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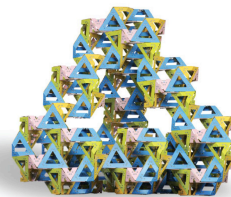
Conference Proceedings



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University of Jyväskylä



UNIVERSITY OF JYVÄSKYLÄ



Bridges

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Preface

This year, the Bridges conference reaches new heights as it crosses the 62nd degree of northern latitude and comes to Jyväskylä, Finland. Jyväskylä is a thriving university town of 140,000 inhabitants beautifully set between several lakes and therefore having its share of bridges. Also called “the Athens of Finland,” Jyväskylä has been traditionally regarded as a stronghold of Finnish language and culture, in a country where Swedish also counts as an official language. Indeed, the first lyceum using Finnish as a teaching language was founded in Jyväskylä in 1858, followed by a teachers’ training college in 1863. The college evolved into a high school of pedagogy in 1934 and into a university in 1966. The university campus boasts several buildings by Alvar Aalto, and the main museum of the world-famous architect is also in Jyväskylä. Today the University of Jyväskylä is one of the largest and most popular multidisciplinary universities in Finland. Its seven faculties host over 15,000 students from nearly 100 countries around the world.

The Bridges Organization is grateful that the University of Jyväskylä has opened its doors to the Bridges Conference for this year. The mission of the Bridges Organization and of this conference is to expose, discuss, and popularize the many connections between mathematics and other elements of art and culture, including fine arts, architecture, music, dance, poetry, origami, puzzles, and the sciences. It attracts a diverse audience of mathematicians, artists, educators, musicians, writers, dancers, weavers, model builders, architects, and computer scientists. This inspiring mix is reflected again in this year’s proceedings and in the various special activities integrated into the conference, such as the art exhibition, the public lectures, the short movie festival, the music, theater, and poetry sessions, and a public day. We are excited that the violin virtuoso Corey Cerovsek, who has performed and lectured at many past Bridges conferences, will be performing a concert with Finnish pianist Paavali Jumppanen.

This year’s Bridges Program Co-chairs are Bruce and Eve Torrence. They coordinated an international Program Committee of over 50 experts who provided extensive reviews and editorial comments on submissions. They also served as co-chairs of the regular paper track. Douglas M. McKenna and Carlo Séquin co-chaired the short papers track, which had a record number of submissions. Kristóf Fenyvesi chaired the workshop submissions. Sarah Glaz edited the Bridges Poetry Anthology, containing poems read at Bridges from 2011 to 2016. Many thanks go to the members of the Program Committee who reviewed the large number of papers received. Special thanks go to Robert Bosch, our movie festival coordinator; Andrea Hawksley, Mike Naylor and Sujana Shrestha, who served as the jury for the movie festival; and to Kristóf Fenyvesi for organizing the public day.

The 2016 edition of the Bridges proceedings includes 44 regular papers, 64 short papers, and 17 workshop papers. A wide range of topics are explored in this publication: you will find new work on fractals, patterns, poetry, polyhedra, weaving, origami, sculpture, visualization, image processing, outreach and education, and more. We have workshops that explore the geometry of bamboo towers designed to harvest water from the air to address Ethiopia’s diminished sources of drinking water, and tradition-based country buildings from regions of the circumpolar north. There are papers that explore the mathematics of juggling patterns, ice-skating, and contra dancing, and a mathematical and historical analysis of maps of Sir Thomas More’s Utopia. We thank all of the authors and reviewers for their generous contributions to this year’s proceedings, with a special thank you to Kelly Delp for her patient guidance and advice. We would also like to acknowledge the efforts of Sujana Shrestha, George Hart, Craig S. Kaplan, Douglas M. McKenna, Reza Sarhangi, and Carlo Séquin who provided extra support.

This year we were able for the first time to offer \$10,000 in student travel scholarships to 11 students who authored accepted papers. We are very grateful to Jade Vinson for his generous contribution, which made this program possible, and to Sujana Shrestha who managed the program.

An exhibition of mathematical art has been an annual feature of Bridges since 2001. This year’s exhibition sets a new record for the number of participating artists, over 160. Artists from Europe, the Middle East, Africa, East Asia, Australia, and North and South America will be represented. A wide

variety of artistic media are included in the exhibition, including 2D and 3D digital prints, painting, beadwork, ceramics, wood, metal, quilting, clothing, and paper folding. Artists drew inspiration from the mathematics of fractals, polyhedra, non-Euclidean and four-dimensional geometry, tiling, knot theory, number theory, and more. This year Katie McCallum and Robert Fathauer served as co-curators of the exhibition, and were joined by Conan Chadbourne and Karl Kattchee to make up the jury. The print catalog was prepared by Conan Chadbourne, and the art submission website was created and administered by Nathan Selikoff. Kati Valpe, Emilia Lampi and Taru-Maija Heilala-Rasimov were the local coordinators in Finland for the art exhibition.

In addition to Bridges' traditional art exhibit, there are several other exhibits offered, including István Orosz and Lajos Szilassi's joint exhibit, Rinus Roelofs' solo exhibit, and an interactive math-art education exhibition and 4Dframe workshop called *Tangram: Discover the Art of Maths!*.

The Mathematical Sciences Research Institute (MSRI) has once again sponsored the Bridges public event. This year an ambitious ice-architecture project will be introduced to our audience. The *Leonardo's Bridge in Ice* project took place in Finland in the Structural Ice program and it was an attempt to build the longest span ice bridge in the world. The project will be presented by Arno Pronk, the lead architect of the Structural Ice program, Juhani Lillberg, the Jyväskylä-based president of the International Association of Snow and Ice Sculpture, and Nina Heikkonen, a Finnish art historian and a project coordinator from the built heritage department of the Alvar Aalto Foundation.

We would also like to thank several people from the University of Jyväskylä who have played a key role in preparing Bridges Finland 2016. In particular, we thank Kristóf Fenyvesi, the scientific secretary of Bridges Finland 2016, and his colleagues Osmo Pekonen and Raine Koskimaa for their leadership in this regard. We also thank Rector Matti Manninen, Vice-Rector Kaisa Miettinen and the Dean of Faculty of Information Technology, Pekka Neittaanmäki for opening the doors of their university to the Bridges Conference for this year. Deans of several further faculties, including Minna-Riitta Luukka (Faculty of Humanities), Marja-Leena Laakso (Faculty of Education), Henrik Kunttu (Faculty of Mathematics and Science), and department heads Tero Kilpeläinen (Department of Mathematics and Statistics) and Heikki Hanka (Department of Art and Culture Studies) have been with us from the beginning and provided the necessary resources for our preparations. Our sincere thanks to this year's local coordinator Kati Valpe (Planning Officer, Department of Mathematical Information Technology, Faculty of Information Technology), Taru-Maija Heilala-Rasimov (Conference Coordinator, Faculty of Humanities), Jaana Ruponen (Marketing manager, Jyväskylä Convention Bureau), and interns Emilia Lampi and Heidi Vasanoja who have put a considerable amount of time and effort into organizing this conference.

We would also like to acknowledge the university museum director Janne Vilkkuna and chief curators Pirjo Vuorinen, Tanja Koskela and their colleagues Jonna Timonen, Silvia Rinne, Jesse Saarinen, Tauri Kankaanpää, Pekka Hassinen, and all the museum staff.

We would like to thank our partners, especially the City of Jyväskylä; Nina Heikkonen, Tommi Lindh and Esa Laaksonen from the Alvar Aalto Foundation; Rauno Hänninen from Athenis Finlandiae; Gábor Richly and Jukka Haverinen from the Hungarian Cultural and Scientific Centre, Helsinki; Kertu Saks from Energy Discovery Center, Tallinn; and Hannu Salmi from University of Helsinki. And finally we would like to thank the Kauko Sorjonen Foundation for making the Bridges Finland 2016 Music Night possible, and our sponsors, the Jutikkala Fund / Finnish Academy of Science and Letters, and the Federation of Finnish Learned Societies.

Once again, welcome to Bridges 2016. We hope you enjoy the conference and find inspiration in this wonderful collection of new ideas.

The Bridges Organization Board of Directors
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