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Bridges 2021: an interlocking mathematical art community

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ABSTRACT

The 24th annual Bridges Conference 2021 amalgamates a series of events, including invited and contributed paper presentations, a juried exhibition of mathematical art, hands-on workshops, a short film festival, a poetry reading, an informal music night, and art performance events. Since 1988, the conference has provided a notable interdisciplinary model as one of the largest conferences on the mathematical connections with art, music, architecture, and culture.

Introduction

Because of the restrictions, uncertainty, and challenges imposed by the ongoing COVID-19 pandemic, the 24th annual Bridges Conference (1–3 August 2021) was held virtually, utilizing the web browser-based application "GatherTown" (gather.town). Henry Segerman and Craig Kaplan designed this virtual interactive space (Figure 1) which included presentation rooms, the art exhibition gallery, and a common area for informal interaction on various themes.

The Bridges 2021 meeting was a friendly and stimulating online experience. Everyone could wander around and mingle between groups to make virtual interactions natural.

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Figure 1. Bridges 2021 GatherTown (gather.town) virtual interactive space, designed by Henry Segerman and Craig Kaplan.

The meeting replicated many aspects of a traditional in-person conference atmosphere and allowed the Bridges community to be involved in exciting discussions, including hobbies, lives, and families. The technological infrastructure allowed many participants across the world to attend and participate in the conference. Instead of only being in Zoom-style rooms where one enters and exits, the custom design of the Bridges 2021 meeting space as an interactive virtual collaborative platform combined with live online presentations offered many ways for participants to engage and interact. The organization included multiple parallel sessions with live presentations, a juried exhibition of mathematical art, workshops, a short film festival, art performance events including a poetry reading and an informal music night and designated social areas for networking opportunities.

The 2021 edition of the Bridges peer-reviewed Proceedings includes 32 regular papers, 34 short papers, and five workshop papers exploring a wide range of topics from topology, symmetry, tiling, knot theory, polyhedra, optimization, and more. The meticulous work and editorial leadership by David Swart (Program Chair), Frank Farris, and Eve Torrence, combined with an international programme committee of 65 experts, resulted in an engaging and well-rounded collection of papers. This year's and all past proceedings from 1998 to 2021 are available here (http://archive.bridgesmathart.org/).

The first day of the Bridges 2021 conference started with an informal social hour where participants could practice walking around and interacting in the virtual space. It was fun to see the enjoyment of the participants as everyone became familiar with the GatherTown and Zoom applications. Fascinating discussions could be heard as one roamed around the virtual interactive meeting areas. Participating in a conference during the global pandemic brought solace and support to the Bridges community. The adoption of GatherTown's
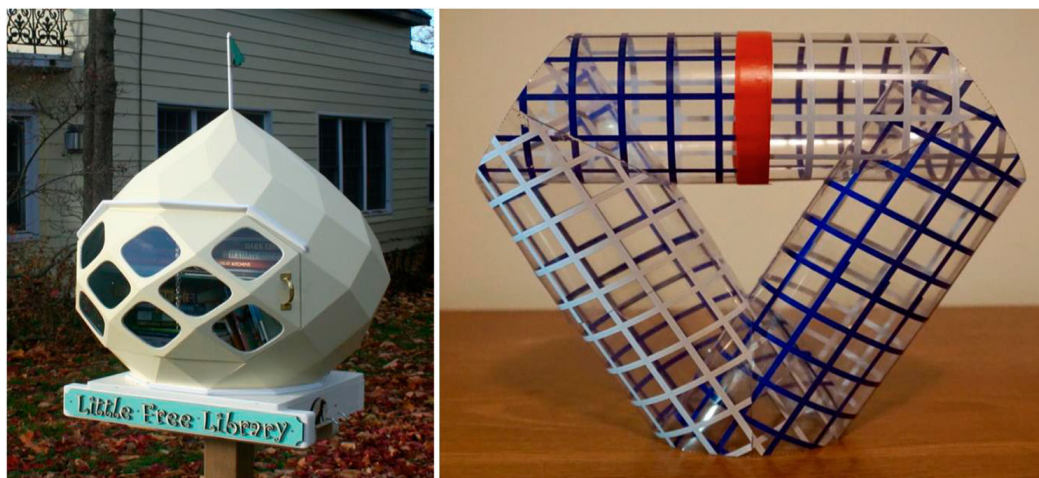
Figure 2. (a) Little Zonohedral Library by George Hart (left), (b) A curved-crease origami sculpture of a flat Klein bottle made from printed transparency film by Stephen Paul (Right).

"game-like" technology as a conference tool carried a mix of enthusiasm and hesitancy, but also hopefulness and excitement.

The academic portion of the conference began with a plenary session with over 300 attendees representing 26 countries worldwide. Jordan Eilenberg gave the first opening keynote. A professor of mathematics at the University of Madison, Wisconsin, with a focus on arithmetic algebraic geometry, his presentation connected the ambiguity and beauty in poetry and mathematics. His sense of humour and creative ways of connecting historical events and characters through poetry and geometry were captivating.

The first parallel session included George Hart's talk on the structural properties of his "Little Zonohedral Library" (Figure 2(a)). He offered insights into this rich family of geometric forms, a special class of polyhedra known for their parallelism, modularity, and expandability with wide-ranging, real-world applicability and strong visual coherence.

The next talk in the session was Stephen Paul, who presented a flat Klein bottle (Figure 2(b)) to illustrate its topological and geometric properties. The use of cutting, creasing, and taping of printed transparency film to show the continuity of a grid pattern was a novel way to illustrate the underlying mathematical properties of this structure.

An exhibition of mathematical art has been an annual feature of the Bridges conference since 2001. This year was no exception. Co-curated by Robert Fathauer and Bruce Torrence and jurors Taneli Luotoniemi and Katie McCallum, the Bridges 2021 mathematical art exhibition offered a wide variety of artistic media. Artists from all over the world drew inspiration from the mathematics of fractals, polyhedra, non-Euclidean and four-dimensional geometry, tiling, knot theory, and number theory. The exhibition showcased works from 87 artists worldwide, and included 2D and 3D digital prints, drawings, paintings, bead work, ceramics, weaving, woodworking, metalworking, quilting, and paper cutting and folding. Past art galleries from 2001 to 2021 are available here, (http://gallery.bridgesmathart.org/exhibitions). (Figures 3–5).

As usual, the Bridges conference delivered unique and brilliant papers. Eve Torrence's paper on a general education mathematics college course used designing and making bead crochet bracelets to introduce graph theory, knot theory, and symmetry to non-majors.

Figure 3. (a) Pentagonal dodecahedron without casing by Friedhelm Kürpig (left), (b) Groovy Hyperbolic Form by Robert Fathauer (Right).

Figure 4. (a) Hyperbolic Phizz net by Hanne Kekkonen (left); (b) (Ir)regularity by Katherine Seaton (Right).

Creative teaching is needed to relate these complex mathematical concepts to designing bead crochet patterns while simultaneously teaching students crochet skills. The innovative designs (Figure 6) and the visual outcomes are a treasure worth noting.

A paper presentation from Roger Antonsen and Laura Taalman was about creating criteria for reducing, filtering, and categorizing Celtic knot designs (Figure 7). Their method, which uses Hamming graphs to explore the design relationships, is complex yet visually inviting.

The next day's keynote speaker was Bathsheba Grossman, a lifelong sculptor who uses CAD/CAM, to make 3D works that span the spectrum of observed, algorithmic, and artistic design. She reflected on the evolution of 3D printing technology using steel, subsurface laser etching in optical glass, and kiln-formed art glass. Her playful design of mathematical 3D glass art objects (Figure 8) imitating the mistakes and flaws of nature is hypnotizing and thrilling. The structures and objects Grossman makes are visually gorgeous and stunningly elegant.
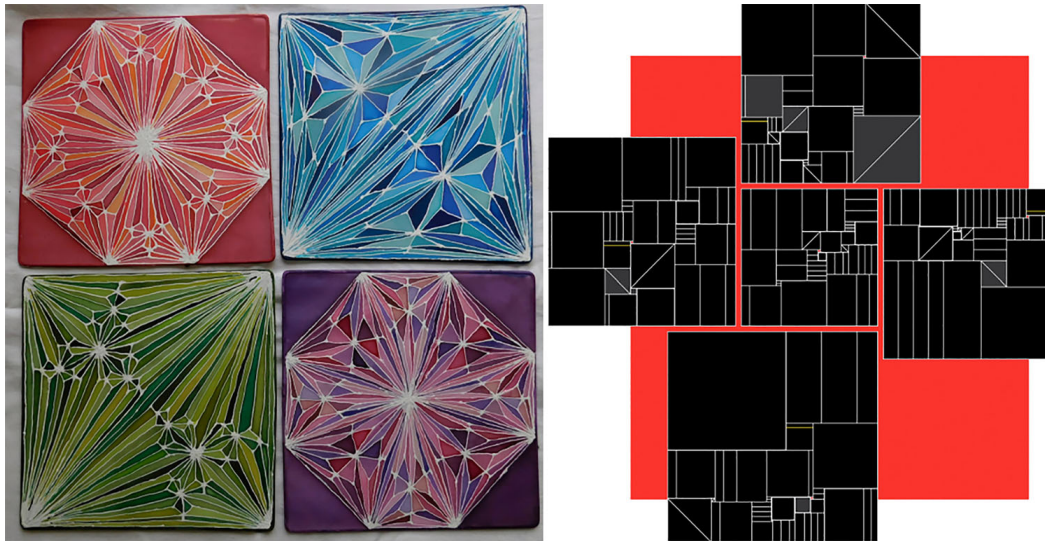
Figure 5. (a) Inside triangles by Jana Kopfová (left), (b) A Quintet of Squared Squares by Margaret Kepner (Right).
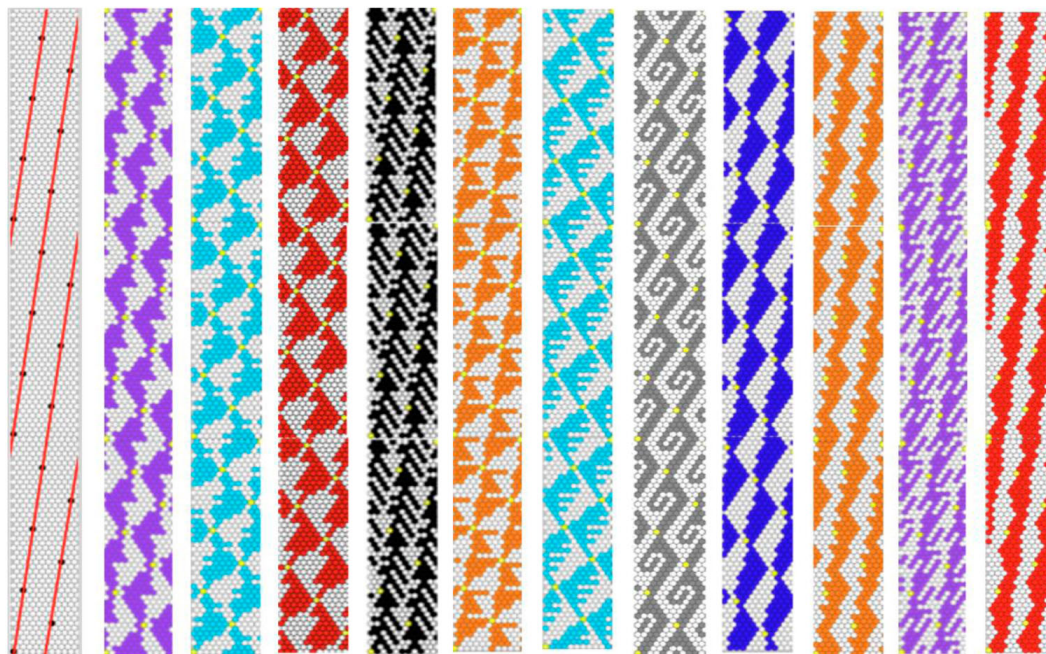

Figure 6. Snakes on a Plane project template. Designed by students of Eve Torrence.

Other events included three informal discussion periods: one about the short films, chaired by Bianca Violet, another on mathematical dance, led by Karl Schaffer, and a third about mathematics and poetry, let by Sarah Glaz. Informal discussion sessions on the second day included one about the life and work of John Sharp, led by Eva Knoll, and one about math and fashion, led by Susan Goldstine and Uyen Nguyen.

There has been a long tradition for participants to offer a broad range of performances and celebrate their love for music with the Bridges community. The event featured classical
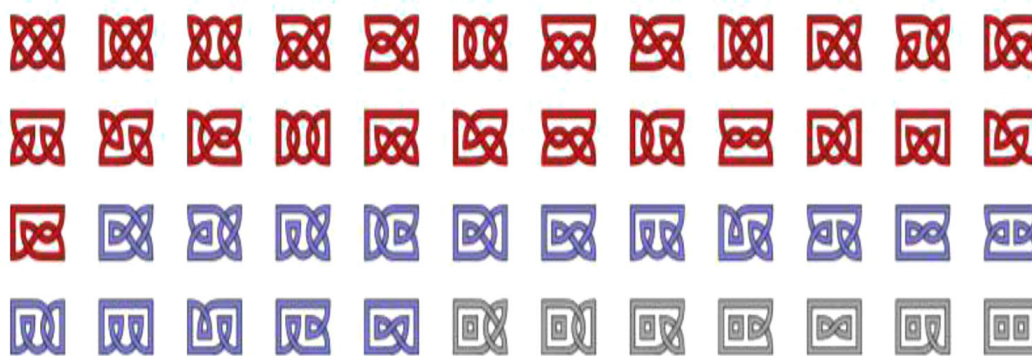
Figure 7. The 48 equivalence classes that are 3 × 2 and type-1; 41 of which are connected by Antonsen and Taalman.

Figure 8. 3D art glass prints featuring Turing patterns and other algorithmic designs by Bathsheba Grossman.

and new genres of music on all kinds of instruments from all over the world. Bridges 2021 concluded with an informal music night with 16 talented musical performances led by Frank Farris. Doug Norton's melody "Doug's Bridges 2021 Song" delighted the audience and helped them reminisce fondly, generating hope and excitement for future in-person Bridges conferences.

Conclusion

After two years of hiatus and interruption caused by the global pandemic, the revival of the Bridges 2021 conference with lively presentations using the virtual interactive space, GatherTown, was welcome news. Bridges 2021 symbolizes resiliency and accessibility, with the community coming together for those, who may not have been able to attend the conference in person, due to the COVID-19 pandemic. The Bridges conferences has transcended one global pandemic, because as Bridges' founder, Reza Sarhangi, often said, "We are like

a large family." Reza's highly resilient family (Shrestha, 2016) will endure and evolve for generations to come.

The year 2021 also marks the 15th anniversary of *the Journal of Mathematics and Arts (JMA). JMA* has been a vehicle for the publication of peer-reviewed works by authors from all over the world. Bridges community celebrated JMA's fifteenth successful year, in which Reza Sarhangi (Fenyvesi, 2016; Shrestha, 2018; Torrence, 2019) was hugely invested in its founding. The diverse mix of scholars with a wide variety of expertise, viewpoints, exchanging ideas, and interlocking of this math-art scholarly community illustrates JMA's ever-expanding global outreach. It is a reminder of Reza's visionary endeavours, born out of his passion for shared and broad interests in the interdisciplinary spiral of mathematics and the arts. He inspired, transformed, and touched the lives of many people around the world. Continually recharged with his inspirational vision, we look forward to our 25th Bridges conference to be held at the Aalto University, Helsinki and Espoo, Finland, 1–5 August 2022.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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