

Bridges Pécs

Mathematics, Music, Art, Architecture, Culture

Conference Proceedings



2010

Celebrating the 13th Annual Bridges Conference in the City of Pécs
European Capital of Culture, Hungary



Bridges Pécs

Mathematics, Music, Art, Architecture, Culture

Bridges: Mathematical Connections in Art, Music, and Science



PÉCS
CULTURAL
CENTRE

Pécs Cultural Centre



Pécs 2010 European Capital of Culture



2010 PÉCS2010
MANAGEMENT CENTRE



MINISTRY
OF EDUCATION
AND CULTURE

ff
hungarofest®

nka
Nemzeti Kulturális Alap

 EUROPEAN CAPITAL OF CULTURE

**EU
JAPAN
fest**

Proceedings 2010

George W. Hart and Reza Sarhangi, Chief Editors
Tessellations Publishing

Bridges Pécs

Scientific Organizers

George W. Hart

Department of Computer Science
Stony Brook University
New York, USA

Reza Sarhangi

Department of Mathematics
Towson University
Towson, Maryland, USA

Kristóf Fenyvesi

Jyväskylä University, Finland
Pécs Cultural Center
Pécs, Hungary

György Darvas

Symmetrion
IRO Hung. Acad. of Sci.
Budapest, Hungary

Pécs Cultural Center Organizers, Pécs, Hungary

Andrea Lakner Brückler, Zoltan Rózsa, Jolán Somlyay, Éva Gergely, Edit Lajtai
Bernadett Dékány Kónya, Edith Kiss, Katalin Judit Gerdei, Zsófia Stiller, Dávid Barkóczy
Gabriella Kollár, Balázs Kajor, Péter Molnár, Béla Fenyvesi, András Bodó
Ibolya Kovács, Róbert Lovas, László Guth

Regional Organizers

Slavik Jablan

Mathematical Institute
Belgrade, Serbia

Ferhan Kiziltepe

Yıldız Teknik Üniversitesi
Istanbul, Turkey

Zsuzsa Dárdai

Mobile MADI
Museum Foundation, Hungary

Bridges Workshops: Creativity and Learning

Mara Alagic

Wichita State University
Wichita, Kansas, USA

Paul Gailiunas

Newcastle, England

Bridges Visual Art Exhibition

Anne Burns (Juror)

Long Island University
New York, USA

Robert W. Fathauer (Curator)

Tessellations Company
Phoenix, Arizona, USA

Nat Friedman (Juror)

University at Albany
New York, Albany, USA

István Orosz (Juror)

West Hungarian University, Sopron
Budakeszi, Hungary

Nathan Selikoff (Webmaster)

Digital Awakening Studios
Orlando, Florida, USA

Conference Website and Electronic Correspondence

George W. Hart

Stony Brook University
New York, USA

Craig Kaplan

University of Waterloo
Canada

Nathan Selikoff

Digital Awakening Studios
Orlando, Florida, USA

Conference Advisory Board

Craig Kaplan

David R. Cheriton School of
Computer Science, University of
Waterloo, Canada

Carlo H. Séquin

EECS, Computer Science
University of California
Berkeley, USA

Chief Editors:

George W. Hart
Department of Computer Science
Stony Brook University, Stony Brook, New York, USA

Reza Sarhangi
Department of Mathematics
Towson University, Towson, Maryland, USA

Bridges Pécs Conference Proceedings (<http://www.bridgesmathart.org>). All rights reserved. General permission is granted to the public for non-commercial reproduction, in limited quantities, of individual articles, provided authorization is obtained from individual authors and a complete reference is given for the source. All copyrights and responsibilities for individual articles in the 2010 Conference Proceedings remain under the control of the original authors.

ISBN: 9780984604203
ISSN: 1099-6702

Printed by Reálszisztéma Dabas Printing House, Managing Director: Magdolna Vágó

Published in the framework of Pécs 2010 European Capital of Culture program organized by Hungarofest Nonprofit Ltd., Managing Director: Rita Rubovszky.

Published by Tessellations Publishing, Phoenix, Arizona, USA (© 2010 Tessellations)
Distributed by *MATHARTFUN.COM* (<http://mathartfun.com>) and *Tarquin Books*
(www.tarquinbooks.com)

All Escher images used in the 2010 Bridges Proceedings are published with the kind permission of the M.C. Escher Foundation, Baan, The Netherlands.

Cover Artworks: Bjarne Jespersen, Krystyna Burczyk,
Antal Kelle and Francesco De Comité

Cover Design: Ergun Akleman

CD-ROM Production: Craig S. Kaplan

Proceedings Program Committee:

Mara Alagic
Department of Curriculum
and Instruction
Wichita State University
Wichita, Kansas, USA

Anne Burns
Department of Mathematics
Long Island University
New York, USA

Douglas Dunham
Department of Computer Science
University of Minnesota
Duluth, Minnesota, USA

Susan Gerofsky
The Department of Curriculum
Studies, University of British
Columbia, Canada

George W. Hart (Chair)
Department of Computer Science
Stony Brook University
New York, USA

Douglas McKenna
Mathemaesthetics Inc.
Boulder, Colorado, USA

Karl Schaffer
Mathematics Department
De Anza College
Cupertino, California, USA

John M. Sullivan
Technische Universität Berlin
Berlin, Germany

Tom Verhoeff
Mathematics and CS
Eindhoven University of
Technology
Eindhoven, Netherlands

Javier Barrallo
School of Architecture
The University of the Basque
Country, San Sebastian, Spain

Jim Bumgardner
Shadow Hills, California
USA

Kristóf Fenyvesi
Jyväskylä University, Finland
Pécs Cultural Center
Pécs, Hungary

Francisco Gómez
Escuela U. de Informática
U. Politécnica de Madrid
Spain

Craig Kaplan
Cheriton School of Computer
Science, University of
Waterloo, Canada

Rinus Roelofs
The Foundation Passages
Hengelo, the Netherlands

Doris Schattschneider
Mathematics and Computer
Science, Moravian College
Bethlehem, Pennsylvania, USA

David Swart
Waterloo
Ontario, Canada

Daylene Zielinski
Mathematics Department
Bellarmine University
Louisville, Kentucky, USA

Robert Bosch
Department of Mathematics
Oberlin College
Oberlin, Ohio, USA

György Darvas
Symmetrion
IRO Hung. Acad. of Sci.
Budapest, Hungary

Paul Gailiunas
Newcastle, England

Rachel W. Hall
Saint Joseph's University
Philadelphia, Pennsylvania

Goran Konjevod
CS and Engineering
Arizona State University
Tempe, Arizona, USA

Reza Sarhangi
Department of Mathematics
Towson University
Towson, Maryland, USA

Carlo H. Séquin
Computer Science Division
University of California
Berkeley, USA

Godfried Toussaint
McGill University
Montreal, PQ, Canada

Contents

<i>Preface</i>	xvii
----------------------	------

Invited Talks

<i>The System Approach and Design</i>	1
Ernő Rubik	

<i>Visual and Logical Beauty in Mathematics</i>	2
László Lovász	

Regular Papers

<i>Quantum Sculpture: Art Inspired by the Deeper Nature of Reality</i>	3
Julian Voss-Andreae	

<i>Models of Surfaces and Abstract Art in the Early 20th Century</i>	11
Angela Vierling-Claassen	

<i>Expressions, Assemblages and Grammars</i>	19
Penousal Machado	

<i>Branching Miter Joints: Principles and Artwork</i>	27
Tom Verhoeff and Koos Verhoeff	

<i>Poetry Inspired by Mathematics</i>	35
Sarah Glaz	

<i>Types of Repetition and Multistable Perception in the Frieze Patterns on the Marble Pavement of the Cathedral of Siena</i>	43
Yang Liu and Godfried Toussaint	

<i>Mirrors and Spheres: The Geometry within the “Tall Tree and the Eye”</i>	51
Chiara Tuffanelli	

<i>Compositional Constraints of Simultaneous Color Contrast: Toward a Classification of Types</i>	59
James Mai	

<i>Tiled Torus Quilt with Changing Tiles</i>	67
Elaine Krajenke Ellison and John Sharp	

<i>About Weaving and Helical Holes</i>	75
Rinus Roelofs	
<i>My Search for Symmetrical Embeddings of Regular Maps</i>	85
Carlo H. Séquin	
<i>Curve Evolution Schemes for Parquet Deformations</i>	95
Craig S. Kaplan	
<i>Some Three-dimensional Self-similar Knots</i>	103
Robert W. Fathauer	
<i>Strip Symmetry Groups of African Sona Designs</i>	111
Darrah Chavey	
<i>Interactive Exploration of Corporate Logos: From Mercedes Benz to Sea Creatures</i>	119
Christopher Carlson	
<i>Vasarely's Work—Invitation to Mathematical and Combinatorial Visual Games</i>	127
Ljiljana Radovic and Slavik Jablan	
<i>Bourgoin's 14-Pointed Star Polygon Designs</i>	135
B. Lynn Bodner	
<i>On Generating Dot Paintings in the Style of Howard Arkley</i>	143
Gary R. Greenfield	
<i>Geometric Tools for the Magic Woodcarver</i>	151
Bjarne Jespersen	
<i>Imaginary Cubes—Objects with Three Square Projection Images</i>	159
Hideki Tsuiki	
<i>Design by Subdivision</i>	167
Michael Hansmeyer	
<i>Artformer Geometry</i>	175
Antal Kelle	
<i>Creating and Modifying Images Using Newton's Method for Solving Equations</i>	183
Stanley Spencer	
<i>Using Mathematics in Art</i>	191
Michael Field	

<i>Regular Polyhedral Lattices of Genus 2: 11 Platonic Equivalents?</i>	199
Dirk Huylebrouck	
<i>Early Modern Art Layouts in Breuer's Design</i>	207
Devrim İşikkaya	
<i>From the Angle of Quasicrystals</i>	215
Jean-Marc Castéra	
<i>Gauss, Bolyai, Lobachevsky—in General Education? (Hyperbolic Geometry as Part of the Mathematics Curriculum)</i>	223
István Lénárt	
<i>A General Procedure for the Construction of Mirror Anamorphoses</i>	231
Francesco De Comit�	
<i>Art with a Double Meaning</i>	239
Istv�n Orosz	
<i>Expanding the Mandelbrot Set into Higher Dimensions</i>	247
Javier Barrallo	
<i>Swirling Squares: A Simple Math Flip-Book Animation</i>	255
Douglas McKenna	
<i>Brunnian Weavings</i>	263
Douglas G. Burkholder	
<i>Eureka and Serendipity: The Rudolf von Laban Icosahedron and Buckminster Fuller's Jitterbug</i>	271
Caspar Schwabe	
<i>Projection of Point Sets to a Lower Dimension with Applications in the Arts</i>	279
Gy�rgy Darvas	
<i>The Vitruvian Figure of Eight</i>	287
Joel C. Langer	
<i>A Fractal Celtic Key Pattern?</i>	293
Paul Gailiunas	
<i>Biblical Cantillations</i>	299
Russell Jay Hendel	

<i>Some Possibilities of Russian Combinatorial Literature</i>	305
Tatiana Bonch-Osmolovskaya	
<i>Amateur and Pioneer: Simon Stevin (ca. 1548–1620) about Music Theory</i>	311
János Malina	
<i>30 Cubes on a Rhombic Triacontahedron</i>	317
Sándor Kabai	
<i>On Growth, Form and Yin-Yang</i>	323
Michael Longuet-Higgins	
<i>Everything is Number—Mathematics Meets Arts</i>	329
Carsten Miller	
<i>Viruses and Crystals: Science Meets Design</i>	335
B.G. Thomas	
<i>Geometrical Representations of North Indian Thāṭs and Rāgs</i>	341
Chirashree Bhattacharya and Rachel Wells Hall	
<i>Hyperbolic Vasarely Patterns</i>	347
Douglas Dunham	
<i>Specialties of Models of the 6-dimensional Cube</i>	353
László Vörös	
Short Papers	
<i>Aesthetic and Mathematical Research: A Comparism with two Examples</i>	359
Tim Boykett	
<i>Alhambra’s Nazari Single Tile Patterns Guided Tour</i>	363
Jesús Hernando	
<i>An Origami Puzzle of Intersecting Cubes</i>	367
Zsolt Lengvarszky	
<i>Beautiful Homework: The Artists’ Critique Group in the Mathematics Classroom</i>	371
Daylene Zielinski	
<i>Parabolic Connections: Linking History, Art, Acoustics, and Mathematics</i>	375
Gail Kaplan	

<i>Mathematical Interpretation of Graphic and Poster Design in Iran</i>	379
Nahid Tootoonchi	
<i>On Torsion Free Subgroups of p^2 and Related Colored Tilings</i>	383
Ma. Louise Antonette N. De Las Peñas, Eden Delight B. Provido and René P. Felix	
<i>Cyclic Symmetric Multi-Scale Turing Patterns</i>	387
Jonathan McCabe	
<i>Constructing Molecules with Beads: The Geometry of Topologically Nontrivial Fullerenes</i>	391
Bih-Yaw Jin, Chern Chuang and Chia-Chin Tsao	
<i>Minimal Flowers</i>	395
John M. Sullivan	
<i>Ivory Polyhedra Turned on a Lathe</i>	399
Tibor Tarnai	
<i>Ribbon Edges: a New Impulse for Geometric Sculpture</i>	403
Charles Gunn	
<i>Moiré II</i>	407
Koert Feenstra	
<i>Constructing Sierpinski Triangle with Rings</i>	411
Mehrdad Garousi and Hamid Reza Dezfoolian	
<i>Mathematical Models for Argentine Tango</i>	415
Carla Farsi	
<i>Toward a Tesseract Theater</i>	419
Nicholas Abruzzo	
<i>Exploring Symmetry in Elementary Schools</i>	423
Andreia Hall, Rosa Amélia Martins and Carlota Simões	
<i>Patterns from Archimedean Tilings Using Generalized Truchet Tiles Decorated with Simple Bézier Curves</i>	427
David A. Reimann	
<i>Playing with the Möbius Band</i>	431
Eleonóra Stettner	

<i>Creating Cartoon Images with Functions: A Pedagogical Project</i>	435
M. G. Marques and M. Pires	
<i>Review of a Cinema Film from the Perspective of Symmetry: “The Pillow Book”</i>	439
Ferhan Kızıltepe	
<i>Sphaerica: Interactive Spherical Geometry Software</i>	443
János Erdős	
<i>Multisculpture or Polymorphic Sculpture: A Different Approach to Sculpture to Challenge and Nurture Reflection: Both in the Sculptor and in the Viewer</i>	447
Jacques Beck	
<i>Borromean Rings & Three Fold Knots</i>	451
Louise Mabbs	
<i>Cylinder Anamorphosis of Impossible Structures</i>	455
Jan W. Marcus	
<i>Ad Quadratum Ad Infinitum</i>	459
Eliana Manuel Pinho	
<i>The K5 Graph Turned into a Golden Pyramid</i>	463
Samuel Verbiese	
<i>Chaos, Noise, Randomness and Coincidence as Constitutional for Generative Art</i>	467
Mike Kostner, Franz Schubert and Carola-Bibiane Schönlieb	
<i>Seeing with the Mind: from the Matrix into the Cloud</i>	471
Pedro Campos and Ana Isabel Portugal	
<i>Mandel-Bach Journey: A Marriage of Musical and Visual Fractals</i>	475
Harlan J. Brothers	
<i>Models of Locally Regular Heptagonal Dodecahedra</i>	479
David I. McCooey	
<i>The Sunflower Spiral and the Fibonacci Metric</i>	483
Henry Segerman	
<i>Classification and Comparison of Different Folk Music Traditions Using Self Learning Algorithms</i>	487
Zoltán Juhász	

<i>Matière of Painting Analyzed by Wavelet Transform</i>	491
Toshihiro Bando, Masamichi Kobayashi, Yuri Sakurai	
<i>Oscillatory Solutions for Sine-Gordon Equation</i>	493
Ion Bica	
<i>Tile Color Matching Using Simple Universal Cycles</i>	495
Anna Virágvölgyi	
<i>Intertransformability</i>	497
John A. Hiigli	
<i>Perspective with Six Vanishing Points</i>	499
Daniel Lőrincz, Brigitta Szilágyi and Ágnes Urbin	
<i>Use of Pseudo Functions in Digital Creation</i>	501
Philippe Bootz	
<i>The Visualization of Flow</i>	503
Joel Varland	
<i>The Qualitative and Quantitative World of Robert Wilson's Theater</i>	505
Julie Rogers Varland	
<i>Revisiting Mat Board Models for A Physical Proof of Five and Only Five Regular Solids or Polyhedron</i>	507
Robert McDermott	
<i>Anamorphic, Kaleidoscopic and Sculptural Mirror Reflections</i>	509
Kenneth Brecher	
<i>Locally and Globally Regular Toroids with Less than 16 Hexagonal Faces</i>	511
Lajos Szilassi	
<i>Impossible Ornaments</i>	513
F. Farkas Tamás	

Workshops

<i>Mathematical Balloon Twisting for Education</i>	515
Vi Hart	
<i>Creative Learning with Giant Triangles</i>	523
Simon Morgan, Jacqueline Sack and Eva Knoll	
<i>A Workshop in Geometric Constructions of Mosaic Designs</i>	531
Reza Sarhangi	
<i>Escher-type Tessellations and Pull-up Polyhedra: Creative Learning for the Classroom</i>	539
E.B. Meenan and B.G. Thomas	
<i>POLY-UNIVERSE—Knowledge Produce Toy Family</i>	545
János Szász Saxon	
<i>Workshop on Mathematics and Dance</i>	551
Karl Schaffer and Erik Stern	
<i>Programming for Artists with Processing</i>	555
Zsófia Ruttkay	
<i>Using Roller Coasters to Bridge Mathematics, Science and the Arts</i>	559
Janka Szilágyi and Jill Zarazinski	
<i>Author Index</i>	561

Preface

Bridges 2010, in Pécs, Hungary promises to offer another exciting and inspiring installment of the annual series of math and art conferences that have been held since 1998. After visiting the USA (several times), Canada (twice), Spain (twice), Britain, and the Netherlands, we are very pleased to be in Eastern Europe for the first time, in the beautiful city of Pécs, Hungary. Pécs has long been a center of learning, as the home of the largest and oldest university in Hungary, dating back to 1367. The city has a long history of Roman, Ottoman, Turkish, and Hungarian culture since its founding in the early second century. Remains of its early history are recognized as a UNESCO World Heritage Site. For 2010, Pécs is being recognized by the European Union as a Capital City of Culture, and the Bridges Conference is proud to be part of this celebration of its cultural life and development.

Hungary is the home of many great mathematicians and artists who will be celebrated in various ways during the Bridges Conference. For example, the artist Victor Vasarely, the designer Marcel Breuer, and the mathematician János Bolyai will each be discussed in presentations during a special Hungarian Day at the conference. The inventor and professor of architecture Ernő Rubik will lead a special discussion about Rubik's Cube and other puzzles he has designed. And the international award winning Hungarian mathematician, László Lovász, will open the Bridges Conference with a plenary talk about the beauty of mathematics.

The Bridges Pécs conference has received enormous support from the Pécs Cultural Center. We thank its director Andrea Lakner Brückler and staff members, especially Kristóf Fenyvesi, for all the local arrangements they have organized. In preparation for the arrival of Bridges, they have been holding an annual art-math conference series, entitled Pécs – Ars GEometrica (PAGE), since 2007 and running a mathematics education program, entitled Experience Workshop, since 2008. In addition, we thank György Darvas for making many local arrangements and invitations.

Pécs is the home of the world famous Zsolnay Porcelain Manufactory, a center for historical and contemporary ceramics and porcelain. To celebrate the arrival of Bridges in Pécs, Dániel Erdély curated and organized the ScienTile Exhibition at the Zsolnay Cultural Center. A panel of judges reviewed and selected the entries. We would like to thank him, his jurors, Simon Erdély, András Fodor, and the Director of the Zsolnay Porcelain Manufactory, Péterné Marosy Katalin, for bringing this exhibition to reality.

The proceedings book has grown in both size and quality. For the first time in the history of Bridges, the number of accepted articles published in the proceedings has surpassed one hundred! This jump is due to an overall increase in the number of submitted articles. The program committee that oversaw the reviewing process spent many hours studying and discussing the articles, with input from an army of external reviewers. To limit the proceedings to a single volume, many submissions were restricted in length. Fortunately the EasyChair system worked well to streamline the process. We are grateful to the University of Manchester, England, for providing this service.

The growth of the community interested in mathematics and art and other connecting fields also shows itself in the large draw of the Art Exhibition, which this year hosts seventy-four artists from all over the world. This important component of the annual Bridges conference is a juried exhibition that is also captured in a marvelous catalog showing all selected works in color photographs. We are very grateful to Robert Fathauer along with Anne Burns, Nat Friedman, and István Orosz for organizing this event and for jurying the many submissions. We also thank Edith Kiss of the Pécs Cultural Center for helping with logistical challenges and the hanging of the exhibition in Pécs. We thank Ergun Akleman for designing

the Proceedings cover and Art Exhibition Catalog cover using artwork selected from the exhibition. Nathan Selikoff is especially thanked for creating a new online system for Exhibition submissions and automatic catalog generation, and for taking over general maintenance of the extensive Bridges website.

The conference also keeps growing in several other directions due to the creativity and special effort of many dedicated individuals. This is most visible in the special Bridges Nights program:

- For our Theater Night this year, the Bridges Conference will present *The Secret Life of Squares*. Karl Schaffer and Erik Stern, both college professors, along with company dancer Saki, show the connections among disciplines through their highly physical, engaging choreography using humor and entertaining audience interactions. Their art addresses symmetry, number sense, the history of ideas and, ultimately, how we think.
- Dmitri Tymoczko, a music professor at Princeton University, is the curator of Music Night, a public concert of accessible music inspired by mathematical themes. It will feature composers such as Fernando Benadon, Clifton Callender, Adrian Childs, and Noam Elkies. These new works will be presented in a concert performance with an explanatory introduction about their mathematical connections. We would like to thank the performers of the musical pieces, the Ávéd-Fenyvesi Quartet, the Handbell Choir of the ANK Primary School of Pécs, and Katalin Gál Poór. We also thank Vi Hart for organizing a separate informal session of music by conference participants.
- More artists and educators than ever are using movies, videos, and animations for different purposes ranging from education, industry, and art. An important objective of the Bridges Organization is to introduce participants to innovative and integrative techniques that promote interdisciplinary work in the fields of mathematics and art. The Math/Art One-Night Film Fest is a new feature of the conference and a new venue for talented and creative minds around the world.

The authors, the artists, and others who come to learn and enjoy the conference through many venues of talks and exhibitions are visiting this year from about thirty different countries around the world. Many others who would have loved to, but could not attend, will still be reached by conference products such as the Proceedings, the Art Exhibition Catalog, and the Bridges website, <http://bridgesmathart.org/>. It records and documents many facets of this conference: the papers, the art work, and photographs taken by participants. Thus, in a virtual way, those who miss these exciting days in Pécs will still be connected and those who do attend can revisit their memories repeatedly.

The Bridges Organization Board of Directors
<http://www.BridgesMathArt.org/>