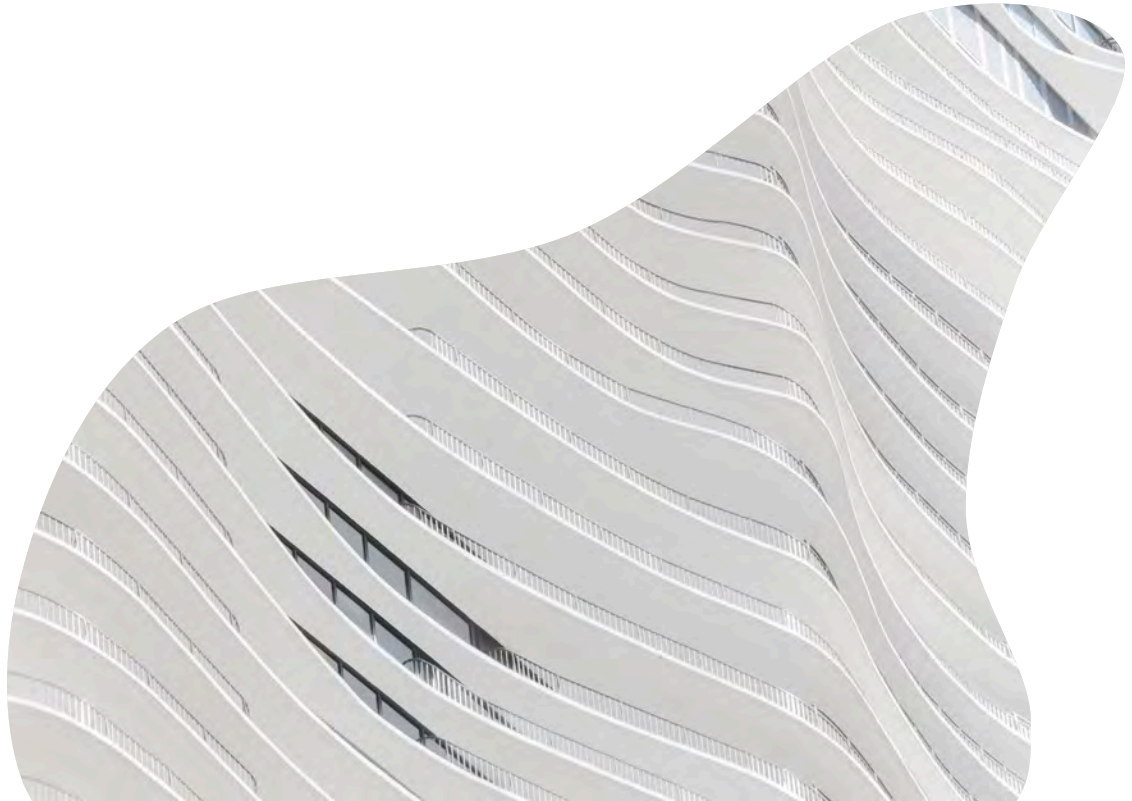
Week 5
Parametric Design



This week we will be looking at parametric design, its relation with computational design, parametricism and parametricism 2.0, parametric design thinking and how designers use parameters.

Photo by Christian Perner on Unsplash

Outline

01

Introduction to Parametric Design

02

Brief historical account

03

Parametricism

04

Parametric Design Thinking

05

Characteristics of Parametric Design System

06

How Designers Use Parameter

Photo by Clark Van Der Beken on Unsplash

Aims and objectives

- To **introduce** the concept of parametric design
- To **contextualise** parametric design within the umbrella of **computational design field**
- To infer **parametric design thinking**
- To provide illustration on **how designers can use the concept** in their practices

Learning outcomes

Students will be able to..

01 Summarise **what is** parametric design and **its key differences** with non-parametric design

02 To infer **main potentials** of parametric design

03 Critically **inform their design practice** with regards to parametric design

(module)

Overarching skills

Theory, history and current debate

Understand historical background of this notion and relevant debates.

Important concepts

Digital fabrication and construction
Digital design cognition
Human-computer interaction
Digital craftmanship
etc

Design precedents

Learning through analysis of completed project

Personal interest

Exploring a preferred scope of design to be developed further

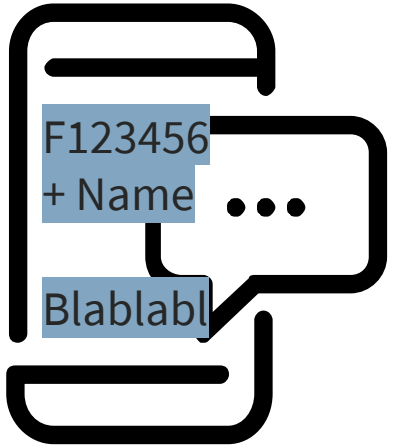
Research skills

Designing through extensive research

Software skills

Rhino, Grasshopper, etc

Discussion



Discuss: To what extent do you agree that Parametricism is a style, as mentioned by Patrik Schumacher?

https://miatedjosaputro.com/2020/03/24/week-5-discussion/

Introduction to Parametric Design

What is Parametric Design?

Photo by Pierre Châtel-Innocenti on Unsplash

- Parametric Design is a process **based on algorithmic thinking.** *
- Enables the expression of **parameters** and **rules** that together; **define, encode and clarify** the relationship between **design intent** and **design response**. *
- A parametric design system is defined by its: **input, algorithm and output.** *
- Focus mainly on **geometry and topology.** *

*Jabi, W. (2013). *Parametric design for architecture*, Laurence King Publishing.

Figure 3 shows that parametric design is the most popular term in literature between 1978-2018.

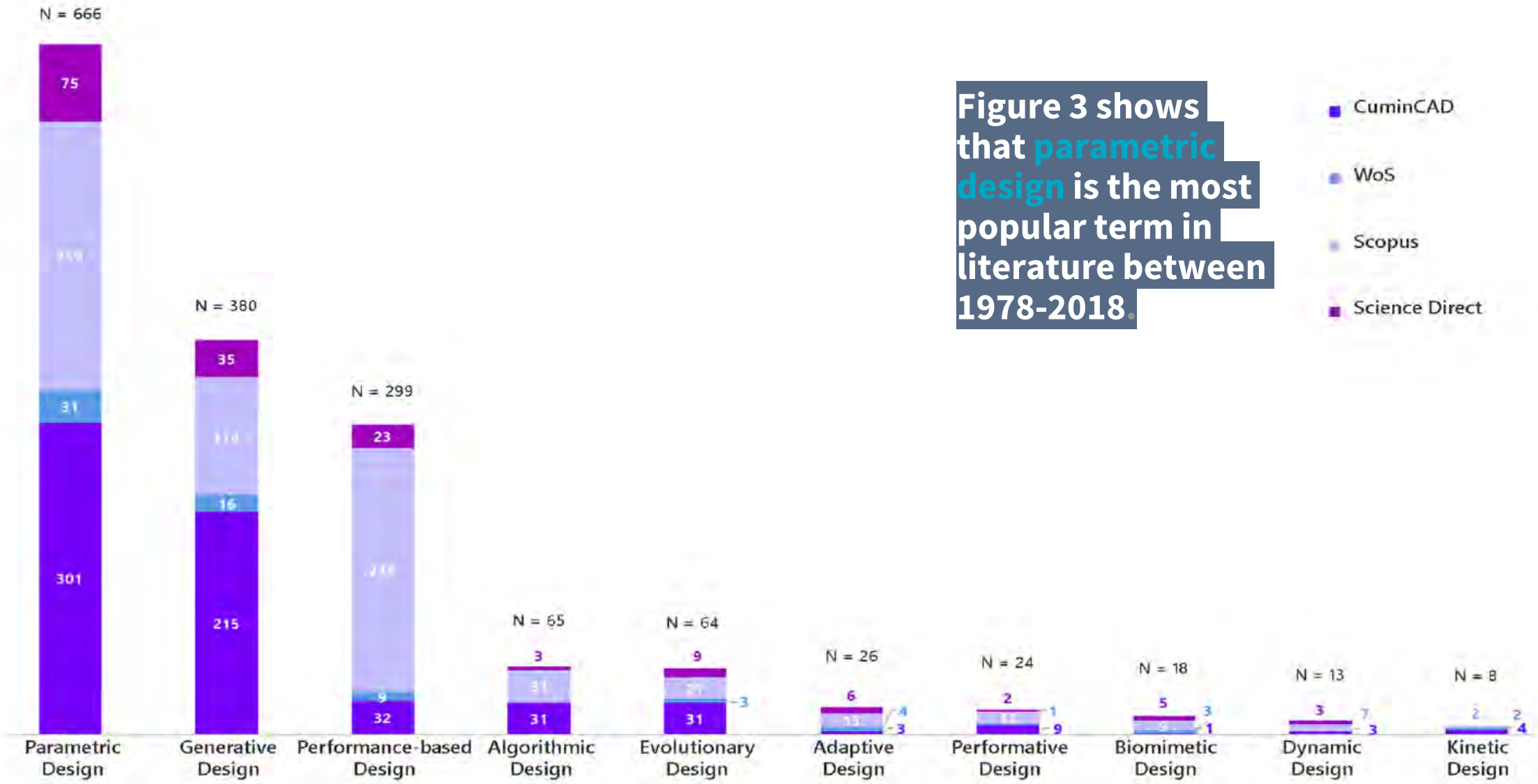
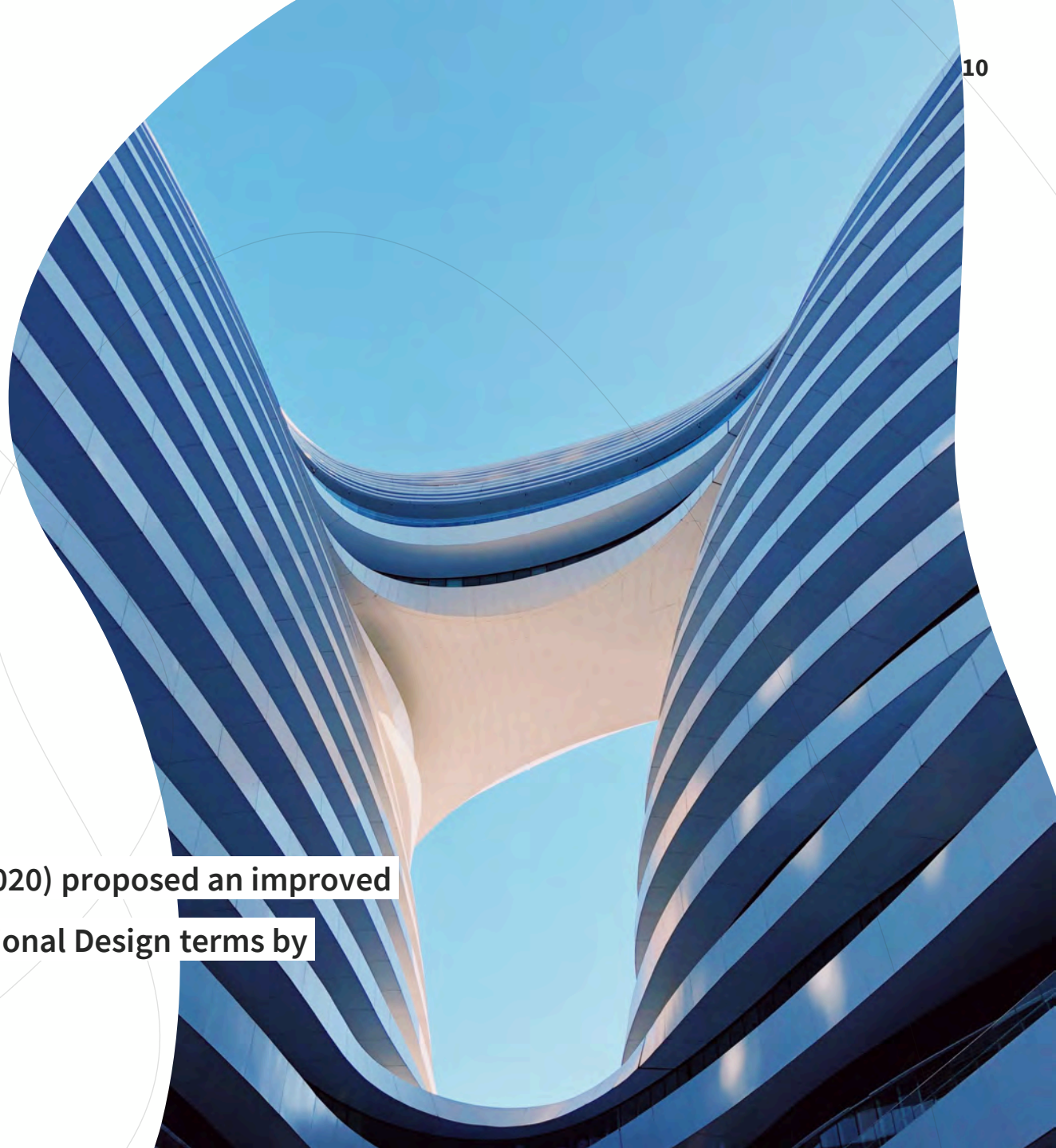


Fig. 3 Number of times each CD term appeared in the literature between 1978 and 2018.

Caetano, I., Santos, L. & Leitão, A. (2020). Computational design in architecture: Defining parametric, generative and algorithmic design. *Frontiers of Architectural Research*.

Computational Design:
1. Parametric
2. Generative
3. Algorithmic Design



Caetano et al. (2020)

Contextualisation of parametric design within other similar approaches. Caetano et al (2020) proposed an improved and sound taxonomy for the set of key Computational Design terms by analysing existing terminology.

Photo by Jimmy Chang on Unsplash

Computational Design:

1. Parametric
2. Generative
3. Algorithmic Design

Caetano et al. (2020)

Parametric Design is design approach based on the use of parameters to describe sets of designs.

Computational Design:

1. Parametric
2. Generative
3. Algorithmic Design

Caetano et al. (2020)

Generative Design is a design approach that uses algorithms to generate designs.

More autonomous than parametric design.

Computational Design:

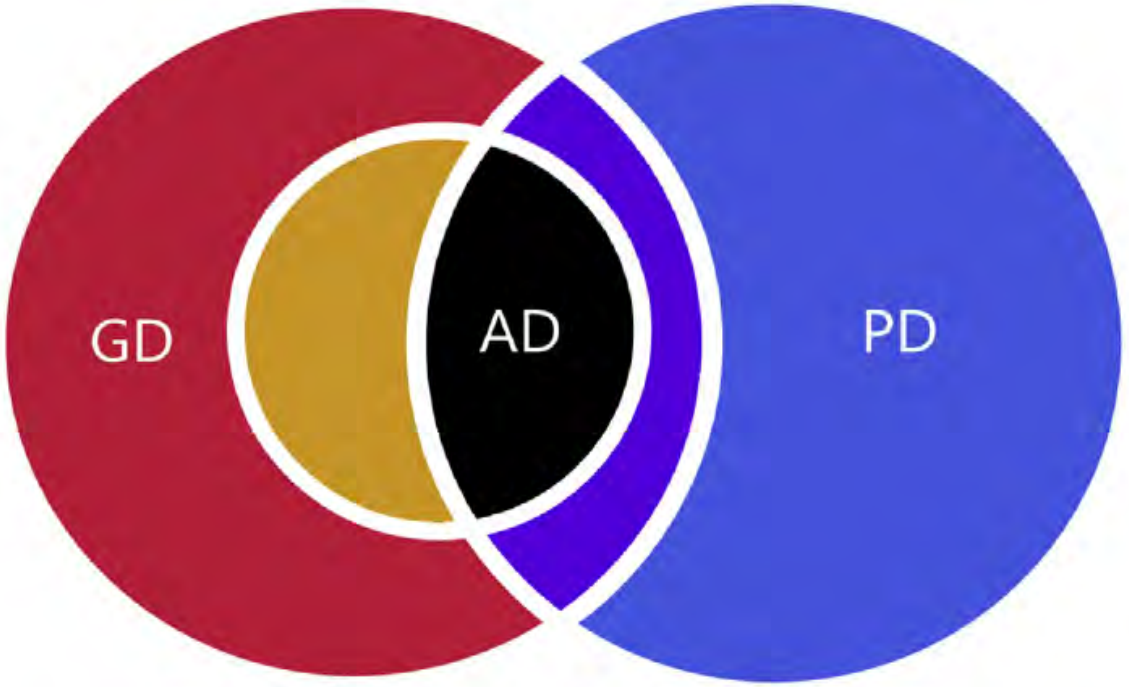
1. Parametric
2. Generative
3. Algorithmic Design

Caetano et al. (2020)

Algorithmic Design is a Generative Design approach characterised by an identifiable correlation between the algorithm and its outcome.

Computational Design:

1. Parametric (PD)
2. Generative (GD)
3. Algorithmic (AD) Design



Caetano et al. (2020) suggest the conceptual representation of the terms' extension regarding the Computational Paradigm.

Algorithm Design (AD) is a subset of Generative Design (GD).

Example of parametric design:

Hangzhou Olympic Sports Centre

NBBJ Architects

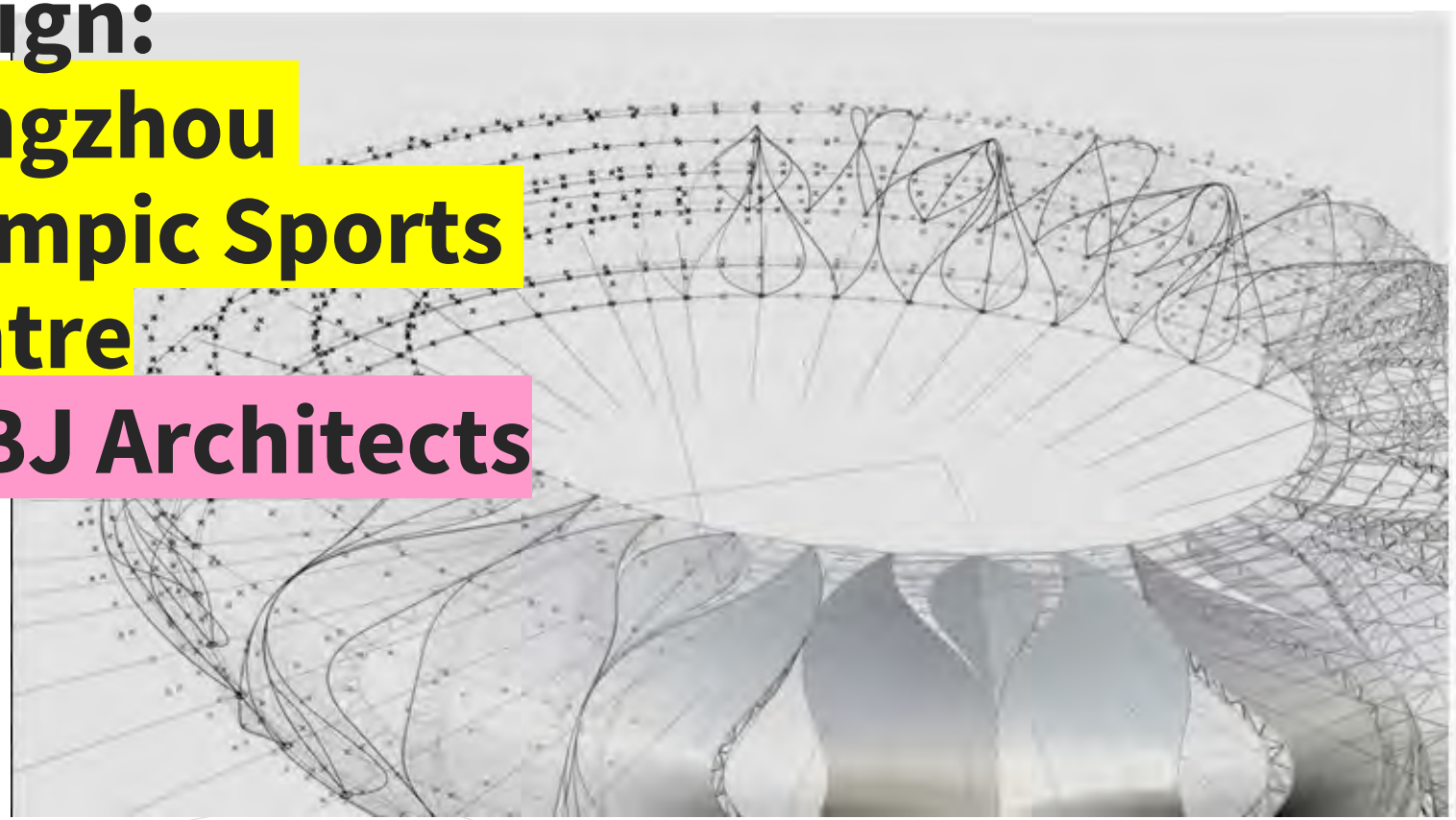
http://www.nbbj.com/work/hangzhou-stadium/#next

Paper on integrated parametric design process:
https://issuu.com/pabloherrera/docs/28122011_hz_tennis_issuu_original_2011

Example of parametric design:

Hangzhou Olympic Sports Centre

NBBJ Architects



Computational Design

NBBJ used computational design tools during schematic design and design development to refine the competition design and explore how best to maximize the fan experience, use less material such as steel and model energy performance.

1 of 10

Example of parametric design:

Hangzhou Olympic Sports Centre

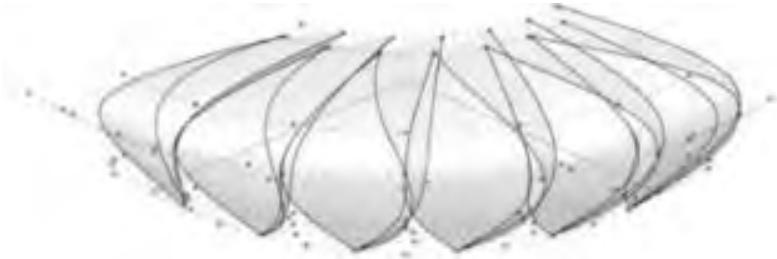
NBBJ Architects

Form variations, based on point cloud constraints

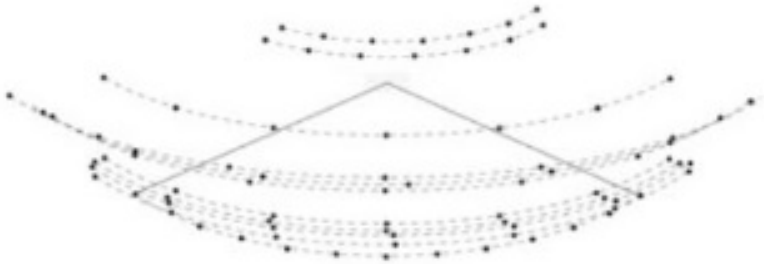
http://www.nbbj.com/work/hangzhou-stadium/#next

Paper on integrated parametric design process:
https://issuu.com/pabloherrera/docs/28122011_hz_tennis_issuu_original_2011

CIRCULAR ARC



CONTROL SURFACES



POINT CLOUD CONSTRAINTS

Example of parametric design:

Hangzhou Olympic Sports Centre

NBBJ Architects

Form variations, based on point cloud constraints

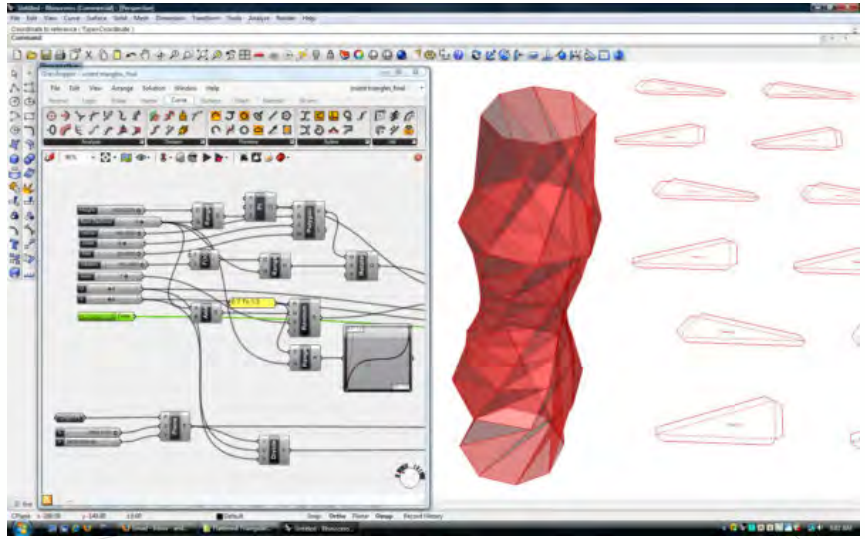
http://www.nbbj.com/work/hangzhou-stadium/#next

Paper on integrated parametric design process:
https://issuu.com/pabloherrera/docs/28122011_hz_tennis_issuu_original_2011

Figure 3. Variations on the exterior envelope. The point cloud constraints were manipulated to create different geometric effects. The number of petal modules could also be increased or decreased.

Common tools (plug-ins mostly) for parametric design

https://www.arch2o.com/10-parametric-plugins-every-architect-should-know/



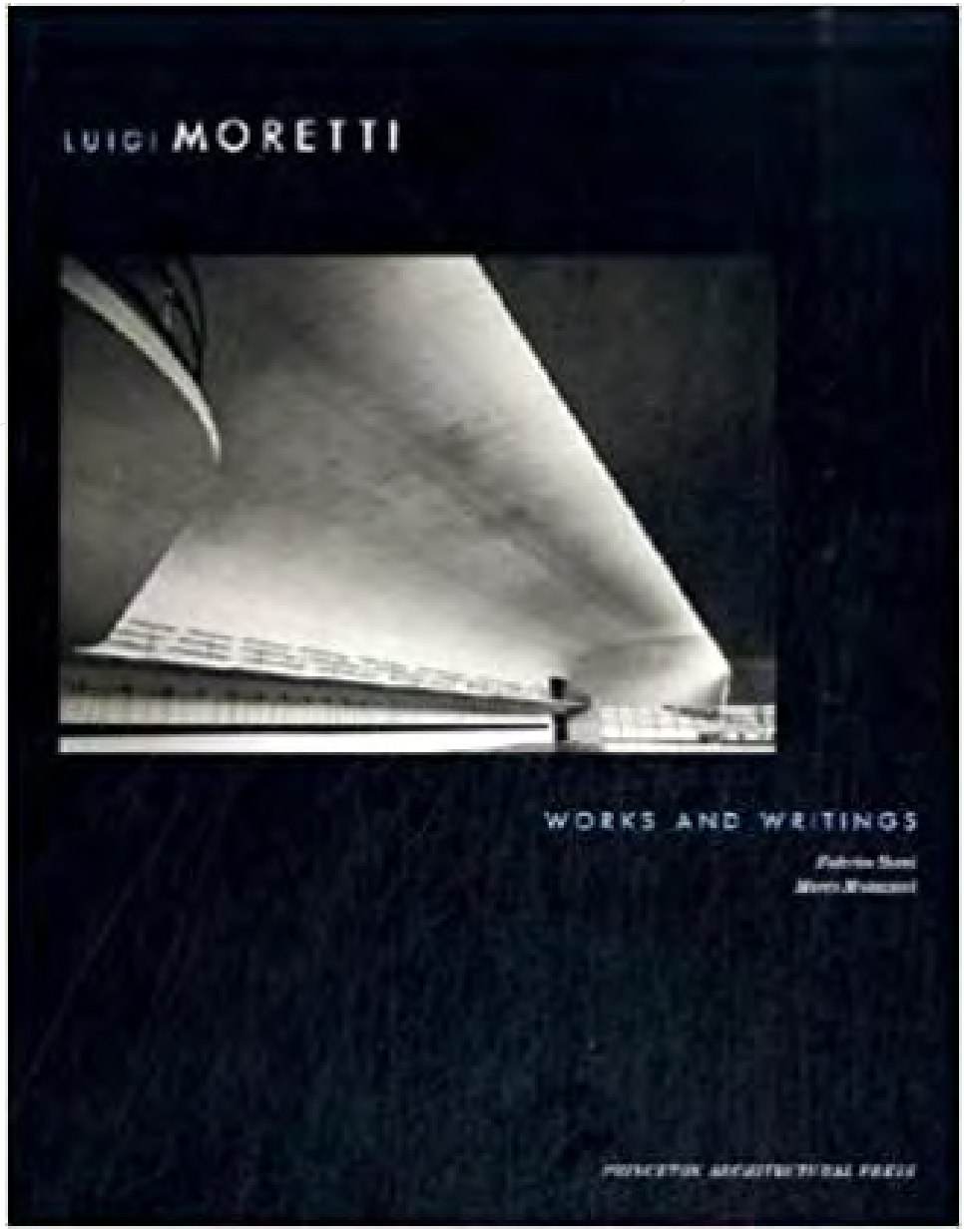
GRASSHOPPER 3D

1. **Grasshopper 3D-** most common
2. Ladybug (Environmental analysis)
3. Honeybee (environmental analysis)
4. Geco (environmental analysis)
5. Heliotrope-Solar (environmental analysis)
6. **Kangaroo** Physics (structural analysis)
7. **Karamba** (structural analysis)
8. BullAnt (structural analysis)
9. Hummingbird (structural analysis)
10. Mantis (structural analysis)

Brief historical account

Photo by Christian Perner on Unsplash

Architettura Parametrica, coined by Luigi Moretti



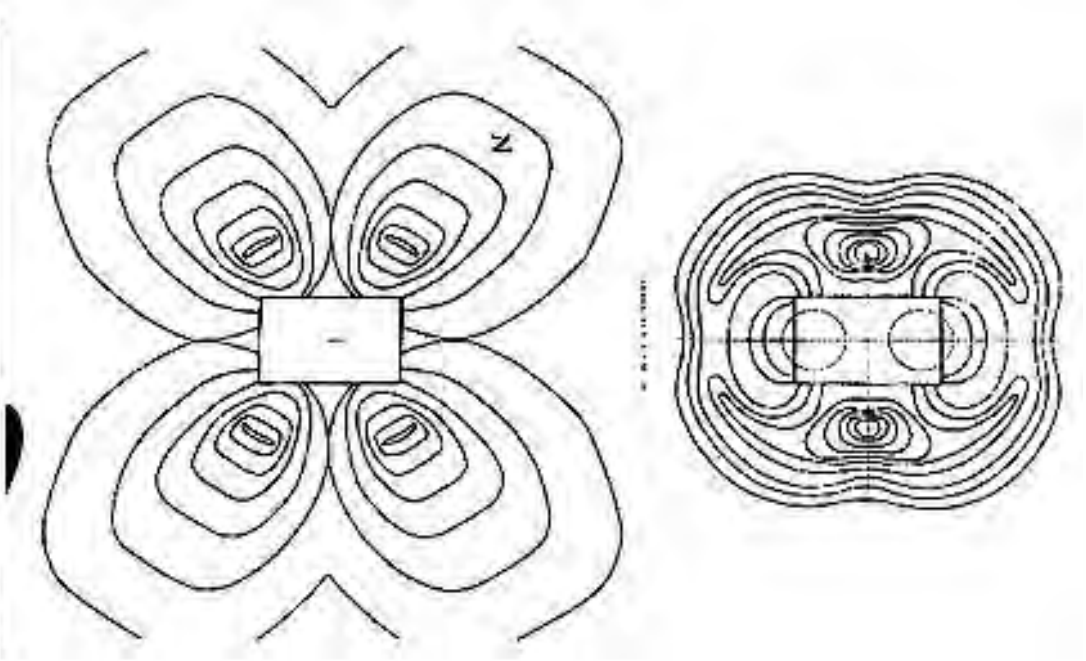
Moretti, L., Bucci, F. & Mulazzani, M. (2002). *Luigi Moretti: works and writings*, Princeton Architectural Press.

Architettura Parametrica, coined by Luigi Moretti

He did a research about the relationship between architectural design and parametric equations under the banner of ‘Architecttura Parametrica’ between 1940-1942. Initially without computer.

Eventually in 1960 he was able to exhibit the models of parametrically designed stadia- *Progetti di strutture per lo sport e lo spettacolo.*

Frazer, J. (2016). Parametric Computation: History and Future. *Architectural Design,* 86**,** 18-23.



Architettura Parametrica, coined by Luigi Moretti

“the relations between the dimensions dependent upon various parameters”

“the parameters and their interrelationships become [...] the code of the new architectural language, the "structure" in the original sense o f the word [...]. The setting of parameters and their relation must be supported by the techniques and tools offered by the most current sciences, in particular by logics, mathematics [...] and computers. Computers give the possibility to express parameters and their relations through a set of (self-correcting) routines".

Moretti, L., Bucci, F. & Mulazzani, M. (2002). *Luigi Moretti: works and writings*, Princeton Architectural Press.

c1960

Sketchpad (1963)

Ivan Sutherland

Sketchpad was defined as *“A Machine Graphical Communication System”*

Parametric system for architectural design

Sketchpad (1963)

Ivan Sutherland

Based on advanced **associative logic**, an innovative feature which facilitated **links** between objects.

Sagrada Familia

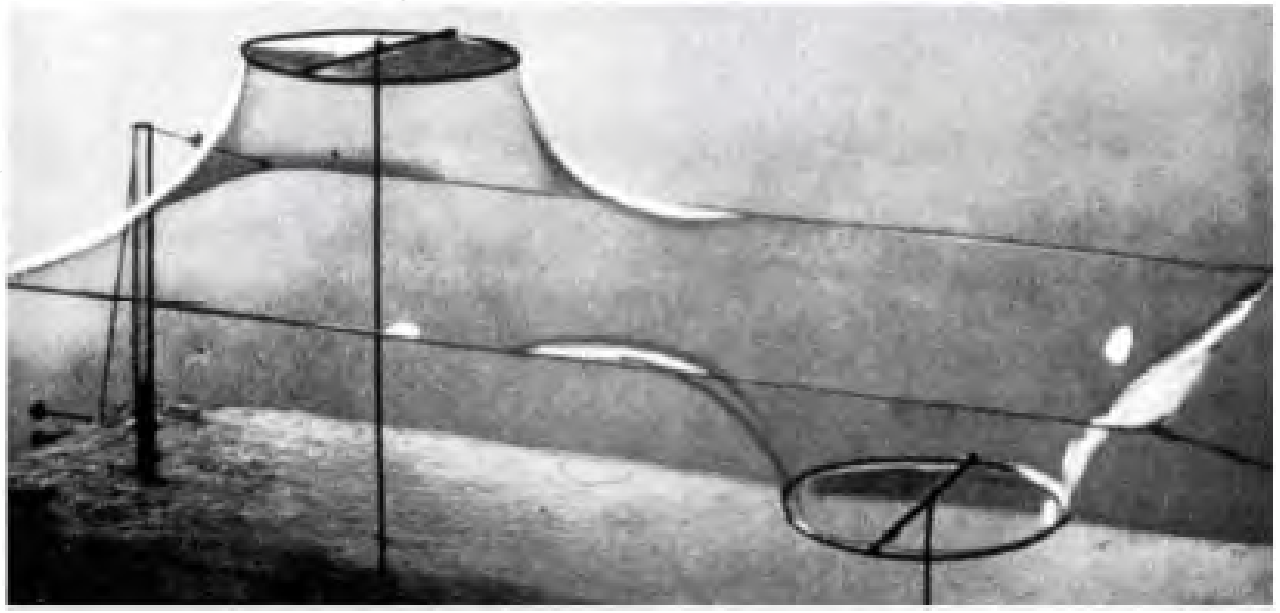
Antoni Gaudi

Used gravity as one of the nature’s parametric outputs.

Frei Otto

Experimental model

Bubbles to emulate tensile structure



Parametric design now:

Dependent on a parametric model

Patrick Janssen defines a parametric model as:
"an algorithm that generates models consisting of geometry and attributes (e.g. material definitions). This algorithm uses functions and variables, including both dependent and independent variables. Some of the ***independent variables*** *can be given a* ***more prominent status****, as the interface to the parametric model – these are referred to as the* ***parameters of the model****."*

Cited in Frazer (2016).

Frazer, J. (2016). Parametric computation: History and future. *Architectural Design,* 86**,** 18-23.

Parametricism

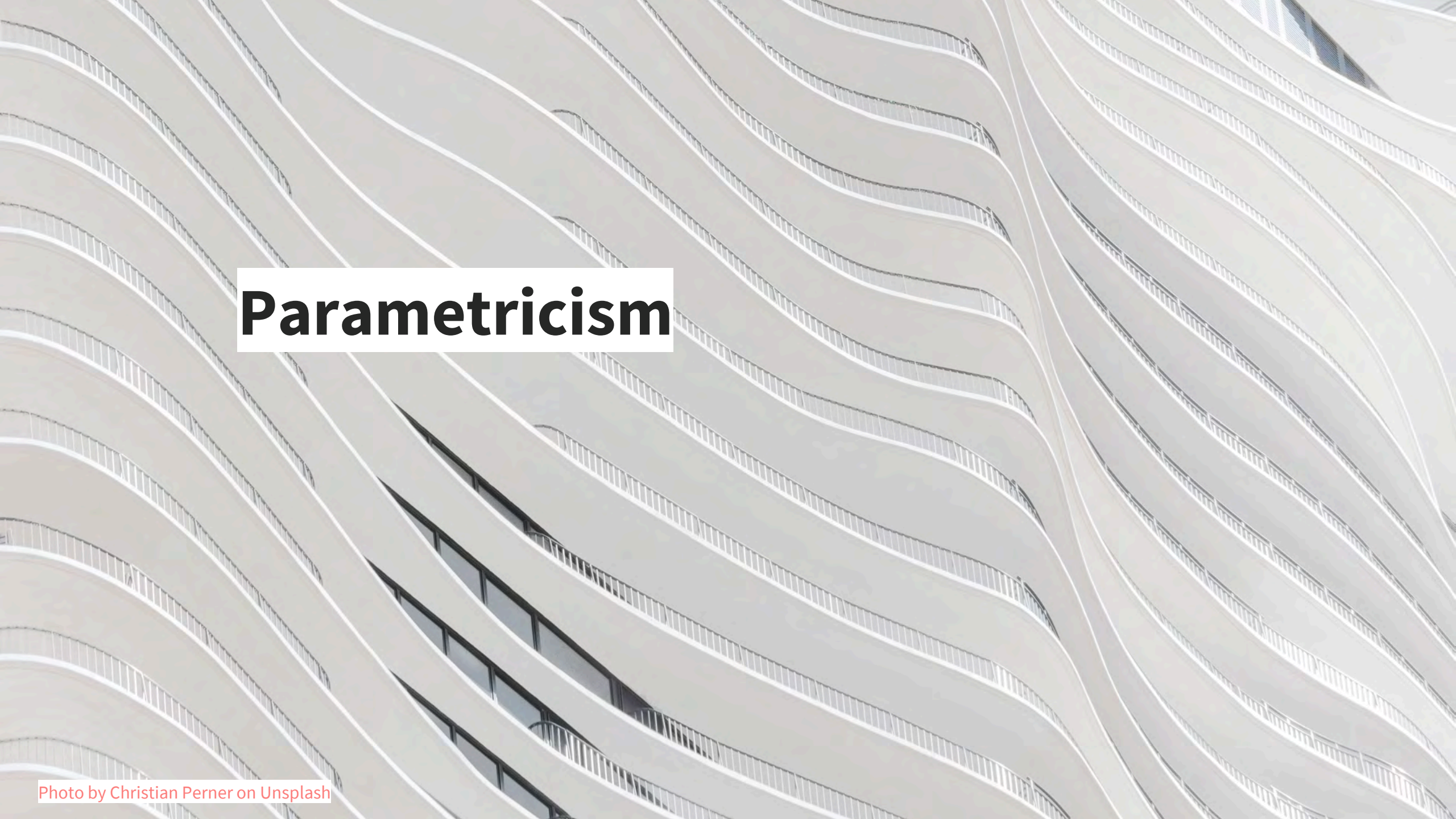


Photo by Christian Perner on Unsplash

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

“Algorithm is a procedure used to return a solution to a question- or to perform a particular task- through a finite list of basic and well-defined instructions.”

It follows human aptitude to split problems to a set of simple steps. So that they can be computed.
A basic analogy to this is a cooking instructions, however it needs to be well-defined.

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

Important properties of algorithm

1. **An unambiguous set of properly defined instructions**
2. **Expects a defined set of input**
3. **Generates well-defined output**

Visual scripting

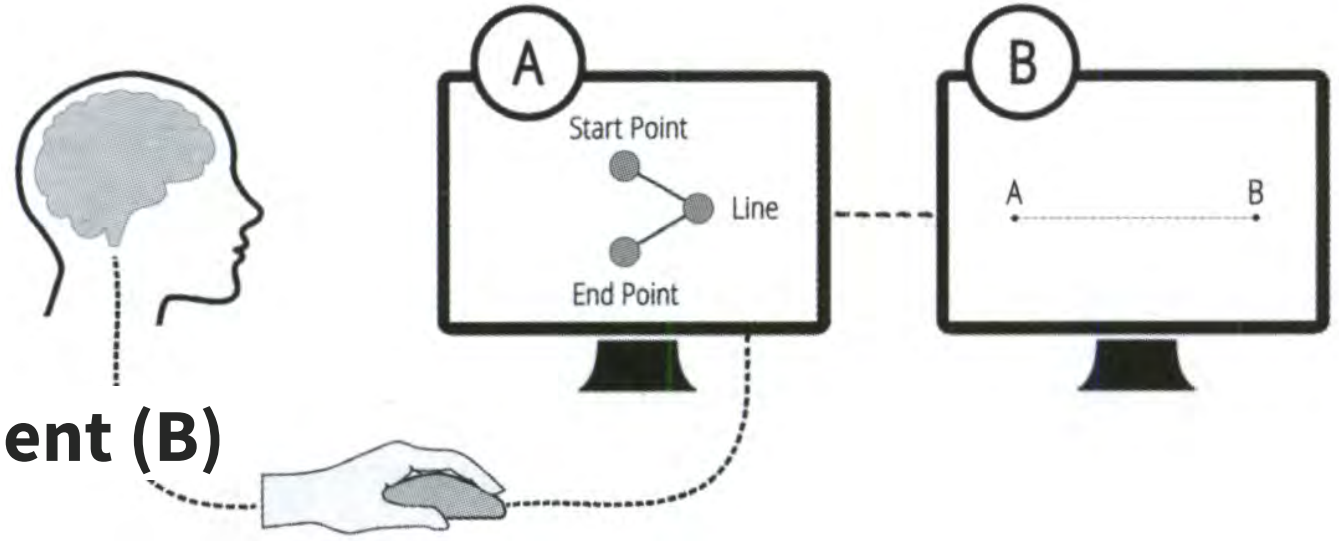
Going back to the cooking instructions we mentioned..

1. Instructions need to be well defined (duration, amount, etc)
2. Amount of ingredients (input) has to be precisely declared
3. No vagueness
4. Well defined output

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

There are two working environments:
Visual Editor (A)
3D Modelling Environment (B)



Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

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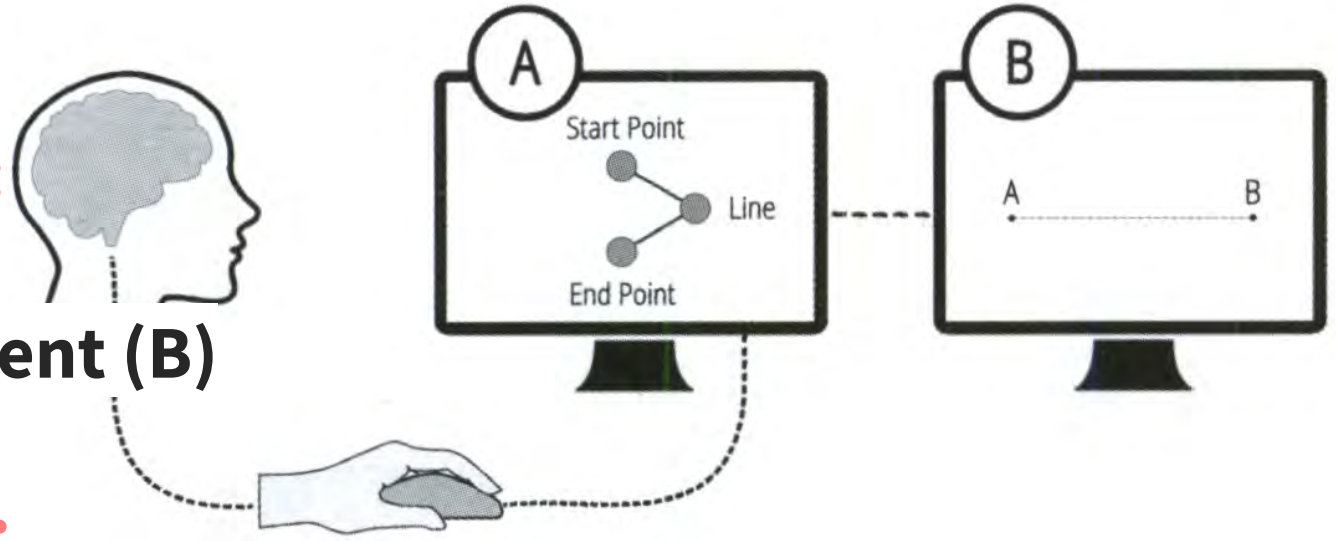
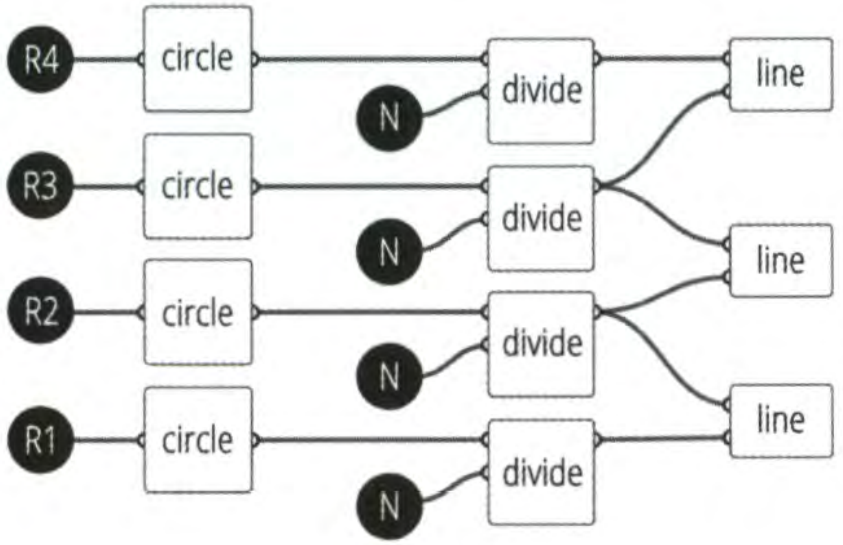


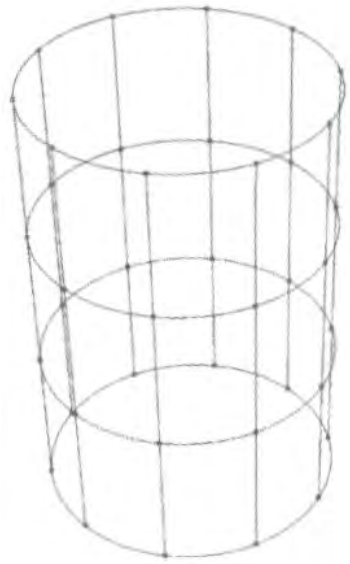
Producing two outputs:
Node diagram, called *parametric diagram*
Output of *parametric diagram* constituted by parametric 3D or 2D geometry.

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

0. ***Draw four circle***
1. ***Subdivide the four circles into N parts, we get N points for each circle***
2. ***Connect the corresponding points***





VISUAL TRANSPOSITION OF THE ALGORITHM

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

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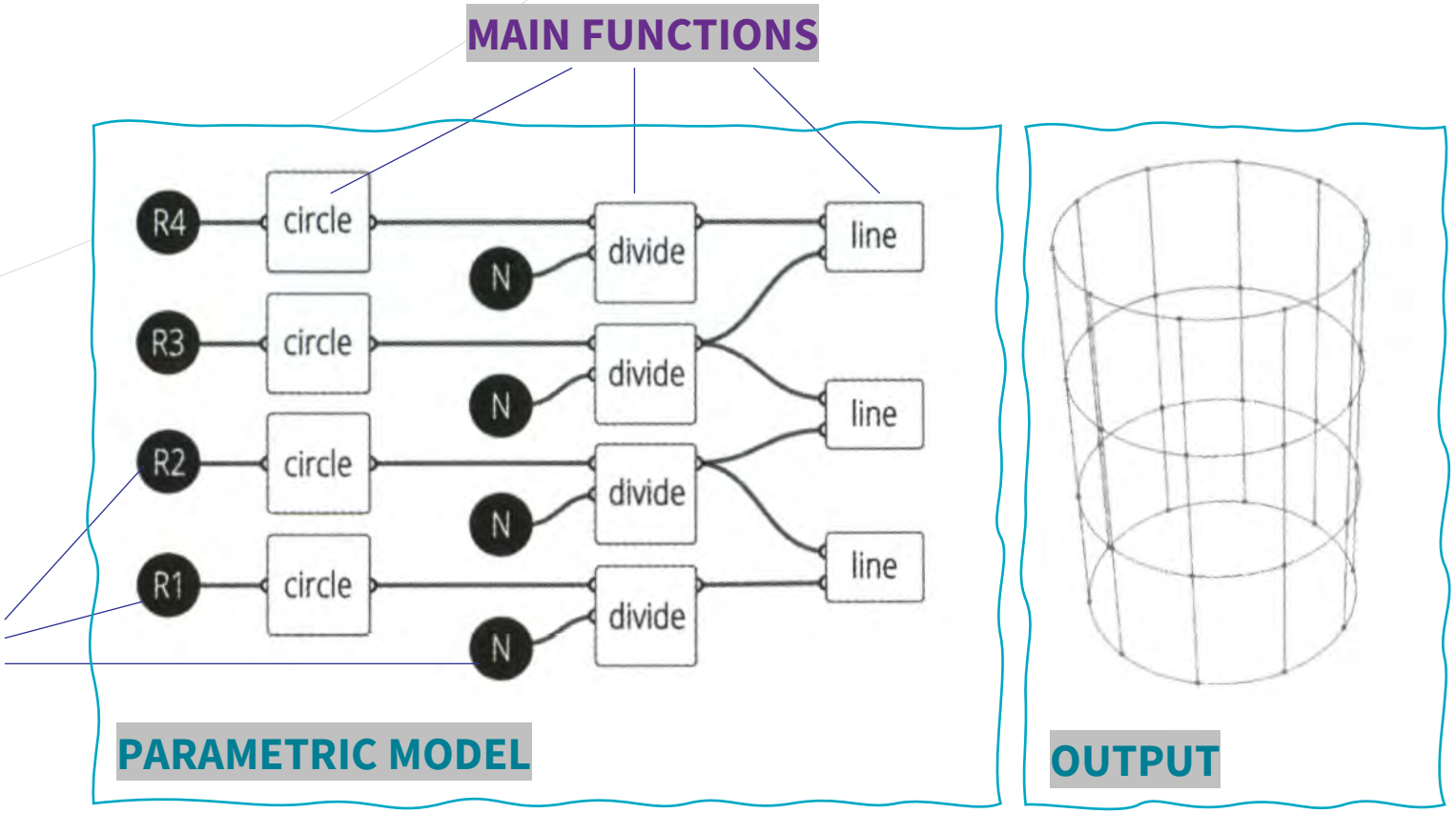


VISUAL TRANSPOSITION OF THE ALGORITHM

The advantage of the *parametric diagram* is in the intuitive logic, which allows designers to manipulate parameters.

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

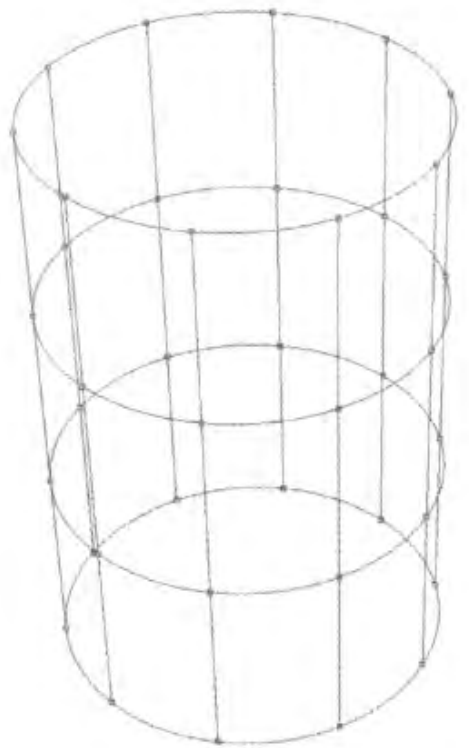
Algorithm can define every type of geometry.

The image Tedeschi illustrate can be sketched by writing following list of instructions:

0. Draw four circle

1. Subdivide the four circles into N parts, we get N points for each circle

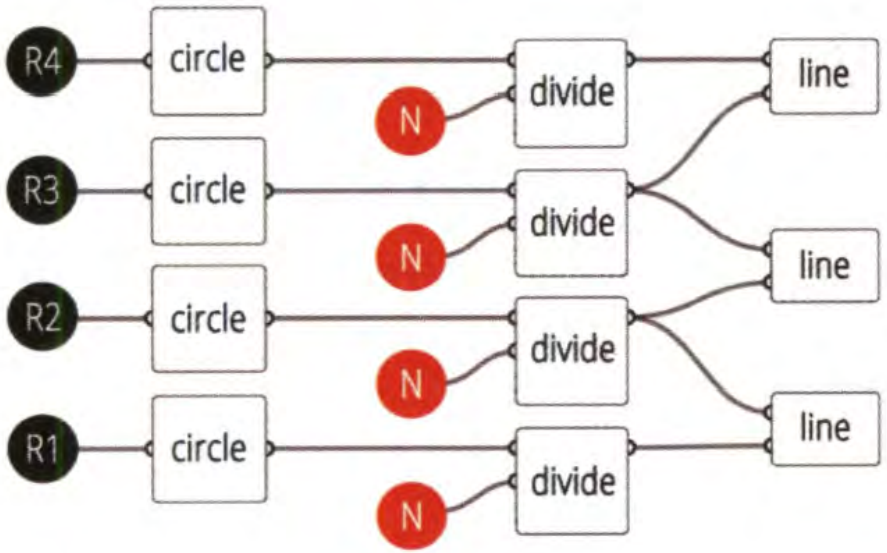
2. Connect the corresponding points

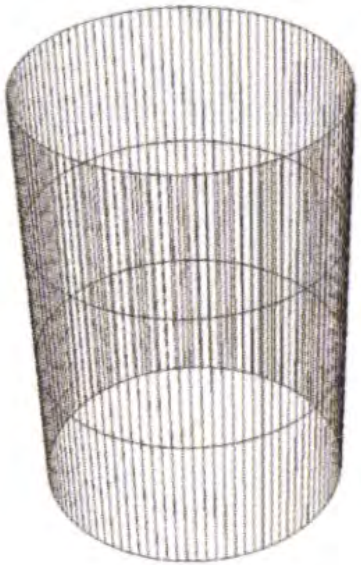


Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

What happen if parameters are being manipulated?



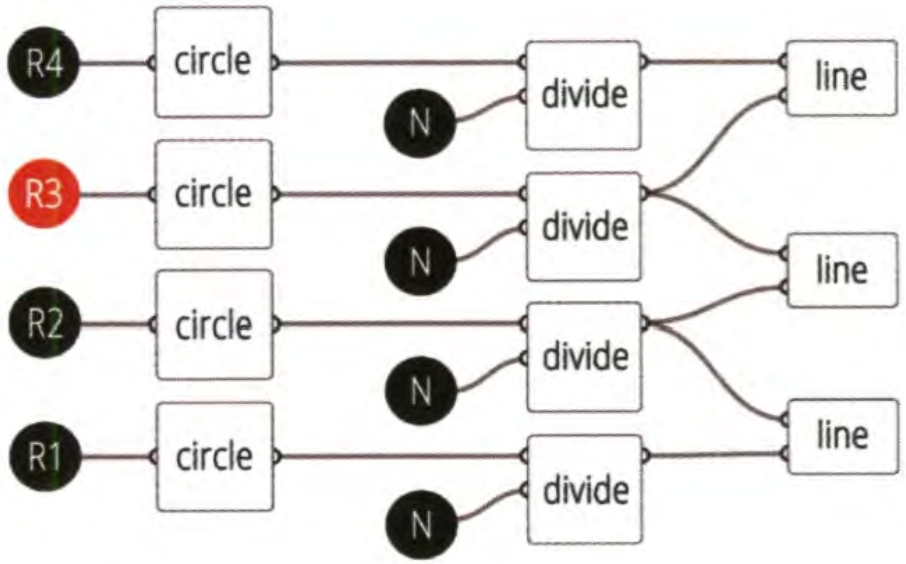


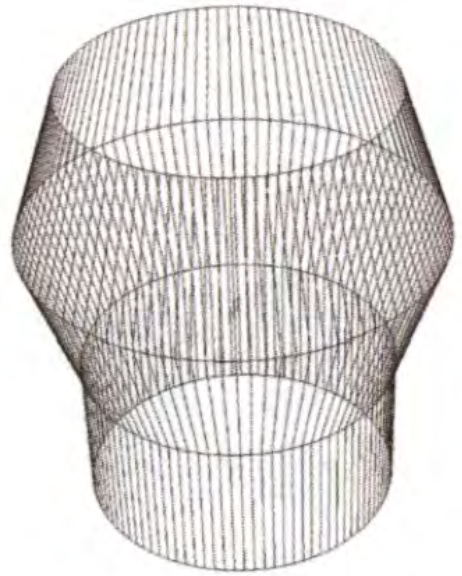
N PARAMETERS ARE MODIFIED, MORE LINES ARE GENERATED

Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

What happen if parameters are being manipulated?





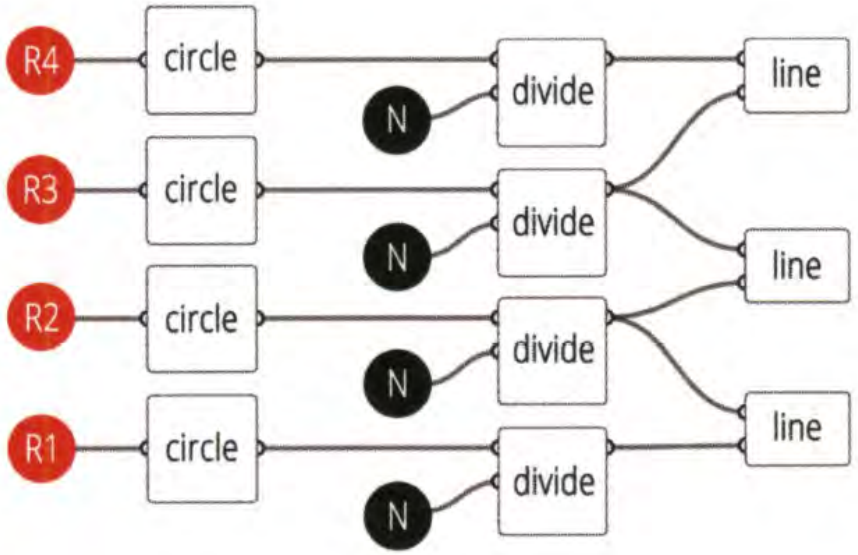
R3 IS MODIFIED, RADIUS OF CIRCLE 3 IS INCREASED IN FIGURE

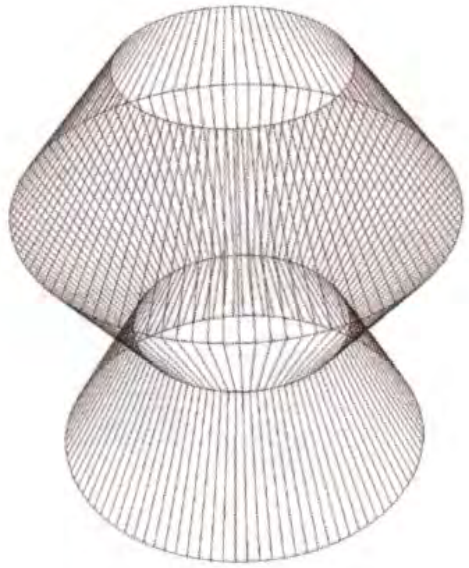
Visual scripting

Tedeschi, A. (2014). *AAD, Algorithms-aided design: parametric strategies using Grasshopper*, Le penseur publisher.

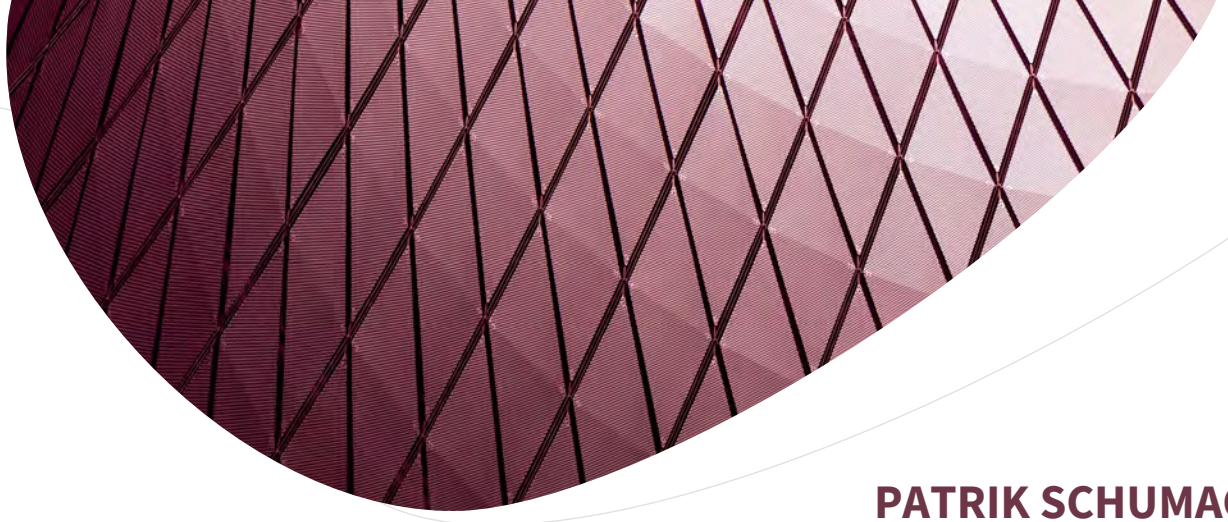
What happen if parameters are being manipulated?

The parametric diagram has potentials to create **associative models** that explore multiple configurations.





R1, R2, R3 AND R4 ARE MANIPULATED

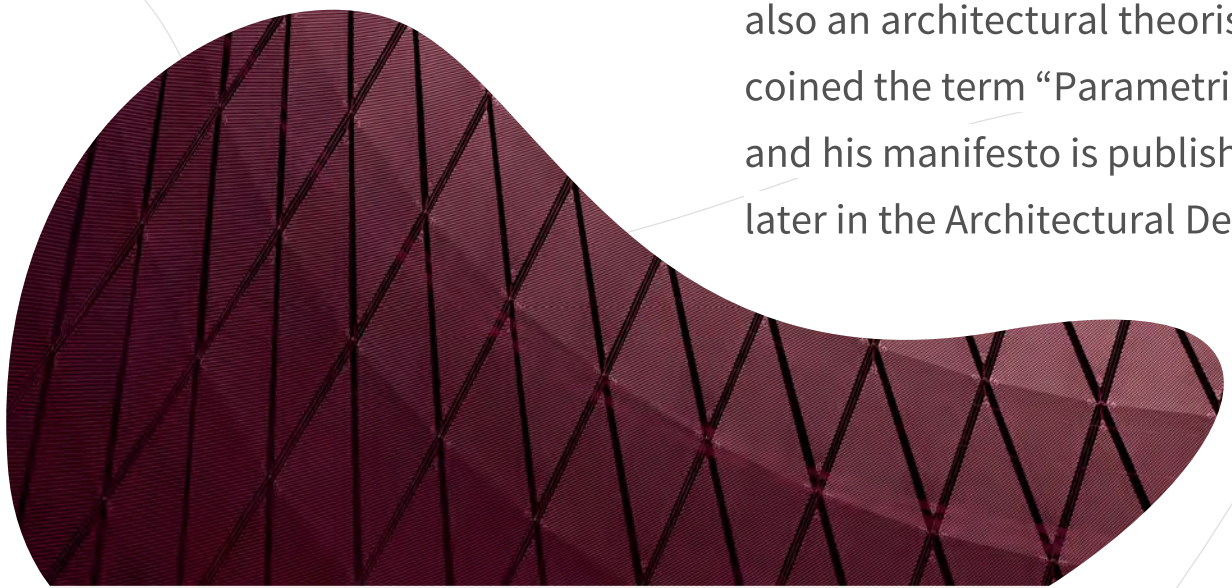


PATRIK SCHUMACHER ON PARAMETRICISM AND PARAMETRICISM 2.0

Patrick serves the director of Zaha Hadid Architects, and has been leading ZHA since Hadid's death in 2016. He is also an architectural theorist . He coined the term "Parametricsm" in 2008 and his manifesto is published a year later in the Architectural Design journal.

He considered Parametricsm as a global convergence in recent avant-garde architecture which elucidates of a new style. Parametricm 2.0, opinionated in 2016, is set to solve socio-environmental problems.

https://en.wikipedia.org/wiki/Parametricism



Parametricism 1.0 (2009-2014)

Schumacher, P. (2009). Parametricism: A new global style for architecture and urban design. *Architectural Design,* 79, 14-23.

Link to publication from Schumacher's website, click here.

- An avant-garde architecture style
- Rooted in digital animation techniques
- Based on **advanced parametric design systems** and **scripting techniques.**
- "The great new style after modernism"
- Parametricism comes **from creative exploitation of parametric design systems** in view of articulating increasingly complex social processes and institutions.
- Relevant on **all scales** from architecture, interior to urban design.

Parametricism 1.0 (2009-2014)

Schumacher, P. (2009). Parametricism: A new global style for architecture and urban design. *Architectural Design,* 79, 14-23.

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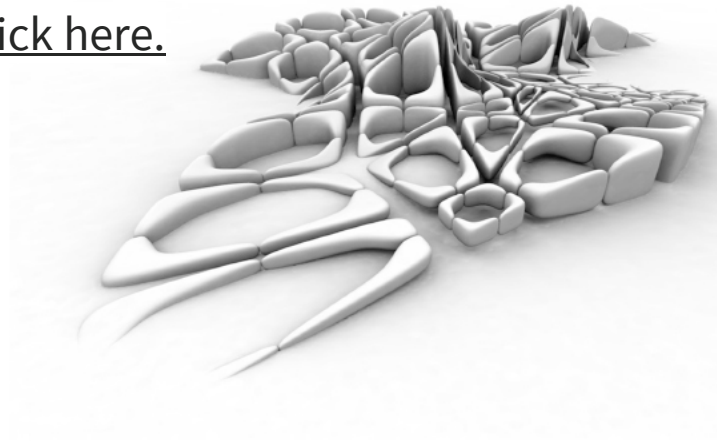
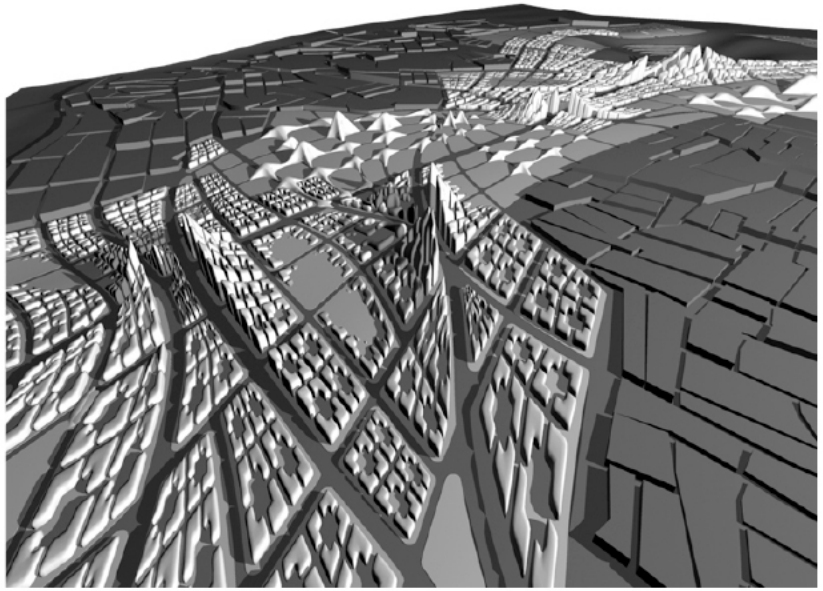
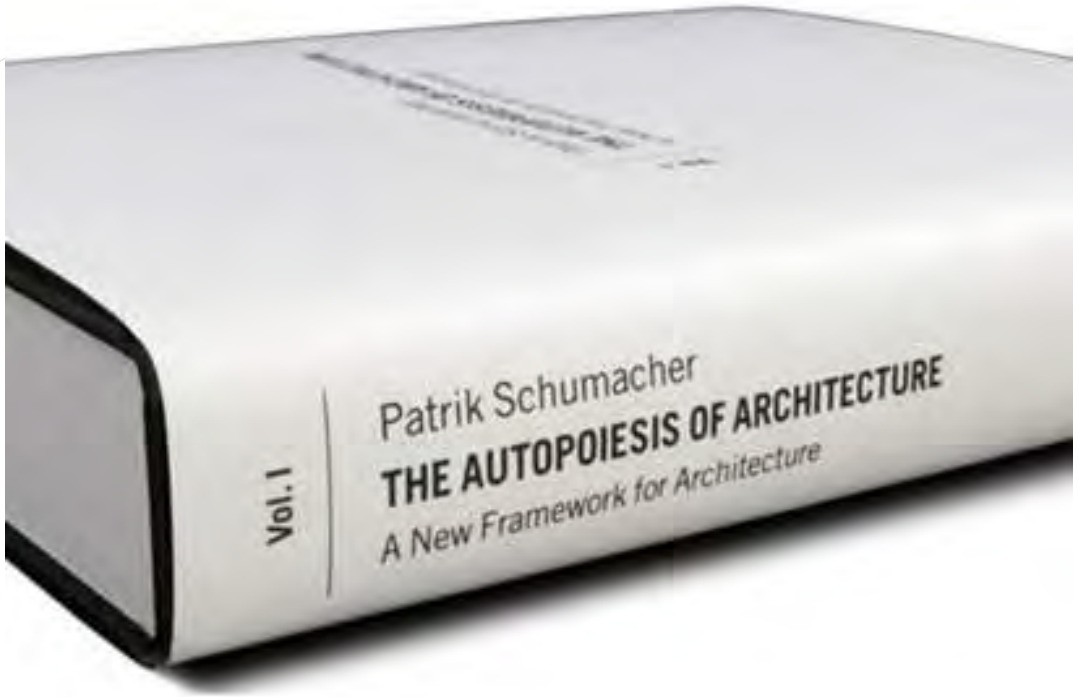




Zaha Hadid Archiects, Kartal-Pendik Masterplan, Istanbul, Turkey, 2006
Fabric study. The urban fabric comprises both cross towers and perimeter blocks. The image shows the morphological range of the perimeter block type. Blocks are split into four quadrants allowing for a secondary, pedestrian path system. At certain network crossing points the block system is assimilated to the tower system: each block sponsors one of the quadrants to form a pseudo tower around a network crossing point.

Parametricism 1.0 (2009-2014)

Schumacher, P. (2011). *The Autopoiesis of Architecture, Volume I: A New Framework for Architecture*, John Wiley & Sons.



Duality in defining and locating Parametricsm:
Visual sense and process-based architecture.

The concept of *autopoiesis* reflects that architecture can be theorised as a distinct ***system of communications.***

Central thesis: phenomenon in architecture is fully grasped when is analysed as **autonomous network** (autopoietic system) **of communications.**

Parametricism 2.0 (2015-present)

*"Parametricism is architecture's **answer** to contemporary, computationally empowered civilisation, and is the only architectural style that can **take full advantage of computational revolution** that now drives all domains of society."*

Schumacher, P. (2016). Parametricism 2.0: Gearing Up to Impact the Global Built Environment. *Architectural Design,* 86**,** 8-17.

Parametricism 2.0 (2015-present)

"Only (parametricism) congenial to recent advances in structural and environmental engineering based on computational analytics and optimisation techniques.

All other approaches are ***incapable of working*** *with the efficiencies…"*

Schumacher, P. (2016). Parametricism 2.0: Gearing Up to Impact the Global Built Environment. *Architectural Design,* 86**,** 8-17.

Parametricism 2.0 (2015-present)

Parametricism is the only contemporary approach than can address challenges posed to architecture by the new **social dynamics** of Information Age.

Schumacher, P. (2016). Parametricism 2.0: Gearing Up to Impact the Global Built Environment. *Architectural Design,* 86**,** 8-17.

Parametricism 2.0 (2015-present)

Schumacher **gathered key protagonists (and experts)** in this edited AD journal of Parametricism in a range of values to illustrate that Parametricism **can** take on relevant, high-performance projects:

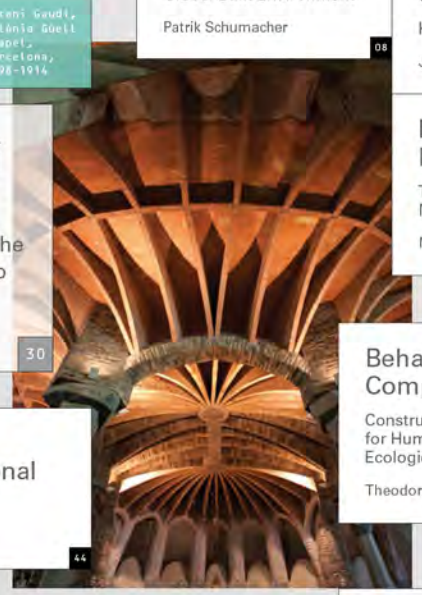
Structural and engineering innovations
Parametricing the social processes
Material culture
Parametric Regionalism
Parametricism in Urban models
Parametricism in Product Design
And many more

Schumacher, P. (2016). Parametricism 2.0: Gearing Up to Impact the Global Built Environment. *Architectural Design,* 86**,** 8-17.

Parametricism 2.0

Guest-edited by Patrik Schumacher

LIST OF CONTENT



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