Events

Geometrias'19 Polyhedra and beyond.
The Geometry of Drawing

Giuseppe Amoruso

Since 2013 *Aproged*, Association of Teachers of Geometry and Design in Portugal, organizes the *Geometrias* conferences, an international community of academics, artists, mathematicians, data scientists, and students promoting research and practical applications in the field of advanced representation, a disciplinary field nowadays revolutionized by emerging digital tools. The 2019 edition of *Geometrias*, the fifth organized by Aproged, was held from 5 to 7 September 2019 at the Mathematics Department of the Faculty of Sciences of the University of Porto.

The global science par excellence, the geometry of drawing, finds extensive space in the conferences *Geometrias*, to be exploited in its paradigms and encourage interdisciplinary discussions and connections between theoretical research and practical studies: polyhedra and geometric constructions but also spatial visualization and computational analysis of art, invention, mechanics, economics of forms for an evolutionary strategy of the most innovative scientific thought. The geometry of drawing, as Riccardo Migliari wrote, is also the process that plans the construction of physical objects, which geometric science controls in shape and size [Migliari 2012]. In short, it is the connection

between idea and its practice. Building according to a creative process that combines form, order and structure following an algorithmic and repeatable process. Graphic synthesis of imagination, geometric place of inventiveness, which expertly uses different tools, persevering in the discovery of the most rational and productive method, even in an optical of beauty and harmony.

All the presentations of *Geometrias'19* (plenary sessions, papers, and posters) favored, with eclectic and productive contributions, discussions on the importance of the geometry of polyhedra for the development of projects and research in architecture, art, engineering and materials science as well as the teaching of geometry. In this regard, keynote lectures of invited speakers, Henry Segerman, Javier Barrallo, Manuel Arala Chaves, Michael Hansmeyer and Rinus Roelofs, were crucial in emphasizing the importance of an accurate geometry and modeling expertise, practicing both physical and virtual reality or including 3D printing at the final stage, an essential workflow, nowadays, to improve visualization in mathematics. Inevitably, computational and generative projects and the enormous possibilities that are now accessible through digital tools have been key

to many of the lessons presented and will certainly continue to be a source of inspiration for upcoming research on the conference topics.

The previous editions of *Geometrias* have progressively contributed to a scientific universe closely linked to geometry and its numerous operations which, as Buckminster Fuller reminds us, play the role of researching and anticipating, to scientists, designers and artists, models to rule spaces, structures, materials and architectures [Gabel, Walker, 2006]. A world whose historical foundations are distant in time and linked to philosophical thought to explain the natural phenomena and that cosmos to which the Greek philosopher Plato, in 360 a. C., refers in his book which takes its name from the Pythagorean Timaeus of Locri [Platone 2009]. To the four fundamental elements of nature, water, air, earth, and fire, Plato associates as many regular polyhedra. The need to give order emerges with great vitality still today by the numerous works presented at *Geometrias'19*, it's an ancestral desire to understand the appearance of things and to go beyond the nature phenomenology: building physical relations between structures, now governed by algorithmic modeling, hold together form and function in formal
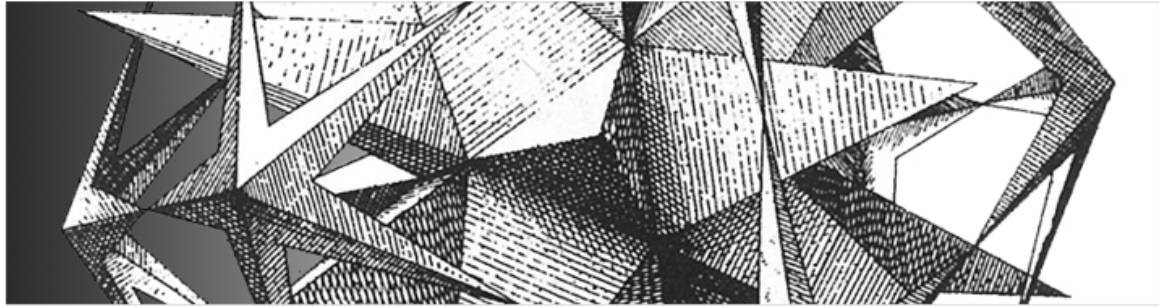
Fig. 1. Event banner.

characterization but also need to untie ideas and things, according to an ideal of harmony that geometry continues to bring in its representations and manifestations. The tetrahedron by fire, the icosahedron by water, the octahedron by air, and the cube by earth; but there remained the fifth combination of faces, edges and vertices and the "demiurge", the divine creator, used it to explain the total image of the universe: it was the figure that Plato loved most, the dodecahedron, the quintessence of a world often mysterious. To make it less intrinsic and hidden, Henry Segerman (Oklahoma State University), in the 2019 edition, presented a keynote lecture entitled *Artistic Mathematics: Truth And Beauty*; his research mission is to realize accurate and effective images, models and visual experiences of mathematical concepts exploring

connections between geometry and three-dimensional topology. Author of the book *Visualizing Mathematics with 3D Printing*, Segerman, a modern demiurge, transfers mathematical art and visualization of complex shapes through 3D printing and virtual reality explorations [Segerman 2019].
Illustrating polyhedra, among the focuses of *Geometrias'19*, through projective applications, modeling, interactive visualizations of augmented reality becomes increasingly a tool in scientific research to expand knowledge and suggest new applications. How can we overcome the boundaries of the imagination in an era where digital manufacturing makes it possible to quickly print constructions in 3D?
Some answers were formulated by Michael Hansmeyer, architect and programmer, who researches on algorithms to generate and fabricate

architectural shapes. In his opening lecture, to address research about what he defined "tools of imagination" Hansmeyer provoked the scientific community with the key question "But can we fabricate more than we can design?"
His words drew attention to how urgent it is to study tools for research and creative exploration of phenomena, rather than simply apply control and execution routines. The designer must be able to experience an iterative cycle that uses technologies and its applications according to a new practical concept of analysis and discovery, moderating processes and incorporating feedback, discovers and proposals from digital resources. For Hansmeyer cosmos is the one that intertwines art, mathematics, and architecture according to generative processes and computational

architectures; his projects are the-atrical scenes, sets and installations, arabesques and three-dimensional grotesque as those built for the recent exhibition *Mutations-Créations/Imprimer le monde* (Centre Pompidou, Paris 2017). Tools are investigated to increase efficiency and precision in representation, according to Hans-meyer, must also evolve in the ability to imagine creative trajectories to overcome the limits of geometry and show the face of complexity, in his words, "to draw the unimaginable and to imagine the unimaginable".

An event of particular interest, held during *Geometrias'19*, was the workshop *Making Paper Polyhedra Models proposed* by Rinus Roelofs and dedicated to the first book historically dedicated to the theme *Underweyssung der Messung*, also known as the *L'arte della misura*, published in 1525 by Albrecht Dürer [Dürer 1525]. One of the illustrations in this book is the folding plane from which the icosahedron is derived. Most likely, Roelofs reminds us, Dürer was not aware of the fact that the same folding plane could be used to create another uniform polyhedron, the tetra-helix: the same plane, the same plane figures to fold but two different models of polyhedra! The author has proposed a series of "dishes" based on polyhedra (his workshop was organized as a lunch with appetizers, first, second and dessert!) proposing combinations and assembly of two solids in a single model: the tetrahedron combined with a cube, then the cube inside the dodecahedron, the star of Escher (designed by the Dutch artist in his namesake woodcut) or the rhombic dodecahedron following Kepler and Poinsot. The polyhedra "dessert", the final assignment, was a tribute to
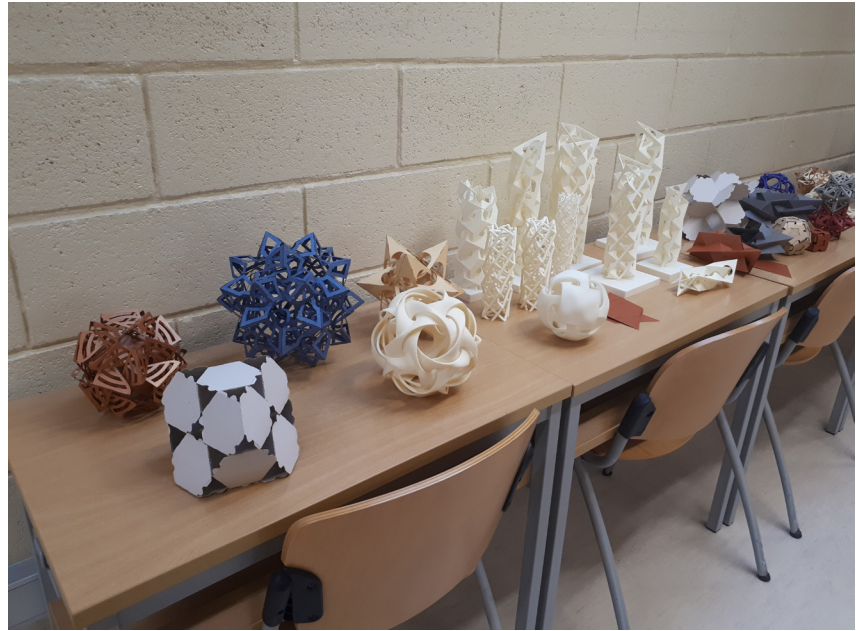

Fig. 2. Some models exhibited during the event.

Branko Grünbaum who in 2003, published some methods through which it is possible to create new uniform polyhedra. One of his methods is called "doubling the faces" or reorganizing the connections of the squares in such a way that twelve square faces again form a normal polyhedron.

During the conference, knowledge, and applications of polyhedra and geometric structures have been widely achieved thanks to the extraordinary commitment of Helena Mena Matos and João Pedro Xavier (Universidade do Porto) and Vera Viana (president of Aproged), promoters of *Geometrias'19*, which once again contributed with multifaceted mastery to enrich the interdisciplinary dimensions and operational

tools of international research on geometry and to bring the world of the arts closer to the world of science.

"Seeing two different worlds in the same place and at the same time makes us feel like we're at the mercy of a spell. Only an artist can give us this illusion and arouse in us an exceptional sensation, a completely new experience of the senses" [Ernst 2007, p. 73] wrote Maurits Cornelis Escher masterfully crystallizing in his works, defining himself as an artist, techniques, and rules of geometry in a harmonious relationship between mathematics and art where senses, surprised and suspended, let appear, to the curious gaze of the observer, one or the other.

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