com

IP6

C^1 Isogeometric Spaces on Multipatch Geometries

One key features of isogeometric analysis is the possibility of smooth shape functions. Within each patch, smoothness up to C^{p-1} continuity is naturally achieved by p-degree splines and NURBS. However, global continuity beyond C^0 on so-called multipatch geometries poses some significant difficulties. We consider a multi-patch parametrization having G^1 continuity at the patch interfaces, and we study the behaviour of C^1 continuous isogeometric spaces under h-refinement. In general, these spaces have suboptimal approximation properties. The reason is that the C^1 continuity condition easily overconstrains the space that, in some cases, is in fact fully *locked* to zero at the patch interface. Optimal convergence is achieved under specific conditions on the geometry parametrization and spline regularity. We develop a mathematical framework and perform numerical tests, with the aim of understanding the possibilities and the rules to follow when constructing C^1 isogeometric aproximations over complex geometries. This work is in collaboration with Annabelle Collin and Thomas Takacs from the University of Pavia.

Giancarlo Sangalli
Dipartimento di Matematica
Unversita' di Pavia, Italy
giancarlo.sangalli@unipv.it

CP0

Analytic Methods for Geometric Modeling Via Spherical Decomposition

We propose a new paradigm for more efficient computation of analytic correlations that relies on a grid-free discretization of arbitrary shapes as countable unions of balls, in turn described as sublevel sets of summations of smooth radial kernels at adaptively sampled knots. Using a simple geometric lifting trick, we interpret this combination as a convolution of an impulsive skeletal density and primitive kernels with conical support, which faithfully embeds into the convolution formulation of interactions across different objects. We provide example applications in formulating holonomic collision constraints, shape complementarity metrics, and morphological operations, unified within a single analytic framework.

Morad Behandish
University of Connecticut Storrs
morad@engineer.uconn.edu

Horea T. Ilies
University of Connecticut
ilies@engr.uconn.edu

CP0

Solving the Initial Value Problem of Discrete Geodesics

Existing discrete geodesic algorithms are mainly designed for solving the boundary value problem, i.e., finding the shortest path between two given points. However, the *shortest* geodesic paths do not simulate properties of geodesics on smooth surface, for example, the *shortest* geodesic paths neither define the discrete geodesic curvature nor the parallel transport of vector fields. When a *shortest* geodesic path through a saddle vertex, it does not provide a unique solution on triangle meshes.In this paper, we focus on the initial value problem, i.e., finding a uniquely determined geodesic path from a given point in any direction. We proposed a first-order tangent ODE method for solving the initial value problem. We construct piecewise G^1 smooth surface and solve the tangent ODE in a Runge-Kutta way. The final result is obtained by projecting the path on piecewise smooth surface to the underlying mesh. Our method is different from the conventional methods of directly solving the geodesic equation (i.e., a second-order ODE of the position) on piecewise smooth surfaces, which is difficult to implement due to complicated representation of the geodesic equation involving Christoffel symbols.

Peng Cheng
Nanyang Technological University Singapore
clearbunny@gmail.com

Chunyan Miao
Nanyang Technological University
ascymiao@ntu.edu.sg

Yong-Jin Liu
Tsinghua University
Beijing,China
liuyongjin@tsinghua.edu.cn

Changhe Tu
Shandong University
Jinan, China
chtu@sdu.edu.cn

Ying He
Nanyang Technological University
yhe@ntu.edu.sg

CP0

An Improved Star Test for Implicit Polynomial Objects

For a given point set, a particular point is called a star if it can see all the boundary points of the set. The star test determines whether a candidate point is a star for a given set. It is a key component of some topology computing algorithms such as Connected components via Interval Analysis (CIA), Homotopy type via Interval Analysis (HIA), etc. Those algorithms decompose the input object using axis-aligned boxes, so that each box is either not intersecting or intersecting with the object and in this later case its center is a star point of the intersection. Graphs or simplicial complexes describing the topology of the objects can be obtained by connecting these star points following different rules.

Lincong Fang
Hangzhou
lincongfang@gmail.com

Dominique Michelucci
Laboratoire LE2i
Université de Bourgogne, France
dmichel@u-bourgogne.fr

Sebti Foufou
Qatar University
Sebti.Foufou@u-bourgogne.fr

CP0

Re-parameterization Reduces Irreducible Geometric Constraint Systems

You recklessly told your boss that solving a non-linear system of size n (n unknowns and n equations) requires a time proportional to n, as you were not very attentive during algorithmic complexity lectures. So now, you have only one night to solve a problem of big size (e.g., 1000 equations/unknowns), otherwise you will be fired in the next morning. The system is well-constrained and structurally irreducible: it doesn't contain any strictly smaller well-constrained subsystems. Its size is big, so the Newton-Raphson method is too slow and impractical. The most frustrating thing is that if you knew the values of a small number $k \ll n$ of key unknowns, then the system would be reducible to small square subsystems and easily solved. You wonder if it would be possible to exploit this reducibility, even without knowing the values of these few key unknowns. This article shows that it is indeed possible. This is done at the lowest level, at the linear algebra routines level, so that numerous solvers (Newton-Raphson, homotopy, and also p-adic methods relying on Hensel lifting) widely involved in geometric constraint solving and CAD applications can benefit from this decomposition with minor modifications. For instance, with $k \ll n$ key unknowns, the cost of a Newton iteration becomes $O(kn^2)$ instead of $O(n^3)$. Several experiments showing a significant performance gain of our re-parameterization technique are reported in this paper to consolidate our theoretical findings and to motivate its practical usage for bigger systems.

Hichem Barki
Qatar University
hbarki@qu.edu.qa

Lincong Fang
Hangzhou
lincongfang@gmail.com

Dominique Michelucci
Laboratoire LE2i
Université de Bourgogne, France
dmichel@u-bourgogne.fr

Sebti Foufou
Qatar University
Sebti.Foufou@u-bourgogne.fr

CP0

A Total Order-Based Convex Hull Algorithm for Points in the Plane

Computing the convex hull of a set of points is a fundamental operation in many research fields, including geometric computing, computer graphics, computer vision, robotics, and so forth. This problem is particularly challenging when the number of points goes beyond some millions. In this article, we describe a very fast algorithm that copes with millions of points in a short period of time without using any kind of parallel computing. This has been made possible because the algorithm reduces to a sorting problem of the input point set, what dramatically minimizes the geometric computations (e.g., angles, distances, and so forth) that are typical in other algorithms. When compared with popular convex hull algorithms (namely, Graham's scan, Andrew's monotone chain, Jarvis' gift wrapping, Chan's, and Quickhull), our algorithm is capable of generating the convex hull of a point set in the plane much faster than those five algorithms without penalties in memory space.

Abel Gomes
Universidade da Beira Interior Covilhã
agomes@di.ubi.pt

CP0

Efficient Data-Parallel Tree-Traversal for Blob-Trees

The hierarchical implicit modelling paradigm, as exemplified by the BlobTree, makes it possible to support not only Boolean operations and affine transformations, but also various forms of blending and space warping. Typically, the resulting solid is converted to a boundary representation, a triangle mesh approximation, for rendering. These triangles are obtained by evaluating the corresponding implicit function (field) at the samples of a dense regular three-dimensional grid and by performing a local iso-surface extraction at each voxel. The performance bottleneck of this rendering process lies in the cost of the tree traversal (which typically must be executed hundreds of millions of times) and in the cost of applying the inverses of the space transformations associated with some of the nodes of the tree to the grid samples. Tree pruning is commonly used to reduce the number of samples for which the field value must be computed. Here, we propose a complementary strategy, which reduces the costs of both the traversal and of applying the inverses of the blending and warping transformations that are associated with each evaluation. Without blending or warping, a BlobTree can be reduced to a CSG tree only containing Boolean nodes and affine transformations, which can be reordered to increase memory coherence. Furthermore, the cumulative effects of the affine transformations can be precomputed via matrix multiplication. We propose extensions of these techniques from CSG trees to the fully general BlobTrees. These extensions are based on tree reordering, bottom-up traversal, and caching of the combined matrix for uninterrupted runs of affine transformations in the BlobTree. We show that these new techniques result in an order of magnitude performance improvement for rendering large BlobTrees on modern Single Program Multiple Data (SPMD) devices.

Herbert Grasberger, Jean-Luc Duprat, Brian Wyvill, Paul Lalonde
University of Victoria
herbert@grasberger.org, jld@acm.org, blob@cs.uvic.ca, n/a

Jarek Rossignac
Georgia Institute of Technology
jarek@cc.gatech.edu

CP0

Consistent Quadrangulation for Shape Collections Via Feature Line Co-Extraction

This paper presents a method that takes as input a collection of 3D surface shapes, and produces a consistent and individually feature preserving quadrangulation of each shape. By exploring the correspondence between shapes within a collection, we coherently extract a set of representative feature lines as the key characteristics for the given shapes. Then we compute a smooth cross-field interpolating sparsely distributed directional constraints induced from the feature lines and apply the mixed-integer quadrangulation to generate the quad meshes. With the aim of aligning the quad-meshing results in a common parametric domain, we develop a greedy algorithm to extract aligned cut graphs across the shape collection.

Ying He, Min Meng

Nanyang Technological University
yhe@ntu.edu.sg, mengmin1985@gmail.com

CP0

Precise Contact Motion Planning for Deformable Planar Curved Shapes

We present a precise contact motion planning algorithm for a deformable robot in a planar environment with stationary obstacles.

Yong-Joon Kim
Technion
kyj24182@gmail.com

Gershon Elber
Technion, Haifa
Israel
gershon@cs.technion.ac.il

Myung-Soo Kim
Seoul National University
mskim.at.snu.ac.kr@gmail.com

CP0

Effective Contact Measures

Contact area is an important geometric measurement in many physical systems. It is also difficult to compute due to its extreme sensitivity to infinitesimal perturbations. In this paper, we propose a new concept called an effective contact measure, which acts as a smooth version of contact area. Effective contact measures incorporate a notion of scale into the definition of contact area, allowing one to consider the degree of contact at different sizes. We show how effective contact measures can yield useful statistics for a number of applications, including analysis of multiphase materials and docking/alignment problems.

Mikola Lysenko, Vadim Shapiro
University of Wisconsin - Madison
mikolalysenko@gmail.com, vshapiro@engr.wisc.edu

CP0

Automatic Generation of Lego Building Instructions from Multiple Photographic Images of Real Objects

We introduce a system to reconstruct large scale LEGO models from multiple two dimensional images of objects taken from different views. We employ a unit voxel with an edge length ratio of 5:5:6 for the shape from silhouette method that reconstructs an octree voxel-based three dimensional model with color information from images. We then convert the resulting voxel model with color information into a LEGO sculpture. In order to minimize the number of LEGO bricks, we use a stochastic global optimization method, simulated annealing, to hollow the model as much as possible but keep its strength for portability. Several real complex LEGO models are provided to demonstrate the effectiveness of the proposed method.

Takashi Maekawa, Takuya Kozaki, Hiroshi Tadenuma
Yokohama National University
maekawa@ynu.ac.jp, kozaki-takuya-vc@ynu.jp, tadenuma-hiroshi-mb@ynu.jp

CP0

Isogeometric Segmentation: Construction of Auxiliary Curves

In the context of segmenting a boundary represented solid into topological hexahedra suitable for isogeometric analysis, it is often necessary to split an existing face by constructing auxiliary curves. We consider solids represented as a collection of trimmed spline surfaces, and design a curve which can split the domain of a trimmed surface into two pieces satisfying the following criteria: the curve must not intersect the boundary of the original domain, it must not intersect itself, the two resulting pieces should have good shape, and the endpoints and the tangents of the curve at the endpoints must be equal to specified values.

Dang-Manh Nguyen
Johannes Kepler University
manh.dang_nguyen@jku.at

Michael Pauley
Johannes Kepler University Linz
michael.pauley@jku.at

Bert Juettler
Johannes Kepler University of Linz
Institute of Applied Geometry
bert.juettler@jku.at

CP0

Generalizing Bicubic Splines for Modelling and Iga with Irregular Layout

Quad meshes can be interpreted as tensor-product spline control meshes as long as they form a regular grid, locally. We present a new option for complementing bi-3 splines by bi-4 splines near irregularities in the mesh layout, where less or more than four quadrilaterals join. These new generalized surface and IGA (isogeometric analysis) elements have as their degrees of freedom the vertices of the irregular quad mesh. From a geometric design point of view, the new construction distinguishes itself from earlier work by a notably better distribution of highlight lines. From the IGA point of view, increased smoothness and reproduction at the irregular point yield fast convergence.

Jörg Peters
University of Florida
Dept of CISE
jorg@cise.ufl.edu

Kestutis Karciauskas
Vilnius University
Kestutis.Karciauskas@mif.vu.lt

Thien T. Nguyen
Missing affiliation
tuanthienbk@gmail.com

CP0

A Statistical Atlas Based Approach to Automated Subject-Specific Fe Modeling

Subject-specific modeling is increasingly important in biomechanics simulation. However, how to automatically create high-quality finite element (FE) mesh, and how to automatically impose boundary condition are challenging. This paper presents a statistical atlas based approach for automatic meshing of subject-specific shapes and automatic transferring of boundary conditions onto the resulting meshes. In our approach, shape variations among a shape population are explicitly modeled and the correspondence between a given subject-specific shape and the statistical atlas is sought within the "legal" shape variations.

Xiaoping Qian, Xilu Wang
Department of Mechanical Engineering
University of Wisconsin-Madison
qian@engr.wisc.edu, xwang666@wisc.edu

CP0

Average Curve of N Smooth Planar Curves

We define the Average Curve(AC) of a compatible set of two or more smooth and planar, Jordan curves. It is independent of their order and representation. We compare two variants: the valley AC(vAC), defined in terms of the valley of the field that sums the squared distances to the input curves, and the zero AC(zAC), defined as the zero set of the field that sums the signed distances to the input curves. Our formulation provides an orthogonal projection homeomorphism from the AC to each input curve. We use it to define compatibility. We propose a fast tracing algorithm for computing a polygonal approximation (PAC) of the AC and for testing compatibility.

Mukul Sati, Jarek Rossignac
Georgia Institute of Technology
mukul@gatech.edu, jarek@cc.gatech.edu

Raimund Seidel
n/a
n/a

Brian Wyvill
University of Victoria
blob@cs.uvic.ca

Suraj Musuvathy
University of Utah
srm@cs.utah.edu

CP0

Surgem: A Solid Modeling Tool for Planning and Optimizing Pediatric Heart Surgeriem

Approximately 1% of children are born with a moderate to severe congenital heart defect, and half of them undergo one or more surgeries to fix it. SURGEM, a solid modeling environment, is used to improve surgical outcome by allowing the surgeon to design the geometry for several possible surgical options before the operation and to evaluate their relative merits using computational fluid simulation. We describe here the solid modeling and graphical user interface challenges that we have encountered while developing support for three surgeries: (1) repair of double-outlet right ventricle, which adds a graft wall within the cardiac chambers to split the solid model of the unique ventricle, (2) the Fontan procedure, which routes a graft tube to connect the inferior vena cava to the pulmonary arteries, and (3) stenosis repair, which adds a stent to expand a constricted artery.

Mukul Sati, Mark Luffel, Jarek Rossignac
Georgia Institute of Technology
mukul@gatech.edu, markluffel@gatech.edu,
jarek@cc.gatech.edu

Ajit P. Yoganathan
Department of Biomedical Engineering
Georgia Institute of Technology
ajit.yoganathan@bme.gatech.edu

Christopher Haggerty, Maria Restrepo, Timothy Slesnick, Kirk Kanter, Pedro del Nido, Mark Fogel
n/a
n/a, n/a, n/a, n/a, n/a, n/a

CP0

Statistical Geometric Computation on Tolerances for Dimensioning

Dimensions are used to specify the distances between different features in geometric models. These dimensions will often be expressed as a range of allowable dimensions. When considering a group of toleranced dimensions, these ranges can be analyzed as either a worst-case bound on allowable ranges, or as a statistical measure of expected distribution. This paper presents a new geometric model for representing statistically-based tolerance regions. Methods for tolerance estimation and allocation on a geometric model are provided by generalizing root sum square (RSS) methods for compositing and cascading over tolerance zones. This gives us a geometric interpretation of a statistical analysis. Tolerance regions are determined by probabilities of variations of dimensions falling into the region. A dependency graph over dimensions can be represented by a topological graph on which the tolerance cascading and tolerance allocation can be processed.

Songgang Xu, John Keyser
Texas A&M University
sxu@tamu.edu, keyser@cs.tamu.edu

CP0

Secondary Laplace Operator and Generalized Giaquinta-Hildebrandt Operator with Applications on Surface Segmentation and Smoothing

Various geometric operators have been playing an important role in surface processing. For example, many shape analysis algorithms have been developed based on eigenfunctions of the Laplace-Beltrami operator (LBO), which is defined based on the first fundamental form of the surface. In this paper, we introduce two new geometric operators based on the second fundamental form of the surface, namely the secondary Laplace operator (SLO) and generalized Giaquinta-Hildebrandt operator (GGHO). Surface features such as concave creases/regions and convex ridges can be captured by eigenfunctions of the SLO, which can be used in surface segmentation with concave and convex features detected. Moreover, a new geometric flow method is developed based on the GGHO, providing an effective tool for sharp feature-preserving surface smoothing.

Jessica Zhang
Department of Mechanical Engineering
Carnegie Mellon University
jessicaz@andrew.cmu.edu

Xinge Li
Chinese Academy of Sciences
lixinge@lsec.cc.ac.cn

Guoliang Xu
Academia Sinica
Beijing, China
xuguo@lsec.cc.ac.cn

Tao Liao
Carnegie Mellon University
taoliao@andrew.cmu.edu

CP0

Efficient Global Penetration Depth Computation for Articulated Models

We present an algorithm for computing the global penetration depth between an articulated model and an obstacle or between the distinctive links of an articulated model. In so doing, we use a formulation of penetration depth derived in configuration space. We first compute an approximation of the boundary of the obstacle regions using a support vector machine in a learning stage. Then, we employ a nearest neighbor search to perform a runtime query for penetration depth. The computational complexity of the runtime query depends on the number of support vectors, and its computational time varies from 0.03 to 3 milliseconds in our benchmarks. We can guarantee that the configuration realizing the penetration depth is penetration free, and the algorithm can handle general articulated models. We tested our algorithm in robot motion planning and grasping simulations using many high degree of freedom (DOF) articulated models. Our algorithm is the first to efficiently compute global penetration depth for high-DOF articulated models.

Hao Tian, Xinyu Zhang, Changbo Wang
East China Normal University
nicktian.ecnu@gmail.com, xyzhang@sei.ecnu.edu.cn, cbwang@sei.ecnu.edu.cn

Jia Pan
Hongkong University
jpan@cs.hku.hk

Dinesh Manocha
University of North Carolina, Chapel Hill
dm@cs.unc.edu

CP0

Geometric Characteristics of a Class of Cubic Curves with Rational Offsets

Planar Bezier curves that have rationally parameterized offsets can be classified into two classes. The first class is composed of curves that have Pythagorean hodographs (PH) and the second class is composed of curves that do not have PHs but can have rational PHs after reparameterization by a fractional quadratic transformation. This paper reveals a geometric characterization for all properly-parameterized cubic Bezier curves in the second class. The characterization is given in terms of Bezier control polygon geometry. Based on the derived conditions, we also present a simple geometric construction of G^1 Hermite interpolation using such Bezier curves. The construction results in a one parameter family of curves if a solution exists. We further prove that there exists a unique value of the parameter which minimizes the integral of the squared norm of the second order derivative of the curves.

Jianmin Zheng
Nanyang Technological University
asjmzheng@ntu.edu.sg

Xing-jiang Lu, Yiyu Cai, Gang Zhao
n/a
n/a, n/a, n/a

CP1

Peicewise Bézier Surfaces over Unstructured Quadrilateral Meshes

Given polynomials of order n and the corresponding Bézier tensor product patches over an unstructured quadrilateral mesh with vertices of any valence, find a solution to the $G^1$1 or $C^1$1 approximation (resp. interpolation) problem and the corresponding minimal determining set. We show that there is always a solution for $n \geq 5$ and under some restrictions for $n = 4$. Domains with cubic boundary curve are considered. Application to approximation or PDE solutions are given.

Michel Bercovier
Hebrew University
School of Computer Science and Engineering
berco@cs.huji.ac.il

CP1

Support Vector Machines for Knot Placement in B-Spline Surface Approximation

We present an algorithm to place the knots for B-spline surface approximation based on a machine-learning approach. A pre-trained support vector machine (SVM) is used to compute an optimal knot-vectors with respect to the surface shape. This SVM is then used to improve the averaging technique by Piegl and Tiller [Piegl, Les A., and Wayne Tiller. "Surface approximation to scanned data." The visual computer 16.7 (2000): 386-395.]. Experimental results show the performance of our algorithm for the approximation of B-Spline surfaces.

Pascal Laube
Institute for Optical Systems
Konstanz University of Applied Sciences
plaube@htwg-konstanz.de

Georg Umlauf
HTWG Konstanz
umlauf@htwg-konstanz.de

CP1

Stable Simplex Spline Bases for C3 Quintics on the Powell-Sabin 12-Split

For the C^3 quintics on the Powell-Sabin 12-split of a triangle, we determine explicitly the six symmetric simplex spline bases that reduce to a B-spline basis on each edge, have a positive partition of unity, a Marsden identity that splits into real linear factors, and an intuitive domain mesh. The bases are stable in the L_∞ norm, have a quasi-interpolant with approximation order 6, and other B-spline-like properties.

Georg Muntingh
SINTEF
georg.muntingh@sintef.no

Tom Lyche
University of Oslo

tom@math.uio.no

CP1

Slices of 3D Surfaces on the Web Using Tensor Product B-Spline Grids

The generation of cutting planes, or slices of function surfaces, is the most unique feature available to users accessing the 3D visualizations in the NIST Digital Library of Mathematical Functions (DLMF). While the feature was difficult to implement and the source of many portability problems, the use of structured tensor product grid generation techniques helped us create code capable of handling complicated multi-connected function domains. We discuss the work and show DLMF examples.

Bonita V. Saunders
National Institute of Standards and Technology (NIST)
bonita.saunders@nist.gov

CP1

Curves with Quadratic Logarithmic Curvature Graphs

In this talk, we propose a new kind of curves which are curves with quadratic logarithmic curvature graphs (QLCG curves). The QLCG curves can be derived by extending log-aesthetic curves[Yoshida & Saito, Interactive Aesthetic Curve Segments, Visual Computer, 2006], which are curves with linear logarithmic curvature graphs (LCGs). To formulate QLCG curves, we add the second degree coefficient γ in the LCG, where curves with $\gamma = 0$ are log-aesthetic curves. We provide equations for drawing the curves and analyze the fundamental characteristics. In comparison with log-aesthetic curves, the proposed curves have following advantages: additional parameter γ for controlling the curve and curves with $\gamma < 0$ have finite arc lengths, and points with 0 and infinite curvature without depending on other parameters.

Norimasa Yoshida
Nihon University
norimasa@acm.org

Takafumi Saito
Tokyo University of Agriculture and Technology
txsaito@cc.tuat.ac.jp

CP1

Truncated B-Splines for Non-Nested Refinement

Various approaches to extend the construction of tensor-product splines have been introduced in order to allow for adaptive refinement in modeling and/or simulations. Our framework is based on truncated hierarchical (TH)B–splines due to their good mathematical properties. We generalize THB–splines in order to allow for using non-nested spline spaces to represent different parts of the model. In particular, we show how to define a spline basis that forms a non-negative partition of unity.

Urska Zore
Johannes Kepler University, Linz
Institute for Applied Geometry
urska.zore@jku.at

Bert Juettler
Johannes Kepler University of Linz
Institute of Applied Geometry
bert.juettler@jku.at

CP2

IgA-Based Solver for Turbulence Modelling on Multipatch Geometries

In this talk, we focus on turbulence modelling with the help of isogeometric analysis based on NURBS objects. We implemented a solver for Reynolds-Averaged Navier-Stokes equations complemented by k-ω model. The solver is intended to run on complex geometries, which cannot be described by one NURBS object. Thus, it is necessary to consider multipatch NURBS domains, which are handled by discontinuous Galerkin method in our solver. The results will be demonstrated on standard benchmark problems.

Bohumir Bastl, Marek Brandner, Jiri Egermaier, Kristyna Michalkova, Eva Turnerova
University of West Bohemia, Faculty of Applied Sciences, New Technologies for the Information Society
bastl@kma.zcu.cz, brandner@kma.zcu.cz, jirieggy@kma.zcu.cz, kslaba@kma.zcu.cz, turnerov@kma.zcu.cz

CP2

Nurbs Models and Volumetric Parameterizations of Water Turbines

In this talk, we focus on creation of parametric geometric models of different water turbines and their volumetric parameterizations based on NURBS objects which are commonly used in current CAD/CAM systems. Such models can be used for the consequent computations based on isogeometric analysis (IGA), especially for flow modelling in our case. Combination of IGA-based simulations with high-quality parametric geometric models can serve as a common base for (semi-)automatic shape optimization methods for water turbines.

Kristyna Michalkova, Bohumir Bastl
University of West Bohemia, Faculty of Applied Sciences, New Technologies for the Information Society
kslaba@kma.zcu.cz, bastl@kma.zcu.cz

CP2

A New One-Sided Spline Filter for Discontinuous Galerkin Solutions on Domains with Boundary

Post-convolving the output of Discontinuous Galerkin computations with symmetric spline filters is known to improve both smoothness and accuracy – except near domain boundaries. To obtain solutions whose accuracy near the boundary is as good as in the interior, we leverage recently-developed one-sided filters with multiple knots to increase the dimension of the filter's spline space but not its support. We present simple explicit formulas for the filter coefficients.

Dang Manh Nguyen
Department of Computer & Information Science and Engineering
University of Florida
dmnguyen@cise.ufl.edu

Jorg Peters
University of Florida

jorg@cise.ufl.edu

CP2

Steady-State and Dynamical Radially-Symmetric Solutions of 2D Nonlinear Viscoelasticity

We treat the initial-boundary-value problems for the radial motions of nonlinearly viscoelastic annular plates and spherical shells of strain-rate type, which are described by the geometrically exact 2D theory. The governing equation is a second-order quasilinear parabolic-hyperbolic PDE in one space variable. In the first part of our work, we study the steady-state solutions of our problem by employing several mathematical tools, each of which has different strengths and weaknesses for handling intrinsic diffculties in the mechanics. In the second part, we study the dynamical solutions of our problem. We first introduce a set of constitutive hypotheses which ensure that solutions are unique, exist for all time, and depend continuously on the data. We then exhibit alternative conditions on the constitutive functions and on the boundary terms ensuring that there are globally defined unbounded solutions and there are solutions that blow up in finite time.

Alexey Stepanov
University of Maryland
alex314@umd.edu

CP2

Adaptively Weighted Numerical Integration in the Finite Cell Method

In this talk, we will demonstrate the application of our newly developed integration scheme called the Adaptively Weighted (AW) numerical integration scheme in the context of the Finite Cell Method which must perform numerical integration over arbitrary domains without meshing. Unlike traditional approaches to integration, in AW scheme, the quadrature weights directly adapt to the complex geometric domain. We demonstrate the computational efficiency of AW over traditional adaptive integration schemes in two and three dimensions.

Vaidyanathan Thiagarajan
Spatial Automation Laboratory
University of Wisconsin Madison
vthiagarajan@wisc.edu

Vadim Shapiro
University of Wisconsin - Madison
vshapiro@engr.wisc.edu

CP3

2D Packing of Large Size Non-Rectangular Quad Items into Smaller Size Polygonal Bins

A greedy technique for packing of large size non-rectangular items into smaller size polygonal bins is outlined. Several quad regions (packable regions) are produced from polygonal bins. Packed items can be larger than packable regions some of whose portions can exceed the bin. After substraction of the packed item from the packable region, polygonal shapes can be formed. Split algorithm decomposes such shapes into quad items each of which will be processed independently during packing.

Erkan Gunpinar
Istanbul Technical University
gunpinar@itu.edu.tr

CP3

Reconstruction and Design of Functionally Graded Material Structures

We propose to represent and control material properties of FGM using the notion of material descriptors which include common geometric, statistical, and topological measures. In particular, Minkowski functionals are widely believed to correlate with mechanical properties of many materials, including bone. Building on ideas from texture synthesis, we formulate the problem of design and (re)construction of FGM structure as a process of selecting neighborhoods from an FGM exemplar, based on target material descriptor fields. We identify the necessary conditions on the target descriptor field to be compatible with the exemplar, and discuss how this conditions can be verified and enforced. The effectiveness of the proposed method in generating a smooth and continuously varying structure of FGM with guaranteed properties is demonstrated by two examples: bone structure reconstruction and design of a functionally graded bone structure.

Xingchen Liu, Vadim Shapiro
University of Wisconsin Madison
xingchen@wisc.edu, vadim.shapiro@gmail.com

CP3

Interpolation and Shape Preserving Design with Hyperbolic Spaces

In this paper we focus on hyperbolic spaces generated by algebraic polynomials, the hyperbolic sine and cosine. The analysis of these spaces leads to constructions that can be reduced to Hermite interpolation problems. We present classical interpolation formulae, such as Newton and Aitken-Neville formulae and a suggestion of implementation. We also express the Hermite interpolant in terms of polynomial interpolants and derive practical error bounds. Applications to shape preserving curve design are also shown.

Jess M. Carnicer, Esmeralda Mainar, Juan Manuel Peña
Universidad de Zaragoza
carnicer@unizar.es, esmemain@unizar.es, jmpena@unizar.es

CP3

On Developable Surfaces in Dental Imaging

We report on recent work on the use of developable splines in the context of exploration of medical volumes. Ruled developable patches over Bzier curves have been introduced by Aumann in 2003 and later extended to B-splines by Fernndez-Jambrina. We consider G1 splines constructed over Catmull-Rom splines of degree three and cone splines over circle splines and compare both techniques. We also look at the planar isometric unfoldings of both types of splines.

Marco Paluszny
Universidad Nacional de Colombia, Sede Medellin
marcopaluszny@gmail.com

Cindy Gónzalez
Universite de Valenciennes

cygonzal@gmail.com

CP3

A Parallel Hash Map for Level-of-Detail-Aware Depth-Map Fusion

We introduce a real-time, memory-efficient method for depth-map fusion and LOD-aware spatial data storage. Image-space reconstruction methods result in a set of view-dependent depth-maps. So, an additional depth-map fusion mechanism in combination with a spatial data storage scheme is used to assemble and store the models. Our approach guarantees memory efficiency by using a hash map approach that can distinguish different data LOD depending on the data resolution of the input depth-maps. It is better suited for modern GPU than tree-based data structures and allows for efficient iterative data updates. The described depth-map fusion method is optimized for massive parallel processing which enables real-time performance. It is designed for tight interaction with the storage system without inefficient CPU interference. An evaluation of the parallel hash-map and the fusion method demonstrates the benefit of our approach for the depth-map fusion and spatial data storage problem.

Georg Umlauf
HTWG Konstanz
umlauf@htwg-konstanz.de

Markus Friedrich
University of Konstanz, Germany
markus.friedrich@uni-konstanz.de

Bernd Hamann
University of California
Department of Computer Science
hamann@cs.ucdavis.edu

CP4

Crystal Growth Shapes in Bond-Counting Models and Continuum Models

When continuum methods are used to model crystal growth, typically an anisotropic surface energy function is selected. We determine the relationship between a crystal's lattice structure, surface energy, and growth shape. Comparing models, we demonstrate that not all growth shapes seen in continuum models are recreatable in bond-counting models. Specifically, we determine that a 12-armed dendrite as modeled in Haxhimali et al. is not a possible growth shape using a bond-counting model under reasonable parameters.

Tim Krumwiede
University of Tennessee
timwiede@math.utk.edu

CP4

Multi-Resolution Geometrical Models of Mammalian Tissues

Understanding mammalian tissue structure and function requires the quantitative monitoring of cellular processes from the molecular to the tissue scale and consequently a geometrical model of the tissue, i.e. an accurate 3D digital representation of the cells forming the tissue with subcellular resolution. We developed an adjustable pipeline for reconstructing geometrical models of tissues from microscopy images covering multiple scales ($1\mu m \div 1mm$) and applied it to the quantitative analysis of liver, kidney and lung tissue.

Hernán A. Morales-Navarrete, Fabian Segovia-Miranda, Piotr Klukowski, Kirstin Meyer, Marino Zerial
Max-Planck-Institute of Molecular Cell Biology and Genetics
moralesn@mpi-cbg.de, segoviam@mpi-cbg.de, piotr.jakub.klukowski@gmail.com, kmeyer@mpi-cbg.de, zerial@mpi-cbg.de

Yannis Kalaidzidis
Max-Planck-Institute of Molecular Cell Biology and Genetics
Faculty of Bioengineering and Bioinformatics, Moscow State U
kalaidzi@mpi-cbg.de

CP4

Blind Reconstruction of a Single-Source Signal from Its Multi-Reflected Data in a Convex Polygonal Room

A new iterative method for the reconstruction of the original signal from multi-reflected signals is proposed and applied to typical cases where a single-source sound is multi-reflected by the room walls, under the assumption that the locations of observation points are known, while the original signal and the locations of the source point and the room walls are unknown. Fairly good results are obtained for the identification of the original signal and the wall locations.

Hirofumi Sasaki
Undergraduate Student, Department of Mathematics
School of FSE, Waseda University
hsasaki.jpn@gmail.com

Fumio Sasaki
Professor
Tokyo University of Science
fsasaki@rs.kagu.tus.ac.jp

Michio Yamada
Reseach Institute for Mathematical Sciences,
Kyoto University
yamada@kurims.kyoto-u.ac.jp

CP4

Multi-resolution Method for Co-propagating High Intensity Pulses

Laser filamentation is an area of research that provides a unique challenges in applied mathematics, physics, computer science and engineering. In this talk I will describe the (3+1)D model of co-propagating nanosecond and femtosecond pulses in air and present the resolution technique that allows to capture all important effects on different time scales.

Alexey Sukhinin
Southern Methodist University
asukhinin@smu.edu

CP4

Anamorphosis Made Simple; Impossible Objects

Made Possible

We have developed a simple method to create a digital anamorphosis, using a rational FFD (Free-Form Deformation). The key idea is to employ homogeneous coordinates with origin at the viewpoint, and then deform the object with a rational Bézier hyperpatch. In a typical anamorphosis, an object appears distorted unless viewed from a particular viewpoint. However, with a clever design, it is also possible to create geometry that look impossible when viewed from a certain viewpoint.

Javier Sánchez-Reyes, Jesús Miguel Chacón
UCLM
Javier.SanchezReyes@uclm.es, jesus-miguel.chacon@uclm.es

CP4

Tree Representations of Streamline Topologies of Structurally Stable 2D Hamiltonian Vector Fields

We show that the streamline topologies of generic Hamiltonian flows in 2D multiply connected domains are in one-to-one correspondence with rooted, labelled and directed plane trees. We also show that a symbolic expression, called a regular expression, is uniquely assigned to each generic streamline topologies. Computationally, it allows us to convert a complex pattern data of a given streamline topology into a simple symbolic text data easily handled by computers.

Tomoo Yokoyama
Kyoto University of Education
tomoo@kyokyo-u.ac.jp

Takashi Sakajo
Kyoto University
sakajo@math.kyoto-u.ac.jp

MS1

Composite Design Primer

Abstract not available.

Agnes Blom
The Boeing Company
agnes.blom@boeing.com

MS1

Composite Analysis

Abstract not available.

Anoush Poursartip
Univ. of British Columbia
anoush.poursartip@ubc.ca

MS1

Future Vision of Advanced Materials and Processes in Design

Abstract not available.

Jan H. Vandenbrande
DARPA
jan.h.vandenbrande@gmail.com

MS1

Composite Manufacturing

Abstract not available.

Kurtis Willden
Boeing
kurtis.s.willden@boeing.com

MS2

A New Basis for PHT-Splines

In this talk, we propose a new basis consisting of a set of local tensor product B-splines for PHT-splines which overcomes the decay phenomenon of the original basis functions. Some examples are provided for solving numerical PDEs with the new basis, and comparison is made between the new basis and the original basis. Experimental results suggest that the new basis provides better numerical stability in solving numerical PDEs.

Falai Chen
Department of Mathematics
University of Science and Technology of China
chenfl@ustc.edu.cn

Hongmei Kang Kang
University of Science and Technology of China
khm@mail.ustc.edu.cn

Jiansong Deng
Department of Mathematics
University of Science and Technology of China
dengjs@ustc.edu.cn

MS2

Hybrid Volume Completion with Mixed-Order Bézier Elements

A methodology to create a hybrid volumetric representation from a 2-manifold without boundaries represented with untrimmed tensor product B-spline surfaces is presented. Near the boundary are trivariate tensor product B-splines with unstructured mixed-order Bézier tetrahedral elements in the interior of the object set to require C^0 smoothness across their interfaces. Our approach to constructing stiffness and mass matrices C^0 smoothness is automatically maintained when performing computer graphics simulations, representing material properties, or performing isogeometric analysis

First Suqin Zeng
School of Computing
University of Utah
zengsuqin@gmail.com

Elaine Cohen
University of Utah
cohen@cs.utah.edu

MS2

On Analysis Suitable T-Splines in Any Dimension

Traditionally, T-splines have been constructed from the topology of the control mesh. From this perspective, properties of the spline space are hard to study and to generalize to arbitrary degree and dimension. We follow a similar approach to that of [Dokken et al, Polynomial splines over locally refined box-partitions, 2013] and propose a local refinement rule, that, by construction, maintains all important properties of univariate B-splines, such as local linear independence, partition of unity, etc. Moreover, our approach is independent of the spatial dimension and works for all polynomial degrees.

Rene Hiemstra
ICES
University of Texas at Austin
rene@ices.utexas.edu

MS2

Bézier Projection and Applications

In this talk well describe Bézier projection. Bézier projection is an optimally accurate local projection scheme based on Bézier extraction. The approach can be applied to both T-splines, nonuniform rational B-splines, and their hierarchical extensions. We will discuss various ways the projection scheme can be used in design and analysis. In particular, well discuss its use in local adaptivity, weakly continuous geometry, and higher-order accurate explicit structural dynamics.

Michael Scott
Civil and Environmental Engineering
Brigham Young University
michael.scott@byu.edu

MS3

Fast, Approximate and Scalable Geometric Optimization (Big Data and High Dimensional Spaces)

Geometric optimization is used to solve a variety of image, model matching, selection and ranking problems (e.g. deformable shape similarity, drug screening, assembly prediction) . The optimization functionals are multi-Dim correlation integrals while the search space is the high-Dim product of deformable transformations. In this talk I shall consider methods to combat the curse of high dimensionality via the JL lemma, and also achieve accuracy-speed tradeoffs for Big data using low-discrepancy samplings and non-uniform FFT.

Chandrajt Bajaj
The University of Texas at Austin
Department of Computer Science
bajaj@cs.utexas.edu

MS3

Modelling Geometrical Big Data Using Locally Refined B-Splines

LRB-spline approximation can be considered the geometrical equivalent of jpeg compression, with a high compression rate in smooth areas. Its approximation of point clouds gives a good rate of compression for surfaces, and we expect the compression to be even more significant for approximations of volumes and higher-dimensional data. In this presentation we present results from the EU-funded projects VELaSSCo and IQmulus, using LRB-splines to model big data, e.g., terrain and simulation datasets from Particle Element Methods.

Heidi E. I. Dahl
SINTEF ICT
Department of Applied Mathematics
heidi.dahl@sintef.no

MS3

Synchronous Visual Analytics on Petabytes of Molecular Simulations-Topology, Geometry and Numerics

We present the integration of topological and numeric algorithms for synchronous visualization of the petabyte output from high performance computing molecular simulations. Techniques are invoked from knot theory for timely warning of potential self-intersections. These self-intersections are of interest to the domain scientists. The topological methods provide performance and reliability advantages over purely geometric techniques for the dynamic visualizations produced.

Thomas J. Peters
University of Connecticut
tpeters@engr.uconn.edu

Kirk E. Jordan
IBM T.J. Watson Research
kjordan@us.ibm.com

Hugh Cassidy, Ji Li
LeanTaaS Inc.
hugh.p.cassidy@gmail.com, hamlet.j@gmail.com

Kevin Marinelli
University of Connecticut
kevin.marinelli@uconn.edu

MS3

Geometric Processing in Statistical Shape Modeling

In this presentation, we present the workflow of geometric processing procedures toward statistical modeling and analysis of biomedical shapes across a population. The input is a collection of CT images or discrete 3D models from a set of subjects. We seek a statistical description of shape variation across the population that can be useful for statistical inference. A B-spline based direct diffeomorphic reparameterization technique for improving shape correspondence across the population will be presented.

Xilu Wang, Yunyang Xiong
Department of Mechanical Engineering
University of Wisconsin-Madison
xwang666@wisc.edu, yxiong43@wisc.edu

Kang Li
Illinois Institute of Technology
kli@iit.edu

Xiaoping Qian
Department of Mechanical Engineering
University of Wisconsin-Madison
qian@engr.wisc.edu

MS4

Issues and Experiences Implementing Cloud-based

CAD

Our company supplies a solid modeling kernel to customers who produce various types of CAD systems, and those CAD system developers are doing some interesting forward-looking development. I will discuss the activities of one customer who is putting their CAD system on the "cloud" - they are obviously not the only ones doing this, but their experiences and requirements are interesting. They have designed a protocol to communicate in a simple manner between server and client. They are also working on enhancing their GPU parallelization, which allows tessellation to be done locally on the client, greatly reducing the amount of data that must be transferred.

Bil Denker
Solid Modeling Solutions
bill_denker@yahoo.com

MS4

Design and Simulation in the Cloud

The I4MS initiative http://i4ms.eu/ in EU's Public-Private Partnership for Factories of the Future addresses HPC Cloud services for engineering and manufacturing industries. One of the I4MS-projects, CloudFlow http://www.eu-cloudflow.eu/ addresses solution oriented workflows in the Cloud in three waves of Experiments. The CAxMan project "Computer Aided Technologies for Additive Manufacturing" (2015-2018, in June 2015 in contract negotiations), will use the CloudFlow infrastructure to make workflows for design, simulation, process planning and process simulation for additive manufacturing.

Tor Dokken
SINTEF ICT, Department of Applied Mathematics
Oslo, Norway
tor.dokken@sintef.no

MS4

Scripted Geometry Processing for Manufacturing

Manufacturing process planning frequently requires complex geometric computations to be performed. Milling requires tool path generation while composite tape deposition requires calculation of geodesics and geodesic offsets. Frequently, the calculations required are specific to particular combinations of machine tool, part, and tool tip. Moreover, achieving high performance can lead to complex trajectory optimization problems. This talk presents a general framework for organizing these computations so that they can be scripted in very high-level ways.

Tom A. Grandine
Boeing
thomas.a.grandine@boeing.com

MS4

Pre- and Post- Design - The Future of Geometric Modeling?

As the importance of the digital model spreads throughout PLM the number of representations has become a Tower of Babel. Isogeometric analysis is our version of Esparanto. I will propose an alternative modeling "language" which will allow designers to work in their own dialect but present their model in "English" to the rest of the PLM world. Because these models have huge amounts of data interacting with them efficiently requires blending computer science techniques with geometric insight. I will give both successful and potential examples.

Tim Strotman
Siemens
tim.strotman@siemens.com

MS5

Free Surface Hydrodynamics Using Isogeometric Analysis

The objective of the present work is to develop an efficient and accurate model for gravitational free surface water waves using isogeometric analysis. We consider the discretization of a set of fully nonlinear potential flow equations that can account for dispersive wave propagation and wave-wave interactions in coastal and offshore areas, and take into account varying bathymetry. The model uses a flexible discretization method based on tensor-product NURBS/B- splines for exact representation of geometric structures and smooth approximation of the flow. The model also provides a basis for accurate kinematics calculations that are of relevance to accurate estimation of peak loads in wave-structure interactions. In this talk, we describe the fundamentals of the proposed isogeometric free surface hydrodynamical model, show some preliminary results on analysis of accuracy, and compare these to results obtained using a recently developed state-of-the-art spectral element model using C0 continuous basis functions. The analysis highlights properties and differences of the methodologies.

Jens Gravesen
Technical University of Denmark
Department of Applied Mathematics and Computer Science
jgra@dtu.dk

MS5

Discrete Surface Uniformization, Theory and Algorithms

Surface uniformization theorem plays a fundamental role in surface differential geometry, which states that any Riemannian metric on a closed surface can be conformally deformed to the one with constant Gaussian curvature. In this talk, the uniformization theorem is generalized to the discrete surfaces. The proofs for the existence, uniqueness of the solution will be explained. When the tessellation is refined, the discrete uniformization converges to the smooth solution. The computational algorithms will be explained, and some applications will be demonstrated.

Xianfeng Gu
Stony Brook University
gu@cs.stonybrook.edu

MS5

Isogeometric Analysis for Wave-Body Interaction Problems

This presentation will deliver a critical review of our work in the area of Isogeometric Boundary Element Methods (BEM) for wave-body interaction problems involving 2D/3D bodies (wing, ships) moving underneath or on the free surface of an ideal (inviscid, incompressible and irrotational) liquid. In this context, the performance (e.g., rate of convergence) of in-house developed NURBS- and T-splines-based isogeometric collocated BEM solvers will be illustrated in conjunction with CATIA- and Rhino3D-based parametric modelers for optimization purposes.

Panagiotis Kaklis
University of Strathclyde
panagiotis.kaklis@strath.ac.uk

Alexandros I. Ginnis
National Technical University of Athens
ginnis@naval.ntua.gr

Konstantinos Kostas
Technological Educational Institute of Athens
Department of Naval Architecture
kvkostas@teiath.gr

Costas Politis
Technological Educational Institute of Athens,
cpolitis@teiath.gr

MS5

Hierarchical Spline Quasi-Interpolation

We present a general and simple procedure to construct quasi-interpolants in hierarchical spaces. Such spaces are composed of a hierarchy of nested spaces and provide a flexible framework for local refinement. The proposed hierarchical quasi-interpolants are described in terms of the so-called truncated hierarchical basis. Quasi-interpolants of full approximation order and/or projections can be easily obtained. The main ingredient of the construction is the property of preservation of coefficients of the truncated basis representation.

Hendrik Speleers
Tor Vergata University
speleers@mat.uniroma2.it

MS6

High-Quality Anisotropic Surface Meshing

Abstract not available.

Xiaohu Guo
University of Texas, Dallas
xguo@utdallas.edu

MS6

Computing Intrinsic Delaunay Triangulations on Polyhedral Surfaces

Delaunay triangulation is a fundamental data structure and has tremendous applications in many engineering fields. Although Delaunay triangulations in Euclidean spaces are well studied and understood, computing intrinsic Delaunay triangulations on polyhedral surfaces has received much less attention. In this talk, we will present a new method for constructing IDTs on manifold triangle meshes. Based on the duality of geodesic Voronoi diagrams, our method can guarantee the resultant IDTs are strongly regular. Our method is non-iterative so that its performance is insensitive to the number of non-Delaunay edges. It has a theoretical $O(n^2 \log n)$ time complexity, where n is the number of mesh vertices. Empirically, it runs in linear time $O(n)$ on real-world models.

Yongjin Liu
Tsinghua University
liuyongjin@tsinghua.edu.cn

Ying He
Nanyang Technological University
yhe@ntu.edu.sg

MS6

A Spectral Method for Anisotropic Quad Meshing

Abstract not available.

Wenping Wang
University of Hong Kong
Department of Computer Science
wenping@cs.hku.hk

MS6

Geodesic-Based Shape Descriptors

Abstract not available.

Shi-Qing Xin
Ningbo University
xinshiqing@163.com

MS7

Bounding Volume Hierarchies for Planar Freeform Curves

We present several different ways of generating bounding volumes for planar freeform curves and compare their relative performance in computing time and storage space. In particular, we focus on the curve approximation methods with cubic convergence and the general case where the given planar curves may change their shape dynamically. We also demonstrate the effectiveness of these construction methods using a few test examples of real-time algorithms implemented for planar freeform curves.

Myung-Soo Kim
School of Computer Science and Engineering
Seoul National University, Korea
mskim@snu.ac.kr

MS7

Hierarchical Data Structures for Freeform Geometric Models

Hierarchical data structure is one of the most widely adapted data structures for the distance related computation. Algorithms based on the hierarchical data structure often show significant performance improvement over nave approaches. However, there are only limited numbers of previous works on hierarchical data structures for the freeform NURBS surfaces. In this talk, we discuss technical difficulties in developing hierarchical data structures for NURBS surfaces and introduce several approaches to tackle this problem.

Yong-Joon Kim
Technion
kyj24182@gmail.com

MS7

Covering 2D Domains Using Random Curves

Covering a given $2D$ domain D with a random curve, C,

has, for example, applications in artistic manufacturing/3D printing. D is considered covered if $\forall p \in D,\ dist(p, C) < \epsilon$. Our distance bound approach computes the complete set of local distance extrema. This involves computing bi-normals and circles co-tangent to three points of C, etc. A constructive algorithm is then proposed to iteratively create C for convex domains. Examples will be presented.

Jinesh Machchhar
Technion
jineshmac@cs.technion.ac.il

Gershon Elber
Technion, Haifa
Israel
gershon@cs.technion.ac.il

MS7

Gpu Approaches to Distance Calculations for Freeforms

We compare sample-based approaches that exploit the massive data parallelism of GPUs for accelerating distance calculations for freeforms. We discuss how to calculate accuracy bounds both for parallel numerical iteration and axis-aligned bounding-box hierarchy approaches, dependent on the sampling as well as the curvature of the surfaces. We discuss implementation decisions and tradeoffs, and the advantages and disadvantages of numerical iteration versus parallel hierarchical culling methods. (Joint work with Iddo Hanniel and Adarsh Krishnamurthy.)

Sara McMains
U.C. Berkeley
Mechanical Engineering
mcmains@me.berkeley.edu

MS8

Weighted T-spline and Its Application in Isogeometric Analysis

To facilitate isogeometric analysis, we present weighted T-spline here, which introduces a weighting idea to T-spline basis functions. Weighted T-spline basis functions satisfy partition of unity and are linearly independent. Less geometrical constraint is applied to the T-mesh, and the number of control points can be decreased. Weighted T-splines are applied to reparameterize trimmed NURBS patches and handling extraordinary nodes, demonstrating that it can generate complicate models for isogeometric analysis.

Lei Liu
Department of Mechanical Engineering
Carnegie Mellon Univer
leiliu@andrew.cmu.edu

Yongjie Zhang, Xiaodong Wei
Department of Mechanical Engineering
Carnegie Mellon University
jessicaz@andrew.cmu.edu, xiaodonw@andrew.cmu.edu

MS8

A Numerical Evaluation of Convergence Properties of Unstructured T-splines in Extraordinary Regions for Isogeometric Analysis

T-splines have been widely studied in recent years as one of the important schemes for isogeometric analysis. They possess important properties of local refinements with similar convergence properties to NURBS. This talk presents a numerical evaluation of convergence properties of unstructured T-splines in extraordinary regions for isogeometric analysis. The results are systematically evaluated for a set of standard geometry stencils representing physical domains against a class of scaled target functions representing different underlying field solutions.

Weiyin Ma
Mechanical and Biomedical Engineering
City University of Hong Kong
mewma@cityu.edu.hk

Xiaoyun Yuan, Yue Ma
City University of Hong Kong
xyuan9-c@my.cityu.edu.hk, aaron.ma@my.cityu.edu.hk

Michael Scott
Civil and Environmental Engineering
Brigham Young University
michael.scott@byu.edu

MS8

Splines on Regular Triangulations in Isogeometric Analysis

Bivariate box splines are splines which can be defined on regular triangulations and can be seen as a natural bivariate generalization of univariate B-splines. They can be easily extended to higher dimensions. Therefore, they constitute an intermediate step between tensor product splines and splines on general triangulations, and can provide an interesting tool in IgA. In this talk we discuss some preliminaries about the use of suitable box splines in IgA.

Carla Manni
Department of Mathematics
University of Rome "Tor Vergata"
manni@mat.uniroma2.it

MS8

Iga on Generalized 3-Direction Triangulations

The talk explains isogeometric analysis with C1 elements on 3-direction triangulations enriched by non-6-valent vertices.

Thien T. Nguyen
Missing affiliation
tuanthienbk@gmail.com

MS8

Isogeometric Analysis and Shape Optimization on Triangulations

In this talk, I will present our recent work on isogeometric analysis using rational Triangular Bezier Splines (rTBS). In this approach, both the geometry and the physical field are represented by multivariate splines in Bernstein Bezier form over a triangulation of the domain. Numerical examples for both two-dimensional and three-dimensional problems will be presented. Optimal convergence rates for both C^0 and C^r elements have been obtained. Its application in shape optimization will also be presented.

Xiaoping Qian

Department of Mechanical Engineering
University of Wisconsin-Madison
qian@engr.wisc.edu

MS9

Smooth k-Vector Fields, k-Measures and Their Boundary

I introduce the boundary of (compactly supported) smooth k-vector fields as primary, and define the exterior derivative of differential k-forms via an integral duality. This is nicely consistent with the way in which boundary and coboundary are introduced in algebraic topology and discrete exterior calculus. The notion of boundary of k-vector fields extends naturally to general k-measures. Then, identifying each k-dimensional submanifold with boundary with the corresponding characteristic k-measure reconciles the different notions of boundary.

Antonio DiCarlo
Università Roma Tre
adicarlo@mac.com

MS9

Computing Harmonic Forms

To solve Poisson's equations for differential forms harmonic forms or fields must be computed. These spaces are needed to make Poisson's equation well-posed. For closed manifolds harmonic k-forms space is isomorphic to k-dimensional cohomology. For manifolds with boundary harmonic k-fields space is isomorphic to k-dimensional relative or absolute cohomology. Thus computation of harmonic forms is a very natural area of interaction between topology and physical problems.

Anil Hirani
Department of Mathematics
University of Illinois at Urbana-Champaign, IL, USA
hirani@illinois.edu

Kaushik Kalyanaraman
University of Illinois at Urbana-Champaign
kalyana1@illinois.edu

Han Wang
North Carolina State University
hanwang1@illinois.edu

Seth Watts
University of Illinois at Urbana-Champaign
seth.e.watts@gmail.com

MS9

LAR: a Novel Representation Scheme of Geometric-Topological Data

This talk points out the design goals of Linear Algebraic Representation (LAR), a novel representation of big geometric-topological data, characterized by a large domain, encompassing 2D and 3D meshes, manifold and non manifold geometric and solid models, and high-resolution 3D images. We aim to demonstrate its simplicity and effectiveness. It is being used in disparate applications, including the extraction of models of liver portal system and building modeling for indoor mapping and loT.

Antonio DiCarlo
Università Roma Tre
adicarlo@mac.com

Alberto Paoluzzi
Roma Tre University
apaoluzzi@me.com

Vadim Shapiro
University of Wisconsin Madison
vadim.shapiro@gmail.com

MS9

Compatibility Equations of Nonlinear Elasticity for Non-Simply-Connected Bodies

We discuss the necessary and sufficient compatibility equations of nonlinear elasticity for non-simply-connected bodies when the ambient space is Euclidean. We show that the necessary and sufficient conditions for compatibility of deformation gradient is vanishing of its exterior derivative and all its periods, i.e. its integral over generators of the first homology group of the material manifold. We will show that not every non-null-homotpic path requires supplementary compatibility equations. We then find the necessary and sufficient compatibility conditions for the right Cauchy-Green strain tensor for non-simply-connected bodies when the material and ambient space manifolds have the same dimensions. We discuss the well-known necessary compatibility equations in the linearized setting and the Cesaro-Volterra path integral. We then obtain the sufficient conditions of compatibility for the linearized strain when the body is not simply-connected.

Arash Yavari
Georgia Institute of Technology
arash.yavari@ce.gatech.edu

MS10

Compact Kronecker Representation of Isogeometric Matrices for Fast Integration

In tensor-product B-spline isogeometric simulations in d spatial dimensions, the problem size n^d is multiplied by a factor of 2^d upon each uniform $h-$refinement. Moreover, memory requirements and computation time for matrix generation are of order $O(n^d p^d)$ and $O(n^d p^{3d})$, respectively. To overcome this "curse of dimensionality" we derive a compact Kronecker product decomposition of the mass and stiffness matrices. As a result, multi-dimensional integration is conveniently reduced to univariate integration. The previous costs become $O(Rdnp)$ and $O(Rdnp^3)$ respectively, where the constant R depends on how complex the computational domain is.

Angelos Mantzaflaris
RICAM, Austrian Academy of Sciences, Austria
angelos.mantzaflaris@oeaw.ac.at

Bert Juettler
Johannes Kepler University of Linz
Institute of Applied Geometry
bert.juettler@jku.at

Ulrich Langer
RICAM, Austrian Academy of Sciences
ulrich.langer@oeaw.ac.at

Boris Khoromskij

Max-Planck Institute, Leipzig
bokh@mis.mpg.de

MS10

Efficient Quadrature Algorithm and Trimmed Geometries

We discuss the sum-factorization approach for the calculation of the integrals on trimmed domains. Within the standard element-by-element assembling paradigm, we reparametrize trimmed elements up to machine precision by tensor-product patches and then take advantage of the tensor-product structure to reduce the quadrature computational cost from $O(Np^{3d})$ to $O(Np^{2d+1})$, where p is the polynomial degree, d is the dimensionality and N the number of mesh elements.

Massimiliano Martinelli
IMATI-CNR Pavia, Italy
martinelli@imati.cnr.it

Gershon Elber
Technion, Haifa
Israel
gershon@cs.technion.ac.il

MS10

Efficient Quadrature for High Degree Isogeometric Analysis

In this talk we present a result on the computation of the linear system arising in the Galerkin isogeometric method. The main interest are the cases where the degree of the approximation is raised, so that the computational cost in assembling become challenging. With a change of paradigm in the quadrature procedure, we obtain a procedure that is ready for parallel implementation and is more efficient compared to the other approaches known in literature. These results are new and are part of a work in progress.

Francesco Calabr
Dep. of Automation Electromagnetism Information Engineering
niversita degli studi di Cassino e del Lazio Meridionale
calabrofra@gmail.com

Giancarlo Sangalli
Dipartimento di Matematica
Unversita' di Pavia, Italy
giancarlo.sangalli@unipv.it

MS10

Truncated Hierarchical Catmull-Clark Subdivision with Local Refinement

We present a new method termed Truncated Hierarchical Catmull-Clark Subdivision (THCCS), which generalizes THB-splines to control grids of arbitrary topology. THCCS basis functions satisfy partition of unity, are linearly independent, and are locally refinable. THCCS also preserves geometry during adaptive h-refinement and thus inherits the surface continuity of Catmull-Clark subdivision. Recently, we extended THCCS to improve the efficiency of local refinement in THCCS, which is demonstrated by several numerical tests.

Xiaodong Wei, Jessica Zhang
Department of Mechanical Engineering
Carnegie Mellon University
xiaodonw@andrew.cmu.edu, jessicaz@andrew.cmu.edu

Thomas Hughes
Institute for Computational Engineering and Sciences
The University of Texas at Austin
hughes@ices.utexas.edu

Michael Scott
Civil and Environmental Engineering
Brigham Young University
michael.scott@byu.edu

MS11

4D Printing for Freeform Surfaces: Design Optimization of Origami and Kirigami Structures

A self-folding structure fabricated by additive manufacturing can be automatically folded into a demanding 3D shape by actuation mechanisms such as heating this is also called 4D printing. However, 3D surfaces can only be fabricated by self-folding structures when they are flattenable. Most generally designed parts are not flattenable. To address this problem, we develop a shape optimization method to design self-folding structures in 4D printing.

Tsz-Ho Kwok
University of Southern California
tom.thkwok@gmail.com

Charlie C. L. Wang
The Chinese University of Hong Kong, China
cwang@mae.cuhk.edu.hk

Yong Chen
University of Southern California
yongchen@usc.edu

MS11

Adaptive and Robust Slicing of Scan Data for Additive Manufacturing

In this talk, I will overview a moving least-squares (MLS) surface based approach for processing scan data for additive manufacturing applications. It slices MLS surfaces into planar contours. The resulting layer thickness and layer contours are adaptive to local curvatures, and this leads to better surface quality and more efficient fabrication. This slicing is also robust due to the use of Morse theory based topological analysis of the underlying surfaces.

Xiaoping Qian
Department of Mechanical Engineering
University of Wisconsin-Madison
qian@engr.wisc.edu

MS11

Designing for Am: Integrating Mesh-Based Modelling Techniques with Parametric Cad

The growing use of additive manufacturing lifts many constraints on form imposed by CNC maching and injection molding, and has lead to a renewed interesting in applying triangle meshes, voxels, and implicit surfaces in real-world CAD systems. However, such systems should inter-operate with legacy B-Rep CAD solid modeling tools. I will discuss our ongoing attempt to combine these two domains, relying on a combination of dynamic triangle meshes and variational mesh processing.

Ryan Schmidt
Autodesk Research
ryan.schmidt@autodesk.com

MS11

Representation and Analysis of Additively Manufactured Parts

Mechanical properties of additively manufactured parts are directly related to manufacturing parameters such as the build orientation, tool path, and machine resolution. Therefore computational performance prediction for additive manufacturing should not be posed on nominal CAD models, but on a representation of the as-manufactured part. We discuss new representations of as-manufactured parts and a query based structural simulation that operates directly on these representations, without the interoperability bottleneck of approaches such as finite element analysis.

Saigopal Nelatu
University of Wisconsin-Madison
saigopal.nelaturi@parc.com

Vadim Shapiro
University of Wisconsin - Madison
vshapiro@engr.wisc.edu

MS12

C1 Assembly of Quadrilateral Patches, Some Properties Relating to their Geometry

We consider a C1 assembly of two patches with a common straight edge and a cubic spline boundary . The corresponding constraints depend strongly on the geometry and the parametric definition of the two patches. We analyze several configurations and show that a construction of basis functions is always possible for unstructured meshes with 5th order tensor Bézier patches , but may fail for 4th order one. We analyze the consequences for Spline based IGA.

Michel Bercovier
Hebrew University
School of Computer Science and Engineering
berco@cs.huji.ac.il

MS12

Adaptive Isogeometric Analysis on Multi Patch Domains

Isogeometric discretizations should allow for adaptive mesh refinement and guarantee optimal smoothness of the numerical solution. Multi-patch discretizations are required for more complex geometries. We present a new framework that enables us to construct bases for isogeometric spline spaces on multi-patch domains. In particular we focus on achieving higher smoothness across interfaces. The advantages of our framework will be demonstrated by numerical examples, showing potential applications of the new bases in Isogeometric Analysis.

Florian Buchegger
Institute of Applied Geometry
Johannes Kepler University Linz
florian.buchegger@jku.at

Bert Juettler
Johannes Kepler University of Linz
Institute of Applied Geometry
bert.juettler@jku.at

Angelos Mantzaflaris
RICAM, Austrian Academy of Sciences, Austria
angelos.mantzaflaris@oeaw.ac.at

MS12

Iga Across Irregularities

Matched G^k constructions for geometry and analysis automatically yield C^k iso-geometric elements also for non-tensor-product layout. The talk reviews the use of such elements towards solving partial differential equations in two and three variables and on free-form surfaces.

Jorg Peters
University of Florida
jorg@cise.ufl.edu

Thien T. Nguyen
Missing affiliation
tuanthienbk@gmail.com

Kestutis Karciauskas
Vilnius University
Kestutis.Karciauskas@mif.vu.lt

MS12

Spline Manifold Spaces for Isogeometric Analysis

We introduce and study a mathematical framework for analysis-suitable unstructured B-spline spaces. In this setting the parameter domain has a manifold structure, which allows for the definition of function spaces that have a tensor-product structure locally, but not globally (including multi-patch B-splines, or unstructured T-splines). Within this framework, we generalize the concept of dual-compatible B-splines. This allows us to prove the key properties needed for isogeometric analysis, such as linear independence and approximation properties.

Giancarlo Sangalli
Dipartimento di Matematica
Unversita' di Pavia, Italy
giancarlo.sangalli@unipv.it

Thomas Takacs
University of Pavia
thomas.takacs@unipv.it

Rafael Vazquez
IMATI CNR
Pavia, Italy
vazquez@imati.cnr.it

MS13

An Interactive Beam Structure Design Method Based on Principal Stress Lines for Additive Manufacturing

We present a novel beam structure design method based on principal stress lines (PSLs). The PSLs in a design domain with given loadings and boundary conditions are first computed. Accordingly a beam structure including its topology and shape can be interactively designed for minimum compliance. Related algorithms are given with multiple test cases. The generated structures illustrate the PSL-based beam structure design method is fast, intuitive, and has good design performance.

Yong Chen
University of Southern California
yongchen@usc.edu

MS13

Support Slimming for Single Material Based Additive Manufacturing

In layer-based additive manufacturing (AM), supporting structures need to be inserted to support the overhanging regions. The adding of supporting structures slows down the speed of fabrication and introduces artifacts onto the finished surface. We present an orientation-driven shape optimizer to slim down the supporting structures used in single material-based AM. The optimizer can be employed as a tool to help designers to optimize the original model to achieve a more self-supported shape.

Charlie C. L. Wang
The Chinese University of Hong Kong, China
cwang@mae.cuhk.edu.hk

Shuo Jin
The Chinese University of Hong Kong
jerry.shuojin@gmail.com

MS13

Perceptual Models of Preference in 3D Printing Direction

This work introduces a perceptual model for determining printing orientations of objects fabricated by FDM and SLA 3D printers. Our model for preference in 3D printing direction is formulated as a combination of metrics known to be important, such as area of supporting, visual saliency, preferred views and smoothness preservation. A training-and-learning methodology is developed to obtain a closed-form solution for our perceptual model. We demonstrate the performance of this method on different objects.

Emily Whiting
Dartmouth College
emily@cs.dartmouth.edu

Charlie C. L. Wang
The Chinese University of Hong Kong, China
cwang@mae.cuhk.edu.hk

MS13

Solid Mechanics Based Design and Optimization for Support Structure Generation for Additive Manufacturing

In this work, we proposed a novel design optimization method for support generation for additive manufacturing processes based on solid mechanics. Finite element analysis method is utilized to study the stress distribution on the support structure. A weighted Voronoi diagram approach is utilized to evenly distribute the support anchors. A tree stump like structure is designed for the contacting area to effectively redistribute the stress concentration. Experimental results verified the effectiveness of the proposed approach.

Chi Zhou
University at Buffalo, The State University of New York
chizhou@buffalo.edu

MS14

LR B-Splines and Linear Independence

A sufficient condition to ensure linear indecency of LR B-splines is that no B-spline has its support nested within the support of another B-spline. However, nested supports don't necessary trigger linear dependency. The talk will look at the relations between B-splines occurring in collections of linearly dependent B-splines. Combining this with other knowledge on LR B-spline refinement will facilitate efficient algorithms guaranteeing that a collection of LR B-splines is linear independent.

Tor Dokken
SINTEF ICT, Department of Applied Mathematics
Oslo, Norway
tor.dokken@sintef.no

MS14

Complexity of Hierachical Refinements for Strictly Admissible Mesh Configurations

An adaptive isogeometric method based on truncated hierarchical spline constructions may be derived by considering a refine module that preserves a certain class of admissibility. It can be shown that the overlay of two strictly admissible meshes is a mesh of the same kind with bounded cardinality. In addition, the complexity of the algorithm can be derived by analysing the interplay between the number of refined elements and the total number of marked elements.

Annalisa Buffa
I.M.A.T.I. - C.N.R.
Pavia, Italy
annalisa@imati.cnr.it

Carlotta Giannelli
Johannes Kepler University Linz
Austria
carlotta.giannelli@unifi.it

Philipp Morgenstern, Daniel Peterseim
Institute for Numerical Simulation
Rheinische Friedrich-Wilhelms-Universität Bonn,
Germany
morgenstern@ins.uni.bonn.de, peterseim@ins.uni.bonn.de

MS14

Splines on Triangles

We consider using splines on triangulations in combination with splines on T-meshes.

Tom Lyche
University of Oslo
Department of Informatics and CMA
tom@math.uio.no

MS14

Polycube-Based Volumetric T-spline Construction

for Isogeometric Analysis

In this talk, several polycube-based schemes are described to construct trivariate solid T-splines for isogeometric analysis. For arbitrary topology objects, the polycube can be constructed using smooth harmonic scalar fields, Boolean operations, skeleton and centroidal Voronoi tessellations. A parametric mapping is then used to build a one-to-one correspondence between the input triangulation and the polycube boundary. After that, we create valid T-meshes through pillowing, quality improvement and applying templates to handle extraordinary nodes.

Jessica Zhang
Department of Mechanical Engineering
Carnegie Mellon University
jessicaz@andrew.cmu.edu

MS15

Perspective in the Conformal Model and in the Standard Homogeneous Model

Abstract not available.

Juan Du
Rice University
wudj320@126.com

MS15

Perspective in R(4,4)

Abstract not available.

Ron Goldman
Rice University
Computer Science
rng@rice.edu

MS15

Perspective Projection in Homogeneous Models

Abstract not available.

Stephen Mann
Cheriton School of Computer Science
University of Waterloo
smann@uwaterloo.ca

MS15

Introduction to Clifford Algebras and Geometries

Abstract not available.

Alyn Rockwood
Retired
alynrock@gmail.com

GD/SPM15 Organizer and Speaker Index

SIAM Conference on

Geometric & Physical Modeling (GD/SPM15)

October 12-14, 2015
Sheraton Salt Lake City Hotel
Salt Lake City, Utah, USA

B

Bajaj, Chandrajt, MS3, 9:30 Mon

Bajaj, Chandrajt, MS3, 9:30 Mon

Bastl, Bohumir, CP2, 9:30 Tue

Behandish, Morad, PS2, 4:10 Mon

Bercovier, Michel, CP1, 2:30 Mon

Bercovier, Michel, MS12, 11:00 Wed

Blom, Agnes, MS1, 9:30 Mon

Buchegger, Florian, MS12, 10:00 Wed

C

Chen, Falai, MS2, 10:00 Mon

Chen, Yong, IP1, 8:00 Mon

Chen, Yong, MS11, 9:30 Wed

Chen, Yong, MS13, 2:30 Wed

Chen, Yong, MS13, 3:00 Wed

Cheng, Peng, PS3, 3:45 Tue

Cohen, Elaine, MS2, 11:00 Mon

D

Dahl, Heidi E. I., MS3, 9:30 Mon

Dahl, Heidi E. I., MS3, 11:00 Mon

Denker, Bil, MS4, 4:00 Mon

Denker, Bill, PD1, 4:45 Mon

DiCarlo, Antonio, MS9, 2:30 Tue

DiCarlo, Antonio, MS9, 2:30 Tue

Dokken, Tor, MS2, 9:30 Mon

Dokken, Tor, MS5, 2:30 Mon

Dokken, Tor, MS4, 2:30 Mon

Dokken, Tor, MS4, 2:30 Mon

Dokken, Tor, PD1, 4:45 Mon

Dokken, Tor, MS8, 9:30 Tue

Dokken, Tor, MS14, 2:30 Wed

Du, Juan, MS15, 4:00 Wed

F

Fang, Lincong, PS4, 9:30 Wed

Foufou, Sebti, PS4, 10:20 Wed

G

Giannelli, Carlotta, MS14, 3:30 Wed

Goldman, Ron, MS15, 2:30 Wed

Goldman, Ron, MS15, 3:30 Wed

Gomes, Abel, PS3, 4:10 Tue

Gonsor, Dan E., MS1, 9:30 Mon

Grandine, Thomas A., PD1, 4:45 Mon

Grandine, Tom A., MS4, 2:30 Mon

Grandine, Tom A., MS4, 3:00 Mon

Grasberger, Herbert, PS3, 9:55 Wed

Gravesen, Jens, MS5, 3:30 Mon

Gu, Xianfeng, MS5, 3:00 Mon

Gunpinar, Erkan, CP3, 2:30 Tue

Guo, Xiaohu, MS6, 10:30 Tue

H

He, Ying, PS2, 3:20 Mon

He, Ying, MS6, 9:30 Tue

He, Ying, MS6, 9:30 Tue

Hiemstra, Rene, MS2, 10:30 Mon

Hirani, Anil, MS9, 3:00 Tue

J

Jin, Shuo, MS13, 4:00 Wed

Juettler, Bert, MS10, 2:30 Tue

K

Kaklis, Panagiotis, MS5, 2:30 Mon

Kim, H. Alicia, IP2, 1:00 Mon

Kim, Myung-Soo, MS7, 9:30 Tue

Kim, Myung-Soo, MS7, 9:30 Tue

Kim, Yong-Joon, MS7, 10:00 Tue

Kim, Yong-Joon, PS3, 2:55 Tue

Krumwiede, Tim, CP4, 9:30 Wed

Kwok, Tsz-Ho, MS11, 11:00 Wed

L

Laube, Pascal, CP1, 2:50 Mon

Liu, Lei, MS8, 11:00 Tue

Liu, Xingchen, CP3, 2:50 Tue

Lyche, Tom, MS14, 4:00 Wed

Lysenko, Mikola, PS3, 3:20 Tue

M

Ma, Weiyin, MS8, 11:30 Tue

Machchhar, Jinesh, MS7, 11:00 Tue

Maekawa, Takashi, PS1, 9:55 Mon

Mainar, Esmeralda, CP3, 3:10 Tue

Mann, Stephen, MS15, 2:30 Wed

Mann, Stephen, MS15, 3:00 Wed

Manni, Carla, MS8, 9:30 Tue

Mantzaflaris, Angelos, MS10, 2:30 Tue

Mantzaflaris, Angelos, MS10, 2:30 Tue

Martinelli, Massimiliano, MS10, 3:00 Tue

McMains, Sara, MS7, 10:30 Tue

Michalkova, Kristyna, CP2, 9:50 Tue

Morales-Navarrete, Hernán A., CP4, 9:50 Wed

Muntingh, Georg, CP1, 4:10 Mon

N

Nguyen, Dang Manh, CP2, 10:10 Tue

Nguyen, Dang-Manh, PS2, 3:45 Mon

Nguyen, Thien T., MS8, 10:00 Tue

P

Paluszny, Marco, CP3, 3:30 Tue

Paoluzzi, Alberto, MS9, 3:30 Tue

Peters, Jörg, PS1, 10:20 Mon

Peters, Jorg, MS12, 10:30 Wed

Peters, Thomas J., MS3, 10:00 Mon

Poursartip, Anoush, MS1, 10:30 Mon

Q

Qian, Xiaoping, PS2, 2:55 Mon

Qian, Xiaoping, MS8, 10:30 Tue

Qian, Xiaoping, MS11, 10:30 Wed

R

Rockwood, Alyn, MS15, 2:30 Wed

Rossignac, Jarek, IP3, 8:00 Tue

S

Sánchez-Reyes, Javier, CP4, 11:10 Wed

Sangalli, Giancarlo, IP6, 1:00 Wed

Sangalli, Giancarlo, MS10, 4:00 Tue

Italicized names indicate session organizers

Sangalli, Giancarlo, MS12, 9:30 Wed
Sangalli, Giancarlo, MS14, 2:30 Wed
Sasaki, Hirofumi, CP4, 10:10 Wed
Sati, Mukul, PS1, 9:30 Mon
Sati, Mukul, PS1, 11:10 Mon
Saunders, Bonita V., CP1, 3:10 Mon
Schmidt, Ryan, MS11, 10:00 Wed
Scott, Michael, MS2, 9:30 Mon
Scott, Michael, MS2, 9:30 Mon
Scott, Michael, MS5, 2:30 Mon
Scott, Michael, MS8, 9:30 Tue
Shapiro, Vadim, IP4, 1:00 Tue
Shapiro, Vadim, MS9, 2:30 Tue
Shapiro, Vadim, MS11, 9:30 Wed
Speleers, Hendrik, MS5, 4:00 Mon
Stepanov, Alexey, CP2, 10:30 Tue
Strotman, Tim, MS4, 3:30 Mon
Strotman, Tim, PD1, 4:45 Mon
Sukhinin, Alexey, CP4, 10:30 Wed

T

Takacs, Thomas, MS12, 9:30 Wed
Takacs, Thomas, MS12, 9:30 Wed
Takacs, Thomas, MS14, 2:30 Wed
Thiagarajan, Vaidyanathan, CP2, 10:50 Tue

U

Umlauf, Georg, CP3, 3:50 Tue

V

Vandenbrande, Jan H., MS1, 9:30 Mon
Vandenbrande, Jan H., MS1, 11:00 Mon
Vandenbrande, Jan H., PD1, 4:45 Mon
Vandenbrande, Jan H., IP5, 8:00 Wed

W

Wang, Charlie C. L., MS11, 9:30 Wed
Wang, Charlie C. L., MS13, 2:30 Wed
Wang, Charlie C. L., MS13, 2:30 Wed
Wang, Wenping, MS6, 9:30 Tue
Wang, Wenping, MS6, 10:00 Tue
Wang, Xilu, MS3, 10:30 Mon
Wei, Xiaodong, MS10, 3:30 Tue
Willden, Kurtis, MS1, 10:00 Mon

X

Xin, Shi-Qing, MS6, 11:00 Tue
Xu, Songgang, PS4, 10:45 Wed

Y

Yavari, Arash, MS9, 4:00 Tue
Yokoyama, Tomoo, CP4, 10:50 Wed
Yoshida, Norimasa, CP1, 3:30 Mon

Z

Zhang, Jessica, PS2, 2:30 Mon
Zhang, Jessica, MS14, 3:00 Wed
Zhang, Xinyu, PS3, 2:30 Tue
Zheng, Jianmin, PS1, 10:45 Mon
Zhou, Chi, MS13, 3:30 Wed
Zore, Urska, CP1, 3:50 Mon

Italicized names indicate session organizers

Notes

GD/SPM15 Conference Budget

Conference Budget
SIAM Conference on Geometric and Physical Modeling
October 12-14, 2015
Salt Lake City, UT

Expected Paid Attendance	150	
Revenue		
Registration Income		$53,080
	Total	$53,080
Expenses		
Printing		$700
Organizing Committee		$2,400
Invited Speakers		$13,000
Food and Beverage		$7,800
AV Equipment and Telecommunication		$6,500
Advertising		$8,100
Conference Labor (including benefits)		$29,407
Other (supplies, staff travel, freight, misc.)		$5,600
Administrative		$8,078
Accounting/Distribution & Shipping		$4,307
Information Systems		$7,766
Customer Service		$2,933
Marketing		$4,607
Office Space (Building)		$2,914
Other SIAM Services		$3,078
	Total	$107,190
Net Conference Expense		-$54,110
Support Provided by SIAM		$54,110
		$0
Estimated Support for Travel Awards not included above:		
Early Career and Students	7	$5,100

Sheraton Salt Lake City
Hotel Floor Plan