

# Mindful Geometries: Making and Moving Inside the Icosahedron

Daniela Bertol

Space Ink, New York, US; danielabertol2018@gmail.com

## Abstract

The role of geometry in human movement is not as evident as the presence of geometric configurations in art, architecture and design. In this paper, I summarize how my research on geometric configurations transitioned, from theoretical explorations and computational design, to built objects and movement practices. The geometric properties of the icosahedron, one of the five regular polyhedra, are applied to interpret the proportions of the human body, guiding and inspiring movements leading to mindfulness.

## Introduction: The Geometry of Movement

Galileo Galilei poetically defined the universe as “written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures” [1]. Mathematics and geometry are essential in the understanding of the physical world, not only as foundation of science, but also as components in the human-made world and the built environment. Geometry is not only a means in physical sciences but also guides and inspires artists, architects and designers: “floor patterns, proportions in architecture, symmetry in paintings, and the harmonic sequences in music, are only a few of the countless examples of the presence of mathematics in human arts endeavors.” [2]

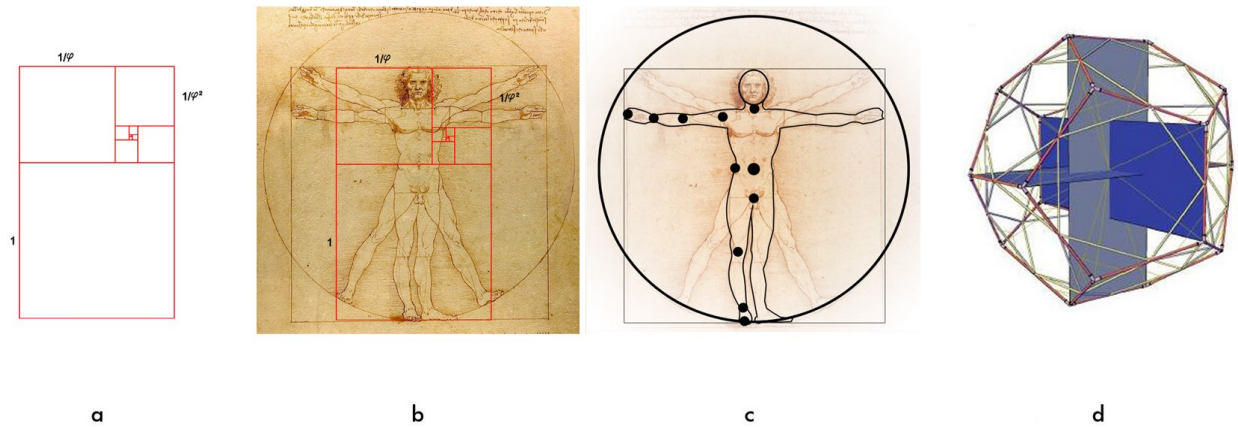
The geometric interpretation of the physical world provides also an understanding of its functioning, as expressed in the statement by the biologist D’Arcy Thompson “form is a diagram of forces” [3]. Thompson explorations of the relationship between geometric forms and structural properties in the fields of biology and morphology were also developed in design and engineering. Branching out of this discourse, the interpretation of form in relationship to physics has led my explorations of geometry from visual art and design to a movement practice, where the configuration of my moving body in space changes in time, embodying geometric forms—as expressed by the title of my doctoral research “Form Mind Body Space Time: The Geometry of Human Movement” [4]. This creative practice-based research explores the relationship between the moving human body and its spatial surroundings: the geometry of space is embodied by movement. A phenomenological first-person approach validates theoretical geometric explorations through methodological actions of designing, making and moving, which develop in cycles and iterations.

My research on the geometry of movement draws on the theories of Rudolph Laban (1879-1958), mainly renown in the field of dance and human movement analysis [5]. Laban established a series of movement sequences related to the five regular polyhedra, as shown by photographs of dancers, practicing and performing inside constructions based on the icosahedron. In my work, I develop the geometric primitives comprising the icosahedron—vertices, edges, faces—into more complex constructs called ‘movement infrastructure’, which evolve into built modular systems at human scale. In the ‘movement infrastructure’ the geometric elements of the icosahedron are developed into structural components whose formal characteristics and aesthetics are suggestive of movement sequences (Figure 2). The interaction between the mover and the ‘movement infrastructure’ supports and enables the production of movement, defined by the human body’s symmetry and proportions in relation to the geometric characteristics of the icosahedron. The aesthetics of movement is inspired by the geometric characteristics of the polyhedron: contractions and expansions follow encounters of faces into edges and vertices. Spiraling movements of arms and legs are often initiated in vertices and expand to the triangular faces of the icosahedron while aligning to edges.

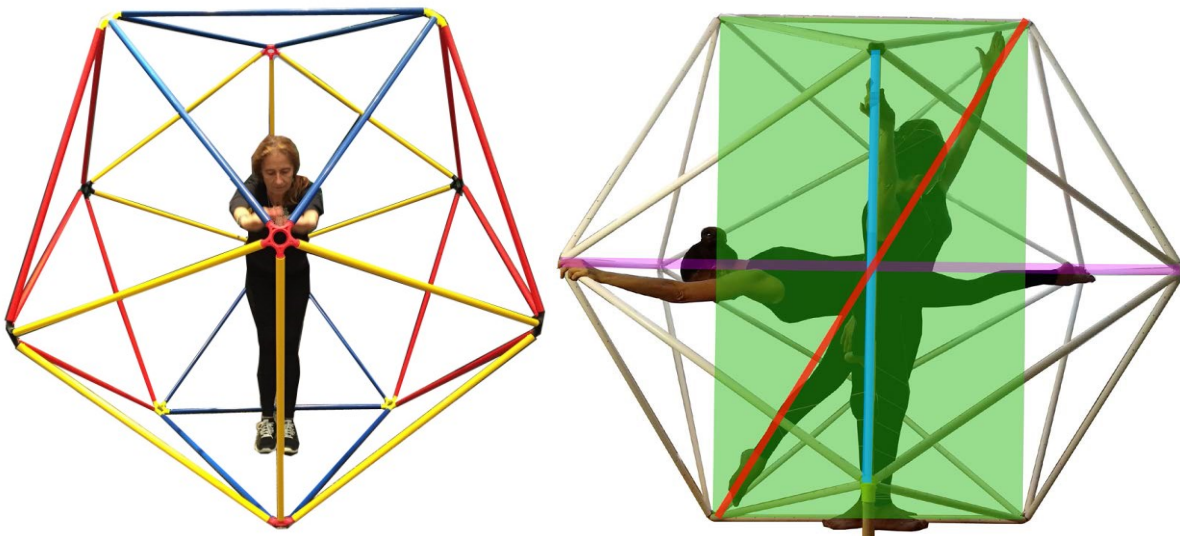
## The Human Body Proportions, the Icosahedron and the ‘Movement Infrastructure’

Though never truly shown, people (starting with Da Vinci) have long posited a relationship between formal geometries and the human body. This leads one to imagine the ergonomic aspects of movement performed inside an icosahedral structure. The twelve vertices of an icosahedron can be grouped to define three sets of orthogonal rectangles which lie in the three anatomical planes—sagittal, frontal, and horizontal—of a human body whose navel is often near the center of such icosahedron. The sides of each rectangle are also proportional to the golden ratio  $\phi$ , equal to 1.61803398875.

Leonardo da Vinci’s *Vitruvian Man* (c. 1490), illustrated a desired relationship between a human body and geometric shapes [6], and can also be interpreted according to the golden ratio (Figure 1), approximated to the ratio between the height and the distance between the navel and feet.



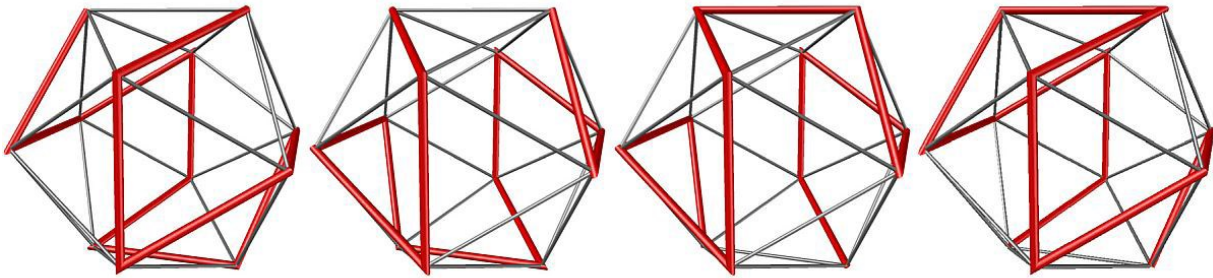
**Figure 1:** Human proportions and the icosahedron: (a) rectangles following the golden ratio; (b) *Vitruvian man* and golden ratio; (c) *Vitruvian man* and movement rotations joints; (d) the three anatomical planes inscribed in the vertices of the icosahedron.



**Figure 2:** The icosahedron and the ‘Movement Infrastructure’: (a) standing on a face; (b) the mover traces golden sections in the icosahedron resting on an edge

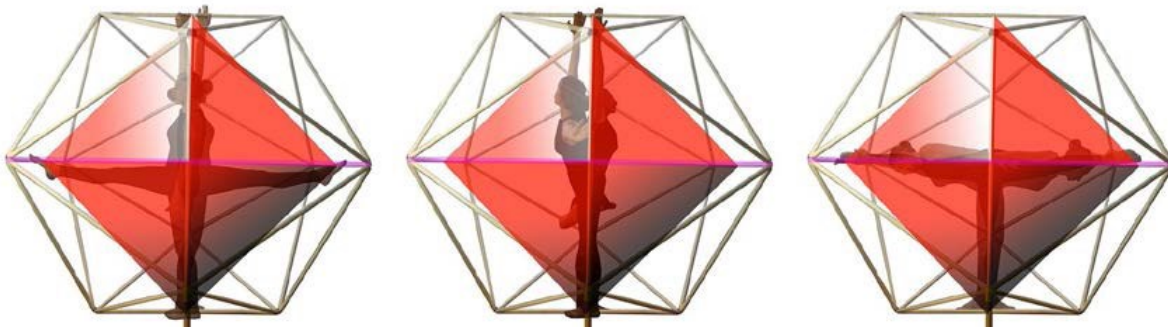
The ‘movement infrastructure’ was designed and constructed according to these considerations in terms of scale and size, based on an icosahedron inscribed in a sphere with a radius measuring 100 centimeters (Figure 2). Prototypes have been fabricated with 3D printed vertices/connections and off-the-shelf pipes. The edges of the icosahedron guide the performer in movement alignments, emphasizing the

geometry of the human body. The initial vertices-edges relationships generate a multitude of more complex geometric explorations associating the performed movements to intersecting spirals, helices and Hamiltonian paths (Figure 3). Some of Laban's dance routines, performed in the icosahedron and called "scales", also follow Hamiltonian paths.



**Figure 3:** *Hamiltonian paths inside the icosahedron.*

The design of the vertices/connectors is concerned not only with the fabrication of a utilitarian object, but is also characterized by an aesthetic intention, suggestive of the movements performed inside (Figures 2—4): the shape alludes to expansion and contraction, converging and diverging. The concentration on each vertex/connector is conducive to mindfulness, by eliciting focused attention: the movement practice becomes a dynamic meditation. The subject is guided by the geometric configuration of the connectors, whose curvilinear shape elicits fluid, wave-like movements.



**Figure 4:** *Geometric movements guided by the 'Movement Infrastructure'.*

### **Geometric Awareness and Mindfulness: Healing Geometries**

The research started with "Form Mind Body Space Time" has evolved in the brand *Healing Geometries* [7], a series of products and psychosomatic practices, establishing a "wholistic" approach to art and well-being as a mind-body practice. The icosahedral structure is both a physical and conceptual framework, a geometric universe where the subject can meditate by focusing the mind while moving—guided visually by structural elements. The flow between geometry inspired postures is based on a yoga vocabulary and, in my own and others' experience, elicits states of mindfulness and relaxation.

The main product of *Healing Geometries* is *PolyConnec*, the structural connector for the 'movement infrastructure' (Figure 5). Several prototypes have been designed and built using digital fabrication technologies. *PolyConnec* is scalable and multifunctional: intended uses range from public art and playground equipment to home fitness.

The logo of *Healing Geometries* (Figure 6) introduces a 'movement infrastructure' based on continuous spiral configurations. Each vertex/connector is the center of five spirals mapped on a spherical surface and transitioning to other sets of five spirals centered on adjacent vertices. The subject moves arms following each spiral and its transition into the next configuration; arm movements can initiate bending and twisting of other anatomical joints in countless cycles of expansion and contraction.

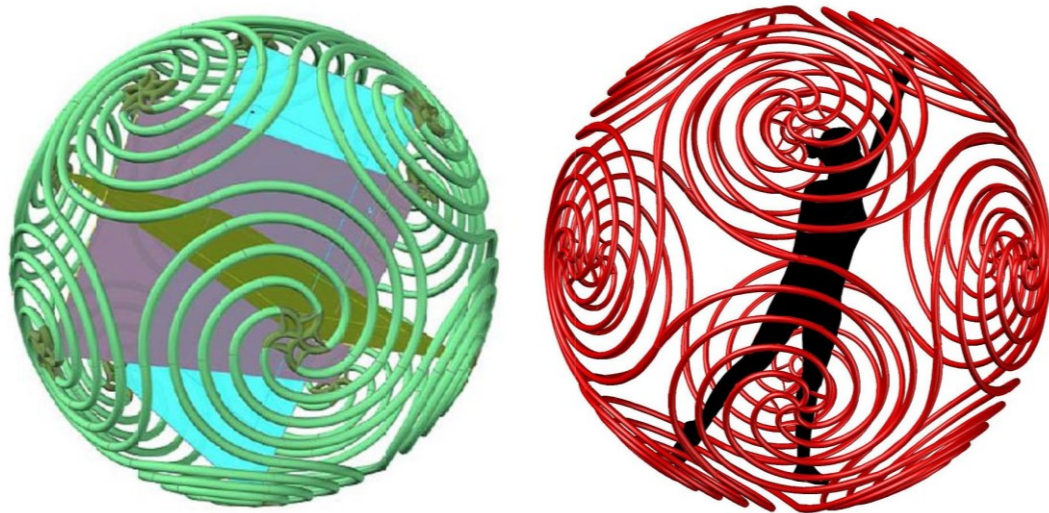




**Figure 5:** *PolyConnec: design digital models and built prototypes*

The movement practices of *Healing Geometries* brought mental, emotional and physical benefits in my life during extremely challenging times: I am a survivor of bullying and domestic abuse. Empirical observations from anecdotal evidence may evolve into clinical trials, tracking the brain activity of the subjects performing the movement sequences inspired by a geometric framework. Data from neuroimaging can be mapped to each sequence of movements; mental states can be associated to movements, in turn mapped to the many geometric patterns defined by the ‘movement infrastructure’.

*Healing Geometries* is a work in progress, bringing mathematical beauty to fulfill the initial intent of this research—how geometry informs several aspects of human life, in the integration of art, design and scholarly research to the service of humanity.



**Figure 6:** *Spirals and the icosahedron (left); Healing Geometries logo (right).*

### References

- [1] S. Drake. *Discoveries and Opinions of Galileo*, Doubleday, New York. 1957.
- [2] D. Bertol. "The parametric making of geometry: the Platonic solids." *International Journal of Rapid Manufacturing* 6, no. 1 (2016): 33-52.
- [3] D. W. Thompson. *On Growth and Form*, Cambridge University Press, 1917.
- [4] D. Bertol. *Form mind body space time—the geometry of human movement*. PhD. Deakin University, 2017.
- [5] R. Laban and L. Ullman. *Choreutics*, London: Macdonald & Evans, 1966.
- [6] P. Vitruvius. *Vitruvius: The Ten Books on Architecture*, New York: Dover Publications, 1960.
- [7] Healing Geometries. <http://healinggeometries.spaceink.net/>