

Art & Mathematics: *The Interstices of the Abstract and Concrete*

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Outline

- Motivation and Concepts
- Art and Mathematics
- Surfaces and Sculptures
- Scenes and Images
- Conclusions and Discussion

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Art and Mathematics

- Questions:
 - *What is the nature of these disciplines?*
 - *Which concepts are important for them?*
- Insights:
 - *Are they related?*
 - *If so, exactly how?*
- Motivations:
 - *Devise a common framework...*
 - *Look for integrated experiences...*

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Mathematics

“The Art of Abstract Constructions”

- Objects
 - Ex: *Set of Natural Numbers, $\{0, 1, \dots\}$*
- Transformations
 - Ex: *Arithmetic Operations, $(+, -, *, /)$*
- Relations
 - Ex: *Inequalities, $(<, >, =)$*

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Art

“The Science of Depicting Thoughts”

- Medium:
 - Ex: *Painting, Sculpture, etc...*
- Technique:
 - Ex: *Oil, Watercolor, etc...*
- Style:
 - Ex: *Impressionist, Cubist, etc...*

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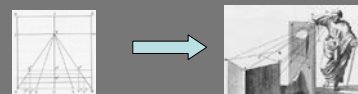
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Abstract and Concrete

- Mathematics
 - *From Concrete to Abstract*



- Art
 - *From Abstract to Concrete*



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Aesthetics

- Webster Dictionary:

Main Entry: ²aesthetic

Function: *noun*

1 : branch of philosophy dealing with the nature of beauty, and with the creation and appreciation of beauty

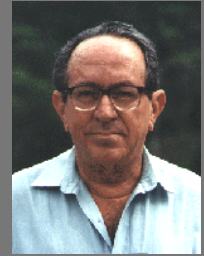
2 : particular theory or conception of beauty : a particular taste for or approach to what is pleasing to the senses
<modernist *aesthetics*>

* **OBS:** *Art* ⁽¹⁾ and *Mathematics* ⁽²⁾

Mathematics and Aesthetics I

Manfredo Perdigão do Carmo

- O Jornal – Maceió (Jan 10, 2002)



"A Matemática é essencialmente uma construção bonita."

"Ela é muito parecida com a música e a poesia".

"Embora tenha utilidade, a sua produção é um processo estético."

"Tento passar essa visão para meus alunos. Eles devem ver a beleza do que estão estudando".

Mathematics and Aesthetics II

G. H. Hardy

- A Mathematician's Apology (London 1941)

"The mathematician's patterns, like the painter's or the poet's must be beautiful; the ideas, like the colors or the words must fit together in a harmonious way."

"Beauty is the first test: there is no permanent place in this world for ugly mathematics."

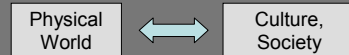
"A mathematician, like a painter or poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas."

"I am interested in mathematics only as a creative art."



Human Endeavors

- Stage



- Actions

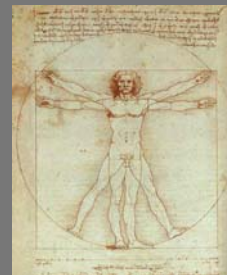
- Discovery
- Invention
- Construction
- Creation

Divided Men

- Mathematician
 - Discovers...
- Scientist
 - Invents...
- Engineer
 - Constructs...
- Artist
 - Creates...

Leonardo da Vinci

- United Man:



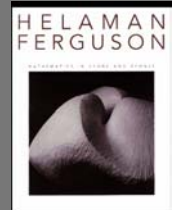
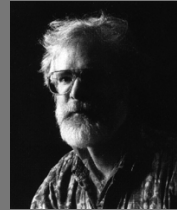
→ Synergism

Two Pathways

- Abstract → Concrete
 - Sculpting Mathematical Surfaces (Helaman Ferguson)
- Concrete → Abstract
 - Authoring Virtual Panoramas (Luiz Velho / André Parente)

Mathematics in Stone and Broze

- *Turning Equations into Sculptures*



How to Describe a Surface?

- Equations:
 - Implicit Form
 - Parametric Form
- Simple Example: (sphere)



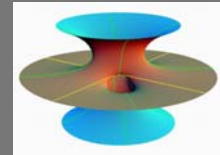
$$\{(x, y, z) \in \mathbb{R}^3 \mid x^2 + y^2 + z^2 - 1 = 0\}$$

or

$$f(u, v) = (\sin u \cos v, \sin u \sin v, \cos u), \quad u, v \in [0, 2\pi]$$

A More Complex Example...

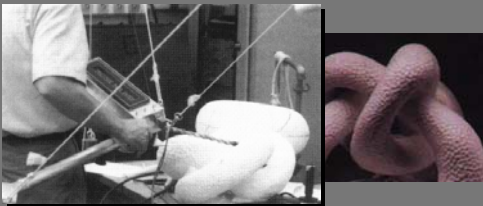
- Costa's Minimal Surface
 - Characterized by a Differential Equation



"Imersões mínimas completas em \mathbb{R}^3 de gênero um com curvatura total finita". C. Costa, Ph.D. Thesis, IMPA, 1982

Craftsmanship

- New Approaches / Traditional Methods



The Costa's Surface

- "Named after Brazilian mathematician Celso Costa, who, inspired by the twirling of a street dancer's skirt, formulated the equations describing a minimal surface with holes."



- Dimensions: 18" x 18" x 18"
Weight: 50 lbs
Materials: Silicon Bronze and Aluminum

Comments by the Author

"This sculpture exemplifies applied mathematics over the course of the past two centuries: start with physical observations about soap films in nature (Plateau), write down a differential equation model describing area minimizing surfaces (Euler-Lagrange), define a minimal surface geometrically in terms of curvature (Gauss), discover a minimal surface with non-trivial topology (Costa), draw computer images of the surface (Hoffman-Hoffman), recognize symmetry and prove the surface has no self intersections (Hoffman-Meeks), discover fast parametric equations for the surface (Gray), and finally return to nature with a sculpture, a solid form of a 'soap film' big enough to touch and climb on. The CRADA between NIST and my studio is a vehicle for applying new technological tools to create aesthetic objects."

Umbilic Torus

"The form of Umbilic Torus NC is a continuous donut-shape surface patterned with a space-filling curve"



- Dimensions: 27" x 27" x 9"
- Weight: 100 lbs
- Materials: Silicon Bronze with Antique Green Patina

Wild Beasts



- **Alexander Horned Wild Sphere.**
Dimensions: 10"x8"x6",
Materials: Silicon Bronze,
1988.



- **Incised Torus**
Dimensions: 8" x 8" x 4"
Weight: 5 lbs
Materials: Polished Silicon Bronze .

Torus with Cross Cap

- Carved out of styrofoam and cast solid by "styrofoam perdue"



$$3x = x + h;$$

$$2x \neq h$$

- Material: Silicon Bronze,
Dimensions: 7"x8"x4",
Weight: 12 lbs

Four Canoes

"Toroidal forms can be thought of as two canoes sewn together and bent round. Translated past and rotated through one another, these double canoe Klein bottle forms with double cross-caps, couple inextricably mysteriously."



- Installation: University of St. Thomas, St. Paul, Minnesota, USA
Dimensions: 9' x 7' x 9' (standing aspect) 21' x 20' (plaza tiling) . Weight: 9 Tons
Materials: Red and black granite, quarried and cut by Cold Spring Granite, MN

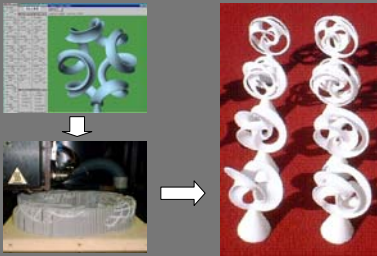
Putting it in Place

- "The piece presented a tremendous technical challenge: how to marry the two Klein Bottles..."



Subtle Point

- What about Hardcopy?



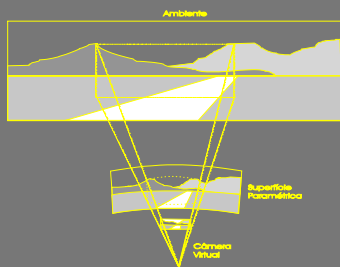
Visorama

“Virtual Reality System Based on Panoramas”

- Joint Project:
 - VISGRAF Laboratory (IMPA)
 - N-Imagem (ECO / UFRJ)
- Multidisciplinary Research:
 - New Technologies
 - New Languages

Virtual Panoramas

- Projection of the World into a Support Surface



Creating a Panorama Model

Shooting



Registering



Stitching



Visualization of Panoramas

Panorama Model

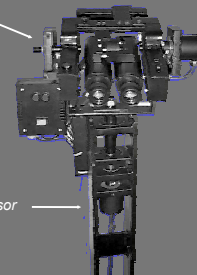


Virtual Camera



Viewing Device

Rotating Head



Tilt Sensor

Pan Sensor

Paão de Açúcar

- Virtual meets Real



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Paisagem Carioca

- Past and Present



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Rear Window Installation



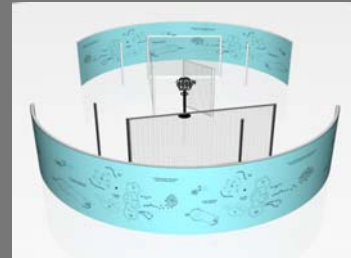
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Atravessamentos

- Collaboration with artist Ricardo Basbaum



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Visorama in the Museum

- Interactive Cinema



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Conclusions

- Experiences with Mathematics and Art
 - Abstract
 - Concrete
- Aesthetic Issues
 - Concepts
 - Embodiment
 - Confrontation

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