Module: Digital Architecture

Week 2

Historical background and current debate

In the second week we will be looking at the prominent historical events which define this emergent field of computational design.

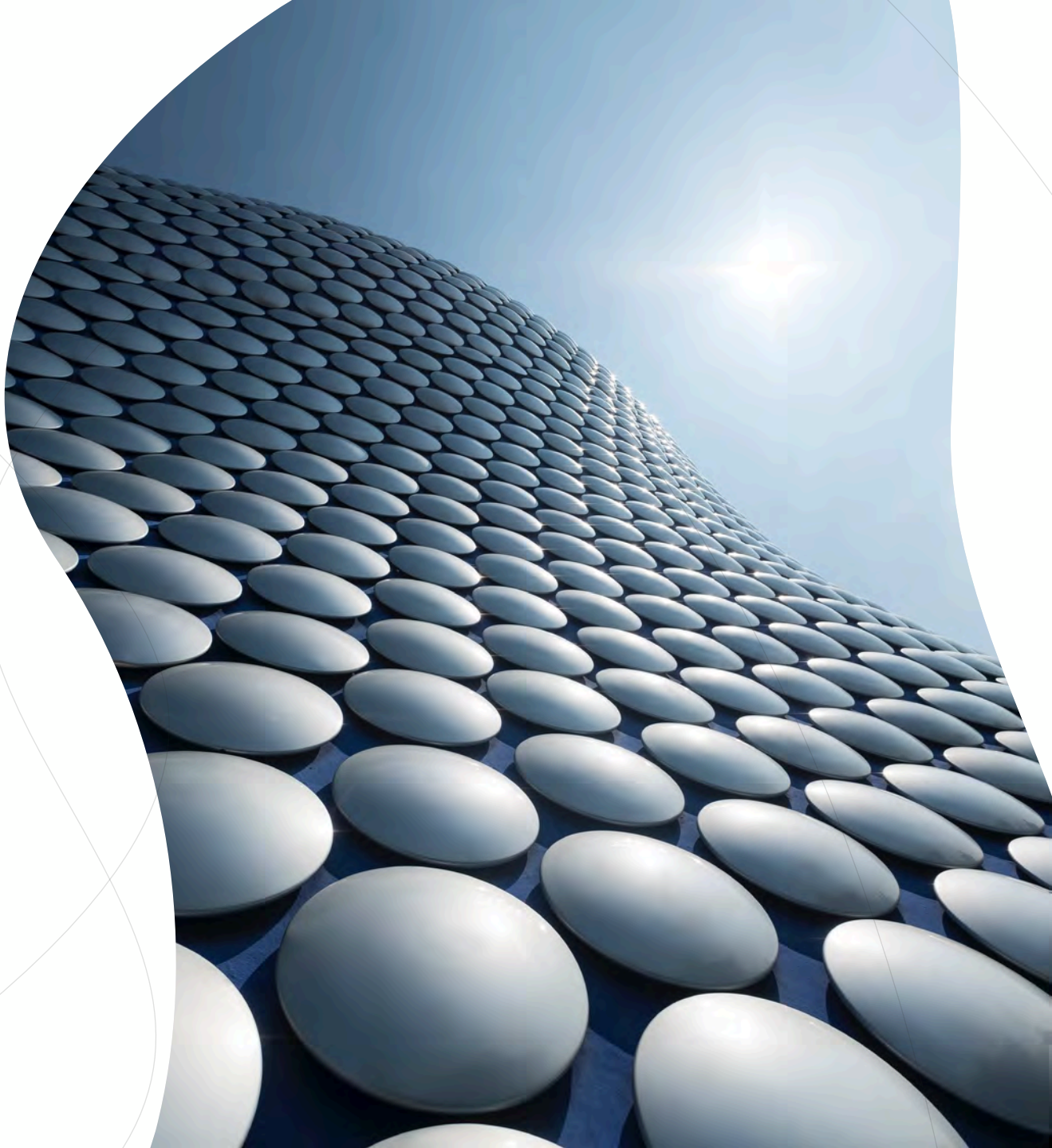
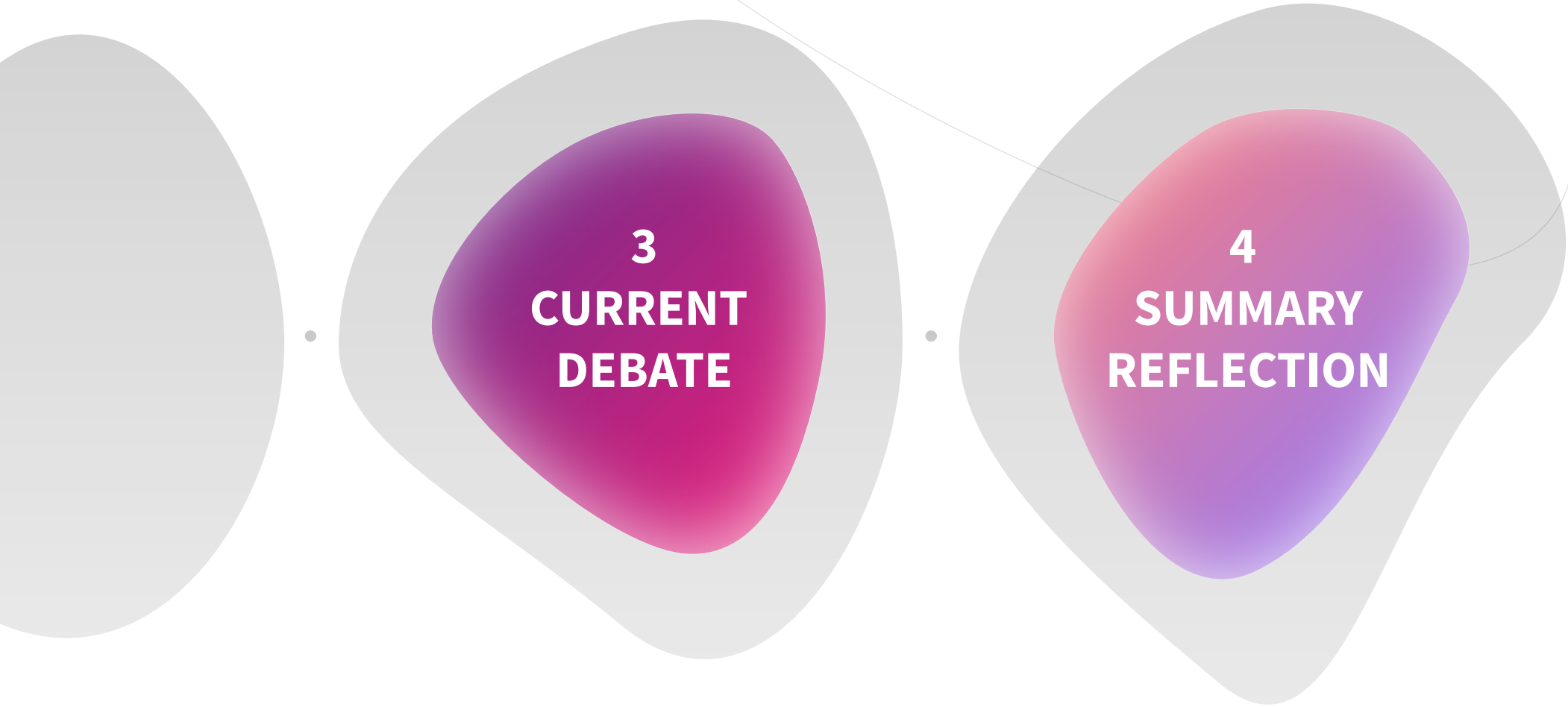


Photo by Christian Holzinger on Unsplash

Outline

1
INTRODUCTION
Aims
LOs

2
BRIEF HISTORY


3
CURRENT
DEBATE
4
SUMMARY
REFLECTION

Aims and objectives

- To expand historical background of this design field.
- To enumerate current debates.
- To elicit key events related to computational design.
- To enumerate key concepts related to development of the fields, in relation with the timeline.

Learning outcomes

Students will be able to..

01 Draw **lessons** from historical perspective of the development.

02 Iterate **personal stances** on how digital tools are used in designing.

03 Become aware of the **current debates.**

(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

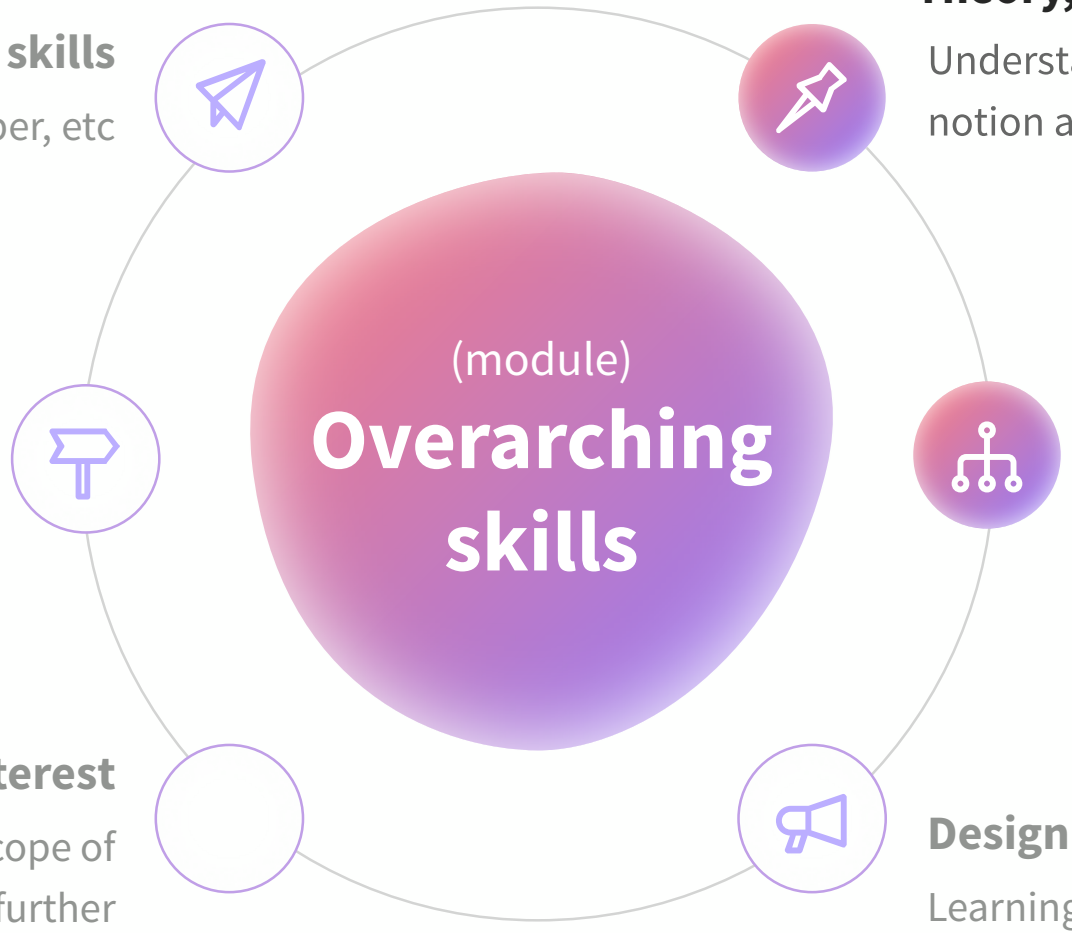
Exploring a preferred scope of design to be developed further

Research skills

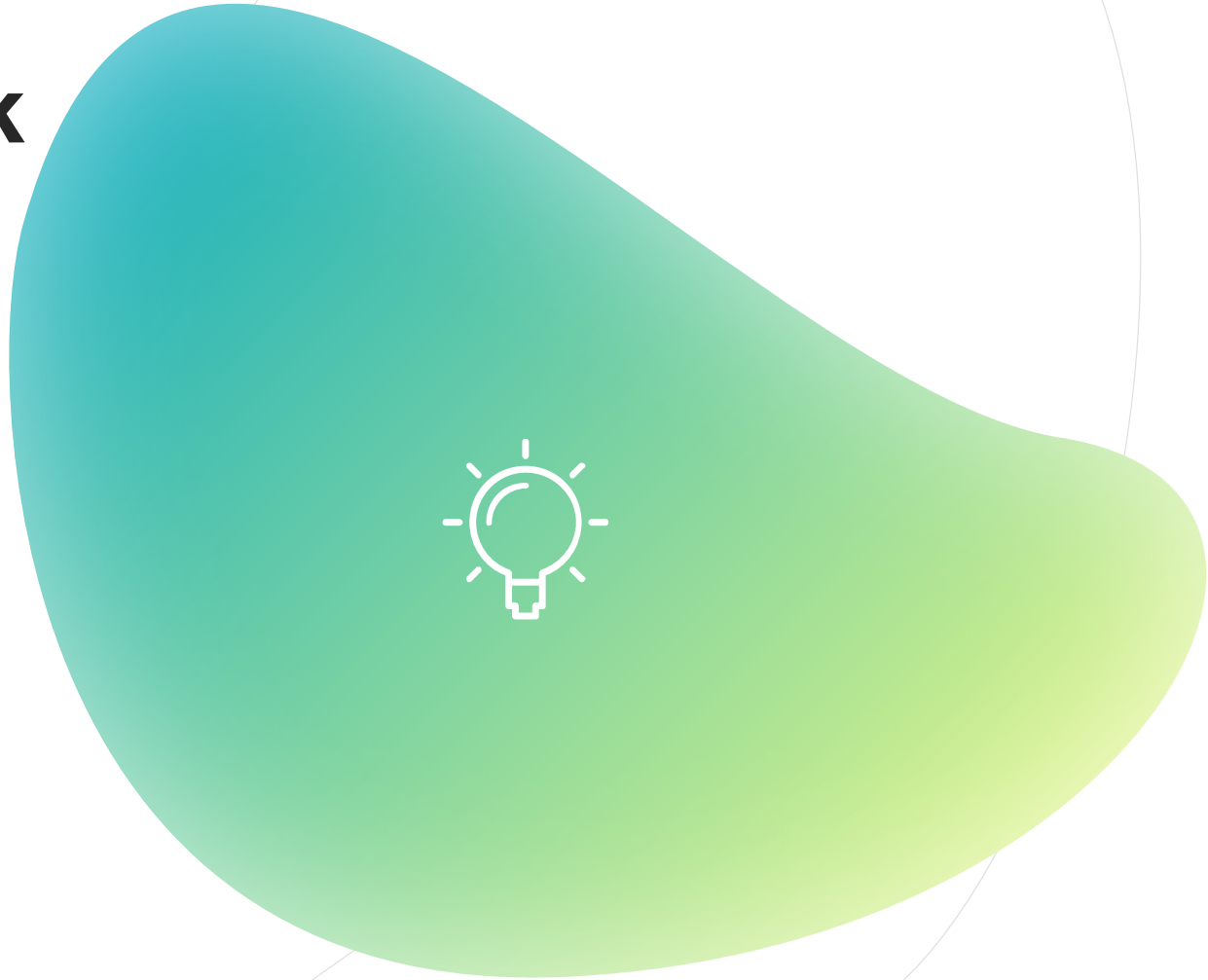
Designing through extensive research

Software skills

Rhino, Grasshopper, etc



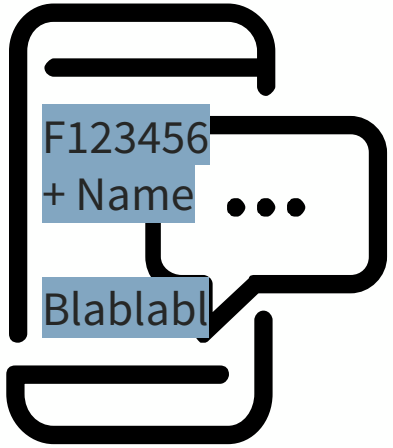
What do we gain from looking back at history?



Crucial understanding what’s at stake when designing with computers

Looking backward to look to the future

Discussion



D1. Putting your **utopian thinking hat**, how do you envisage your own version of futuristic built environment? You can also upload a quick sketch.
https://miatedjosaputro.com/2020/03/04/week-2-discussion-1/

D2. How can digital tools enable architects and designers to create better architecture for more people?
https://miatedjosaputro.com/2020/03/04/week-2-discussion-2/

Historical background

Photo by Thomas Kelley on Unsplash

How architecture practice was

https://www.demilked.com/life-before-autocad/

Timeline: key events

- Third Industrial Revolution, or referred as “Digital Revolution”

1960s

- Utopian thinking
- The Fun Palace project and other utopian thinking projects
- Sketchpad by Ivan Sutherland
- Remote Reality

- Proto-parametricists
- Mark Burry on Gaudi’s models of Sagrada Familia

1970s

- The Generator project
- First personal computers became available by the end of 70s

Timeline: key events

1980s

- Autodesk AutoCAD was released in 1982
- Architects began to investigate other forms of experimental practice, from other fields such as aeronautical and automobile.
- Digital tools enabled architects to rationalise form
- Cyberpunk

Timeline: key events

- First digital turn (Mario Carpo)
- Digital design and fabrication
- Digital mass customization
- The “blob” style

1990s

- “Folding in Architecture” in 1993
- “Technological constructions”
- Gugghenheim Bilbao as celebrated turning point in architecture, “Bilbao effect”
- Rhinoceros 3D was released in 1992

Timeline: key events

- Grasshopper was released
- Augmenting reality
- First digital fabrication projects

2000s

- Digital design as discipline
- Theoretical body for “digital design”
- Authors such as: Rivka Oxman, Kostas Terzidis, and Toni Kotnik
- Programmed Wall (2006), first successful use of robotic arm to achieve complex curvature

Timeline: key events

- Larger scale of digital fabrication
- Wiki House
- “Cyber-physical approach”
- “Big Data” revolution
- The “discrete” approach

2010s

- Key concepts started to be formalised:
  - Digital architecture
  - Digital tools
  - Algorithmic design
  - Parametric design
  - Generative design
- Second digital turn (Mario Carpo)
- Fourth Industrial Revolution (4IR)

PRIOR TO 1960s

Mario Carpo mentioned that the digital can be traced back to Renaissance era. He illustrates that 3D scanning can be traced back to the development of reproduction and representation since the Renaissance [1].
Antoni Gaudi worked computationally but in analogue way on his Sagrada Familia models (1882-1926),
Luigi Moretti, an Italian Architect appeared to be the first to have formulated the concept of Parametric Architecture in 1940.

[1] Artforum (2017). Mario Carpo on the Rise of 3-D Technology. https://www.artforum.com/video/mario-carpo-on-the-rise-of-3-d-technology-66940

PRIOR TO 1960s

In addition, the development of the field is also originated from the birth of computer science in 1920. Pioneers such as Alan Turing and John Von Neumann are to thank for. In architecture, the concepts of *computing* and *informatics* started to be considered in the beginning of 1960s.

Circa 1960

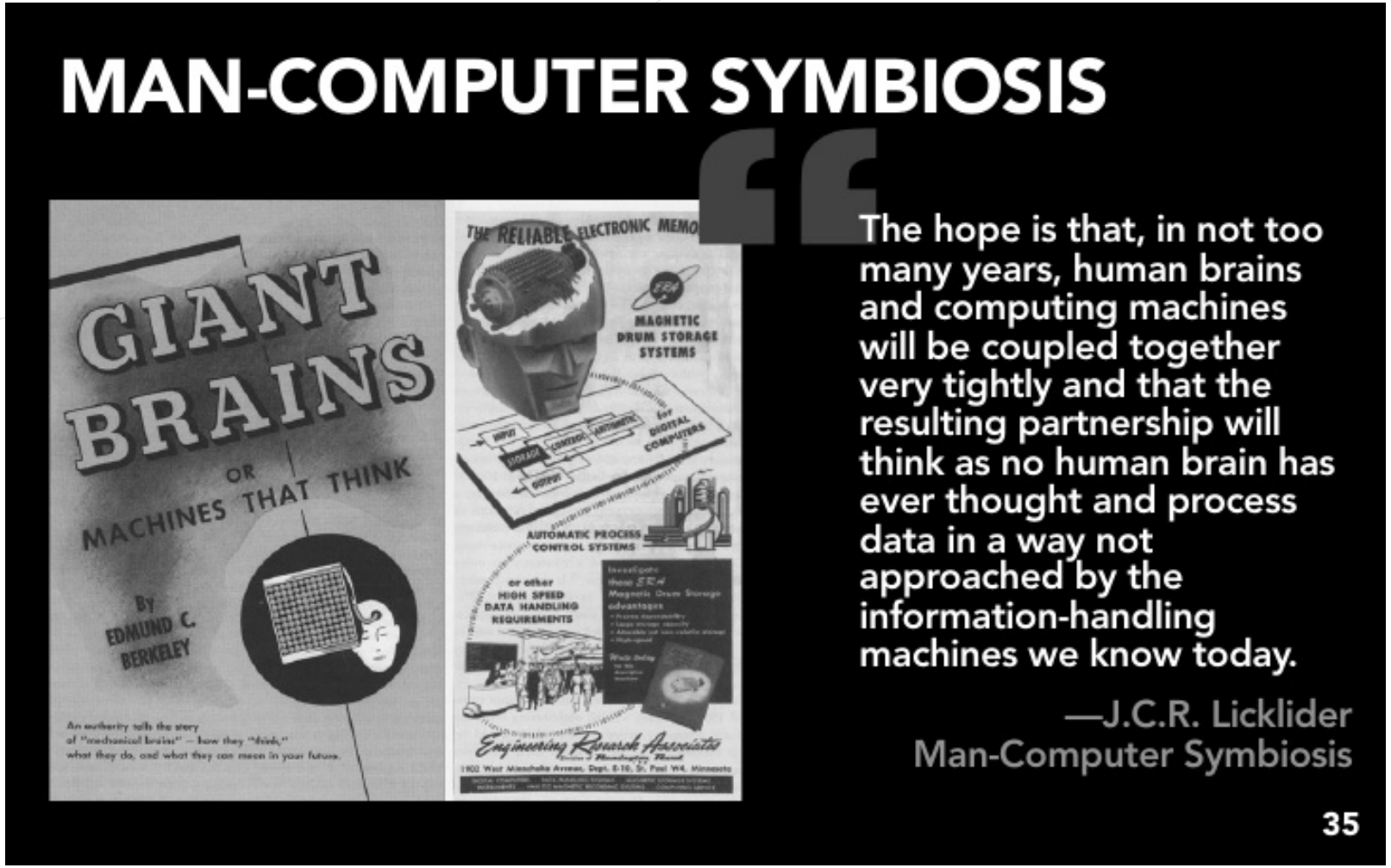
About

This exciting area was imagined with a collaboration of man and machine. Utopian thinking encouraged the intellectual experiments by imagining futuristic architecture.

c1960

In computer science

“Man-computer Symbiosis” In 1960.



Licklider, J. C. (1960). Man-computer symbiosis. *IRE transactions on human factors in electronics*, 4-11.

Pioneer “Man-computer Symbiosis” in architecture

Gordon Pask
Pask, G. (1969). The architectural relevance of cybernetics. *Architectural Design,* 39**,** 494-496.
Common philosophy of architecture and cybernetics.

Cybernetics: theory that all behaviour (human and machine) is part of a system of feedback loops, includes inputs and outputs. First defined by Norbert Weiner in his book (1947).

Utopian thinking and projects

Utopian spirit of 60s encourages “intellectual experiments”.
Architects did not posses knowledge in technology or have the technology
Nor opportunity to put them in practice.
Computing becomes a common ground for **reflections** and **theoretical thinking.**
Later Frazer (2005) highlighted it as “computing without computers”.

Frazer, J. (2005). Computing without computers. *Architectural Design,* 75**,** 34-43.

“Intellectual experiment”

Fun Palace (1958-1964)

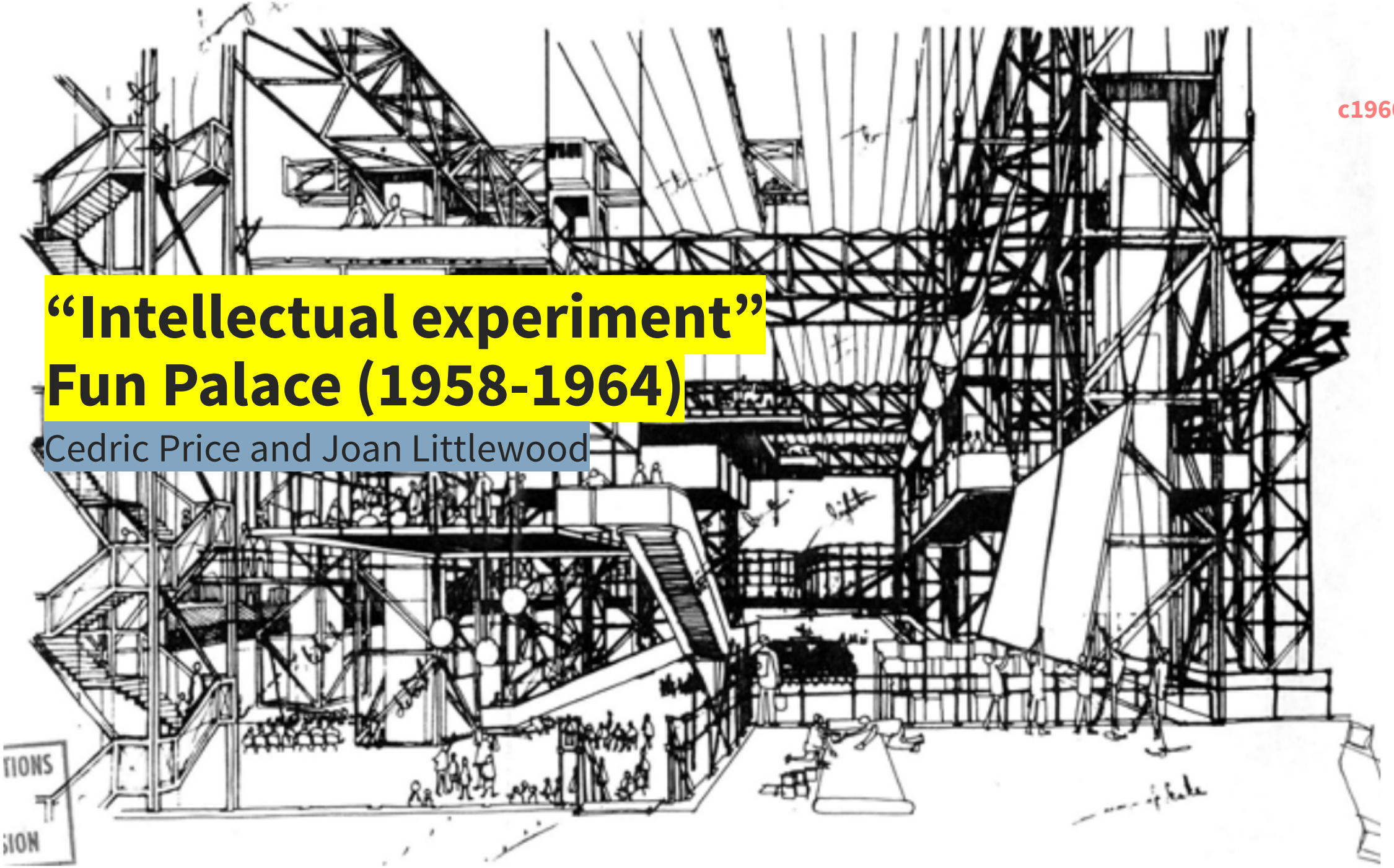
Cedric Price and Joan Littlewood

*“The fun palace was not a building in any conventional sense, but was a socially interactive machine, highly adaptable to the shifting cultural and social conditions.” **

A model for the 1976 Centre Pompidou

*Mathews, S. (2005). The Fun Palace: Cedric Price’s experiment in architecture and technology. *Technoetic Arts,* 3**,** 73-92.

c1960



“Intellectual experiment” Fun Palace (1958-1964)

Cedric Price and Joan Littlewood

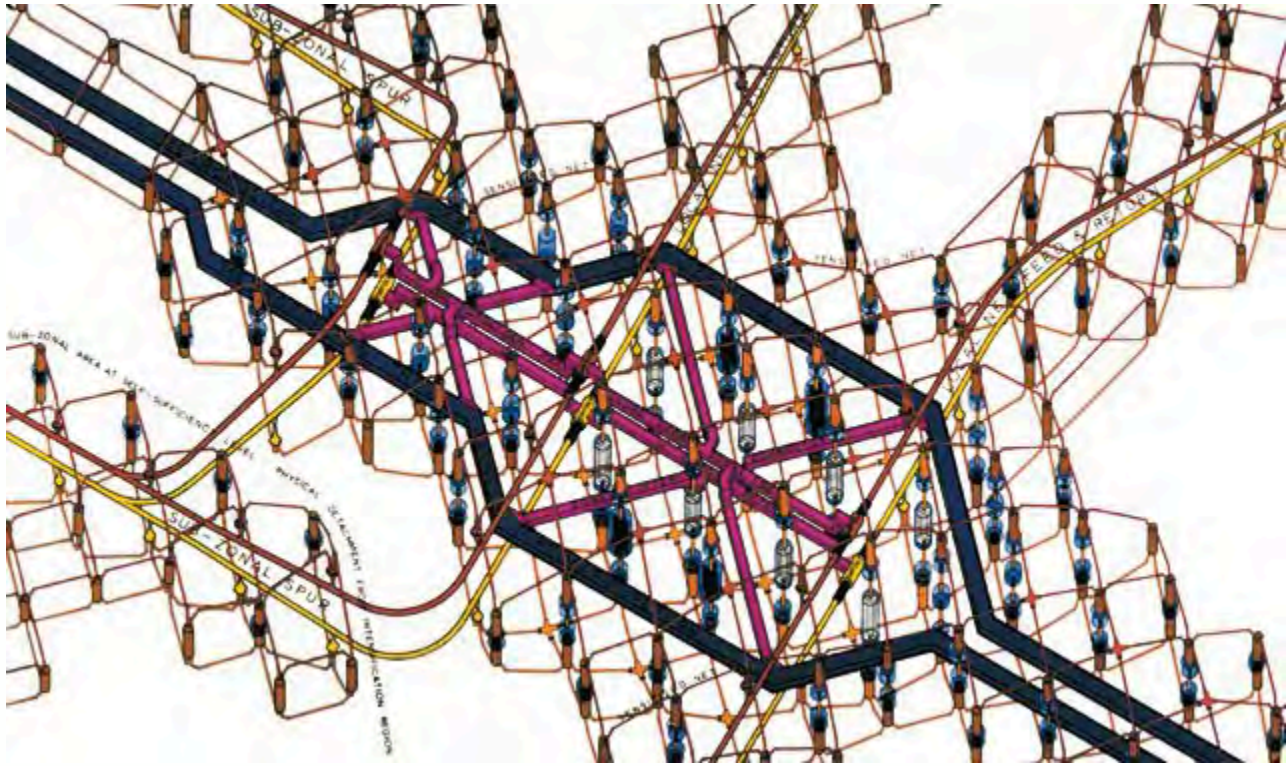
“Intellectual experiment”

Computer City (1964)

Dennis Crompton, Archigram

A system of sensors and electronic devices interconnected for the monitoring, control and management of different processes and activities that takes place in the urban environment.

Source: Archigram Archives
https://www.archigram.net/portfolio.html

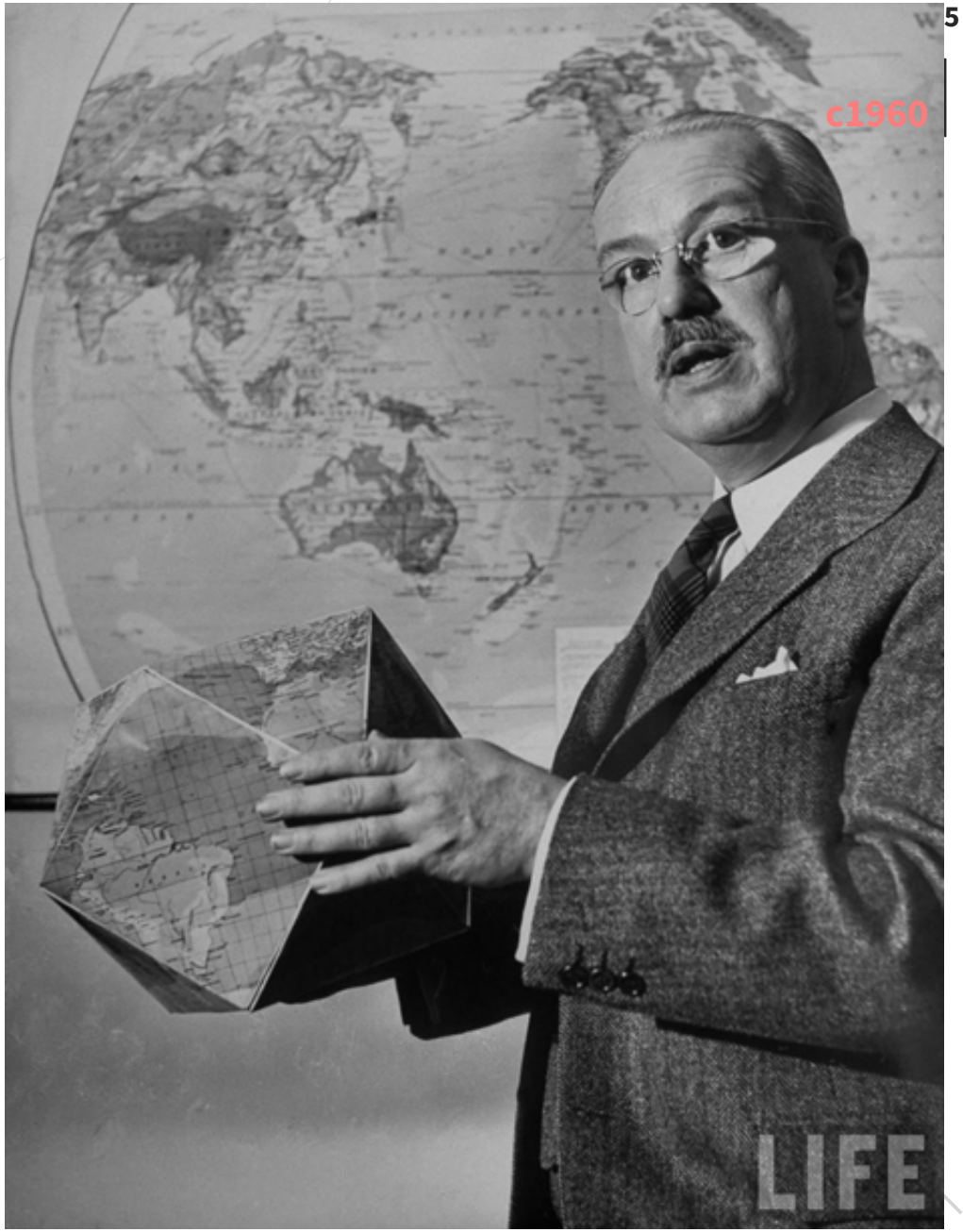


“Intellectual experiment”

World Game (1967)

Buckminster Fuller

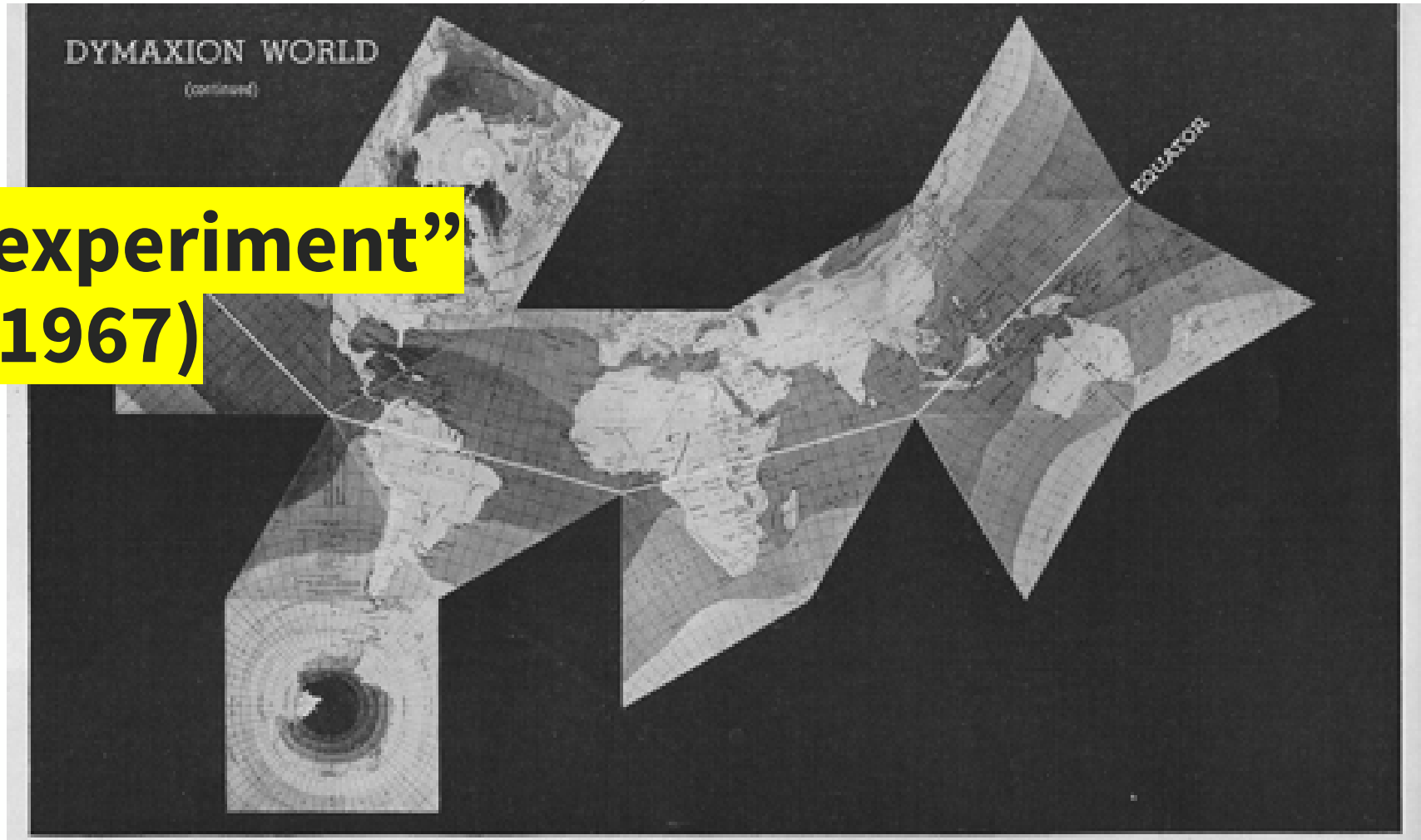
First considered in 1954. Dymaxion World embodies his effort to resolve the dilemma of how to depict a flat surface this spherical world. Officially presented at the “World Design Science Conference” in 1967.



c1960

“Intellectual experiment” World Game (1967)

Buckminster Fuller



MERCATOR WORLD

Here the tiles are laid in a pattern that approaches the familiar appearance of the Mercator projection. The equator is a continuous line, orienting the world east to west. Not shown on the true Mercator are the poles, which appear here. The Mercator is still the best and standard base map of navigation, but its perspective is that of the 16th, not the 20th Century.

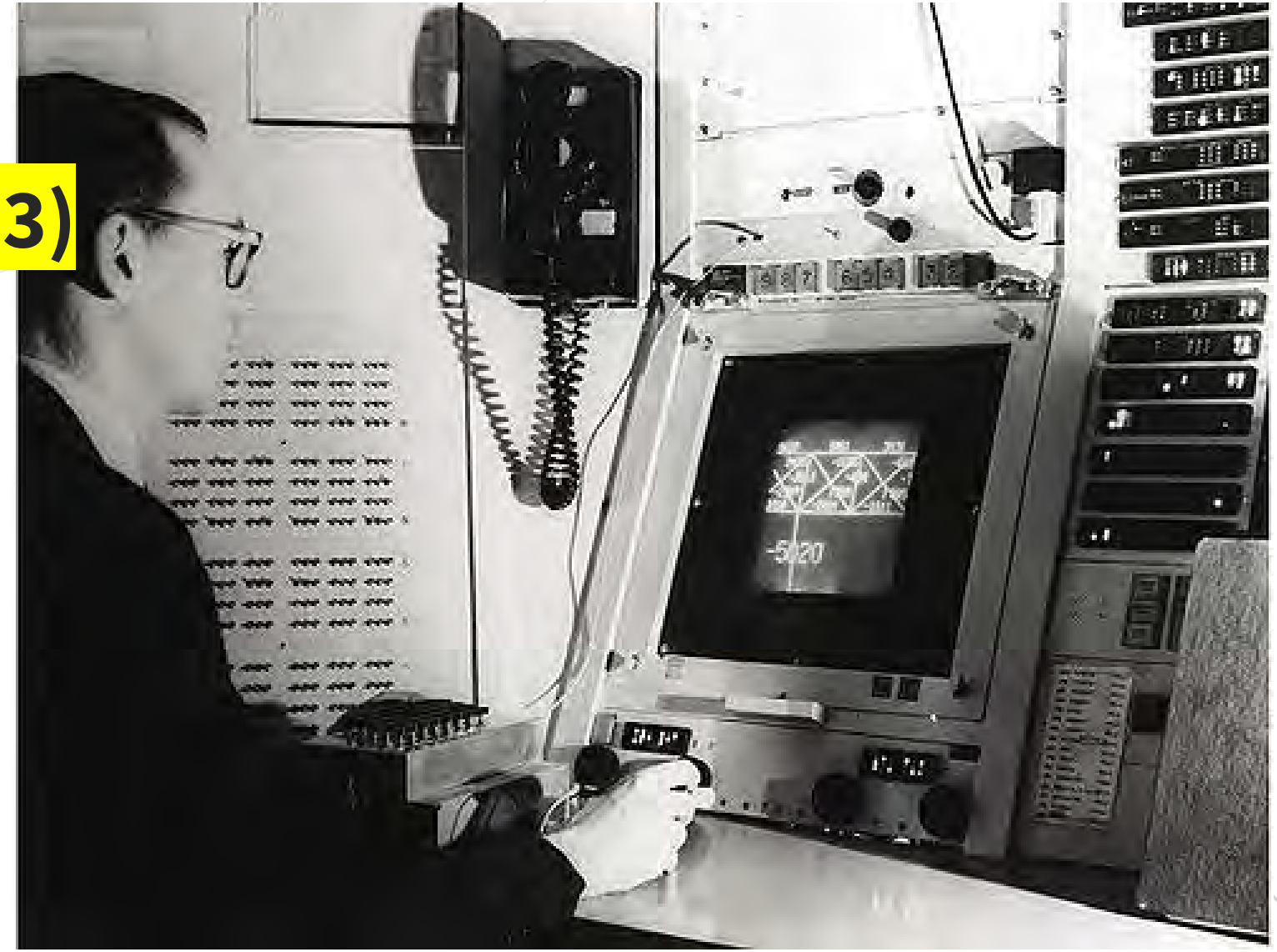
This Dymaxion map approximation of the Mercator projection brings character of the Renaissance world into bold relief. Most striking is the vast expanse of ocean, the world's highway. Though a few hardy explorers hunted a Northwest Passage, the course of empire and trade was southward along the coast of South America and eastward around Good Hope into the Orient. It was in this period that the Dutch cartographers and Papal fiat divided the world in hemispheres,

c1960

Sketchpad (1963)

Ivan Sutherland

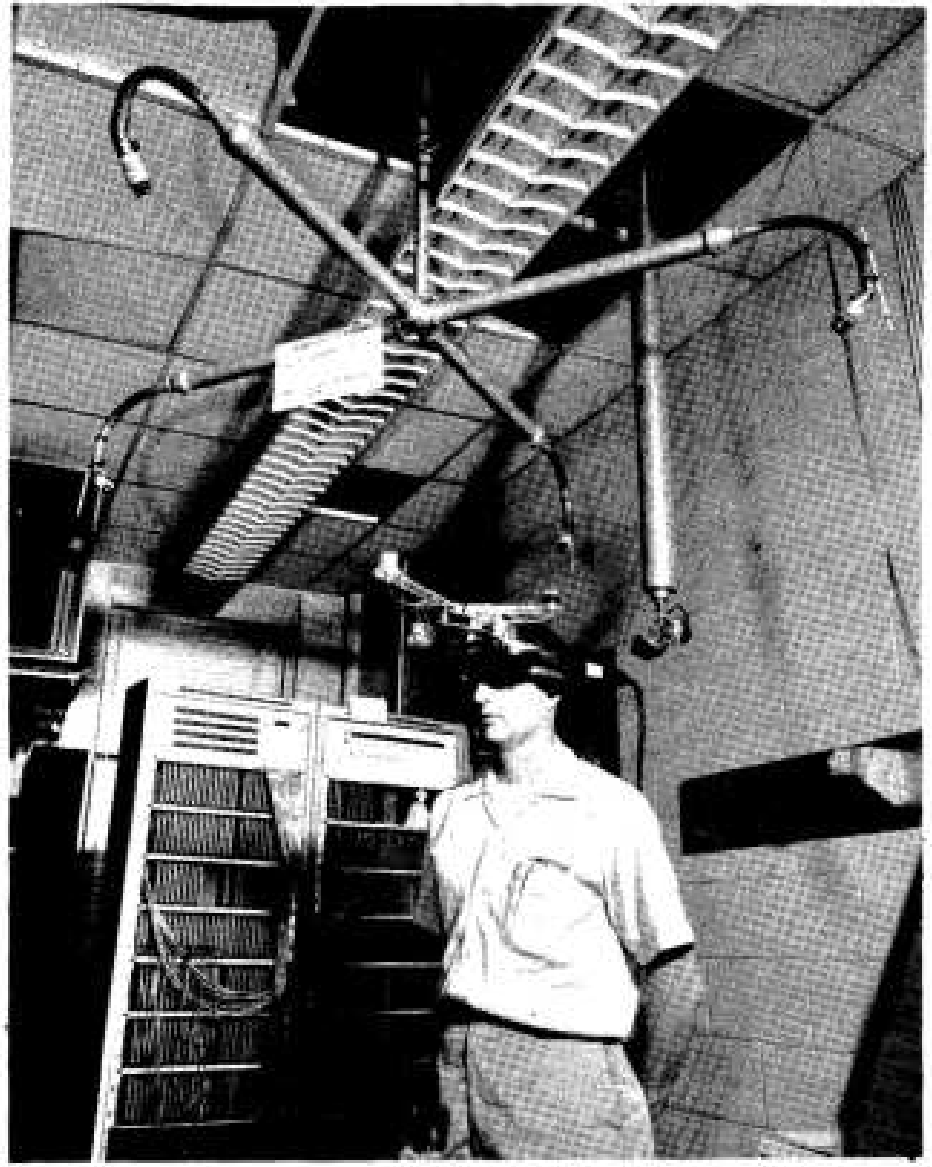
Pioneering:
Computer Graphics and
Computer Aided Design



Remote Reality (1966)

Ivan Sutherland and
Bob Sproull

Pioneering:
Virtual Reality,
Although the name was
not invented by them

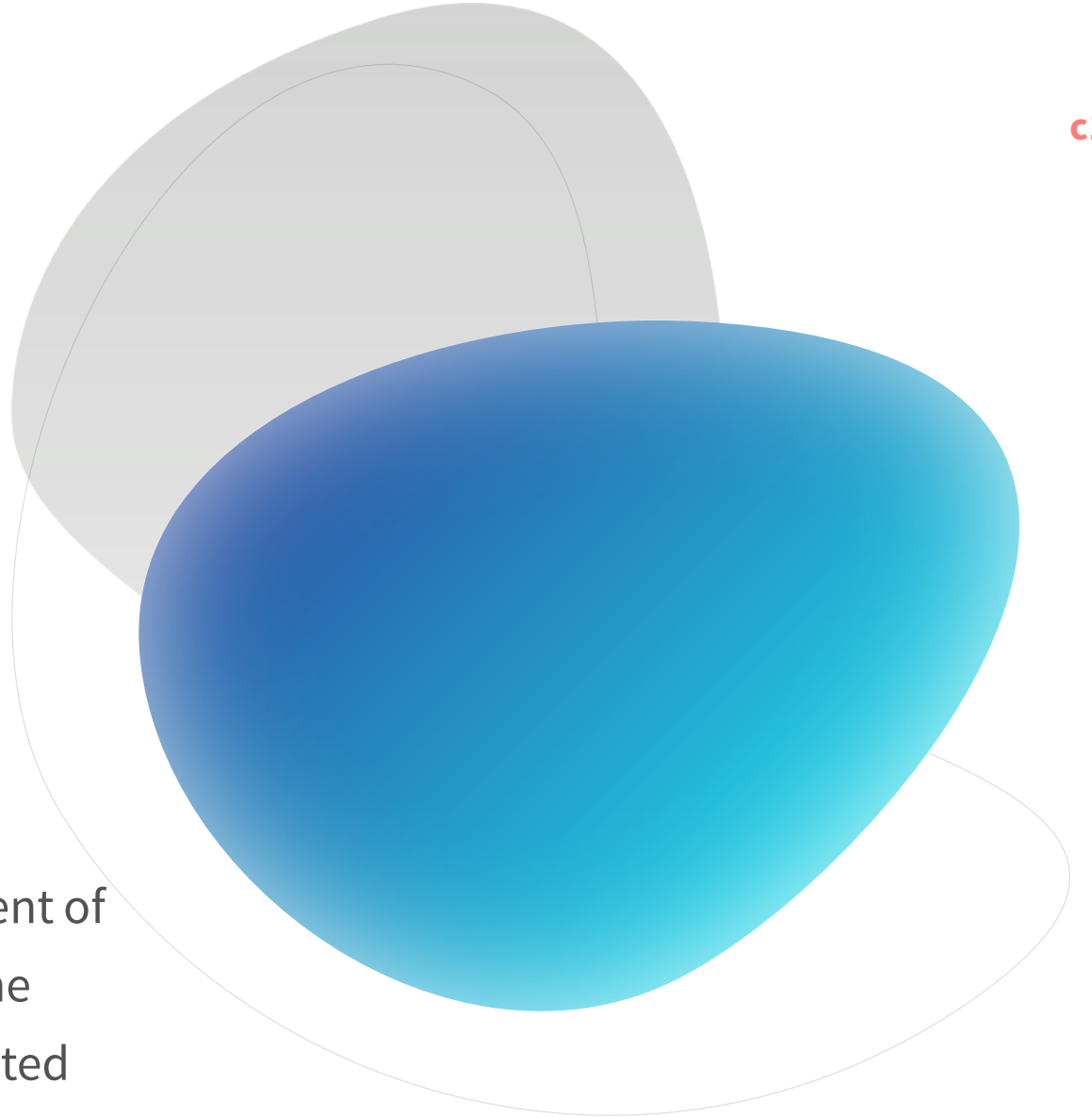


https://www.i-programmer.info/history/people/329-ivan-sutherland.html?start=1

“How It’s Made”
Fred Scott (1968)

Highlights resistance of architectural discipline to assimilate new technology.

Circa 1970



About

The era focused on mainly development of technological tools. On other hand, the vast development of technology resulted in disconnection between technology and reality.

c1970

Pioneers “Man-computer Symbiosis” in architecture

Nicholas Negroponte
Computer being the true work partner
A machine capable of interacting with architect
“Architecture Machine Group” at MIT in 1973

Proto-parametricists

Access to design technologies was not possible.
The use of **morphogenetic thinking** in analogue way.
Proto-parametricts means: using analogue means to compute using parameters.

c1970

Proto-parametricists:

Munich Olympic Stadium (1972)
Frei Otto

Used complex physical model to analyse, understand, document and compute how these structures were formed and performed. Photographed by precision cameras.

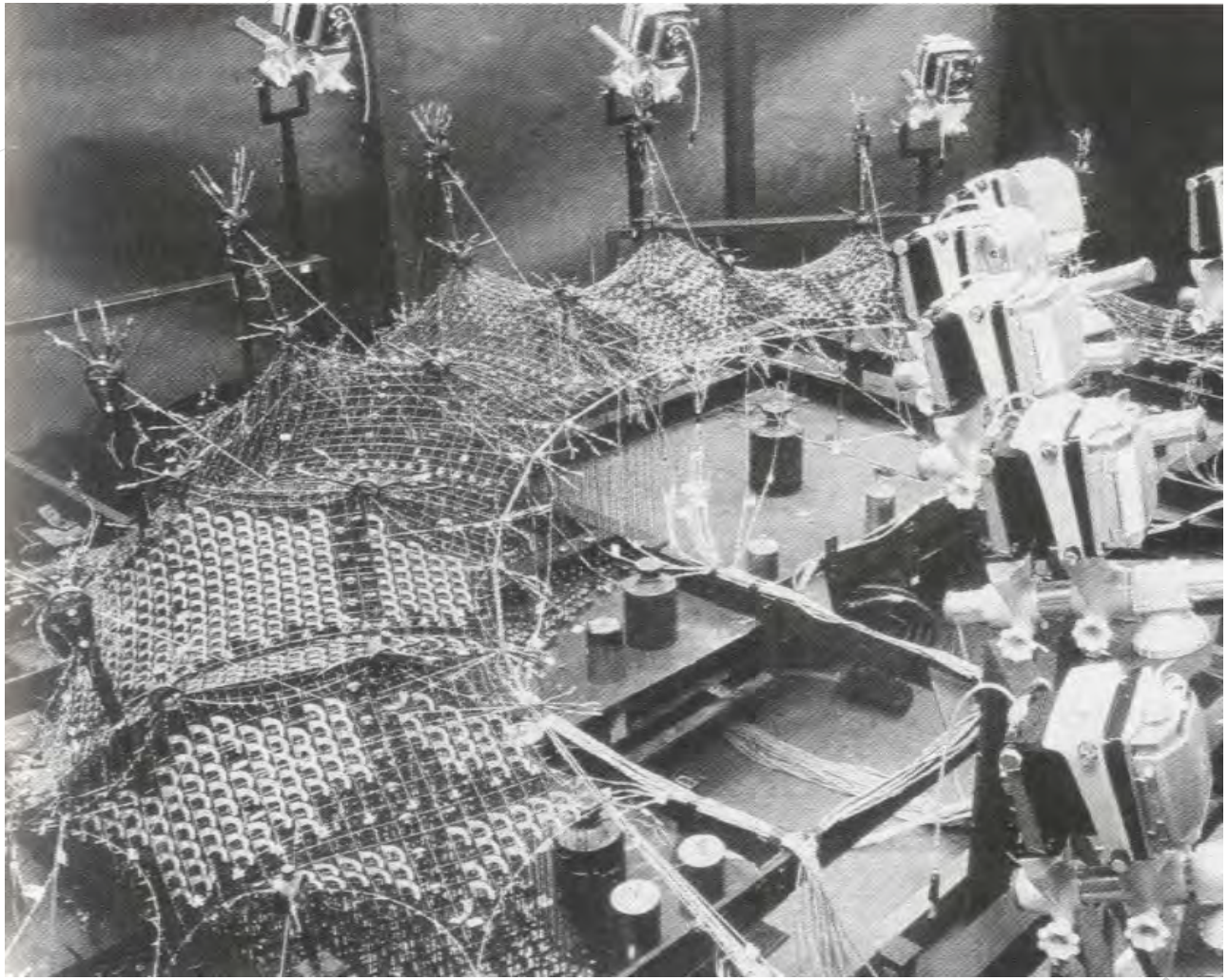


Image source: https://iam.tugraz.at/workshop14s/2014/03/24/munich-stadium-roofs-by-frei-otto-gunther-behnisch/

Personal computer became available to public (1975)

1976

Apple I was launched

First word processing program

5.25” floppy drive

The Generator (1976-1979)

Cedric Price
John and Julia Frazer

(unbuilt)

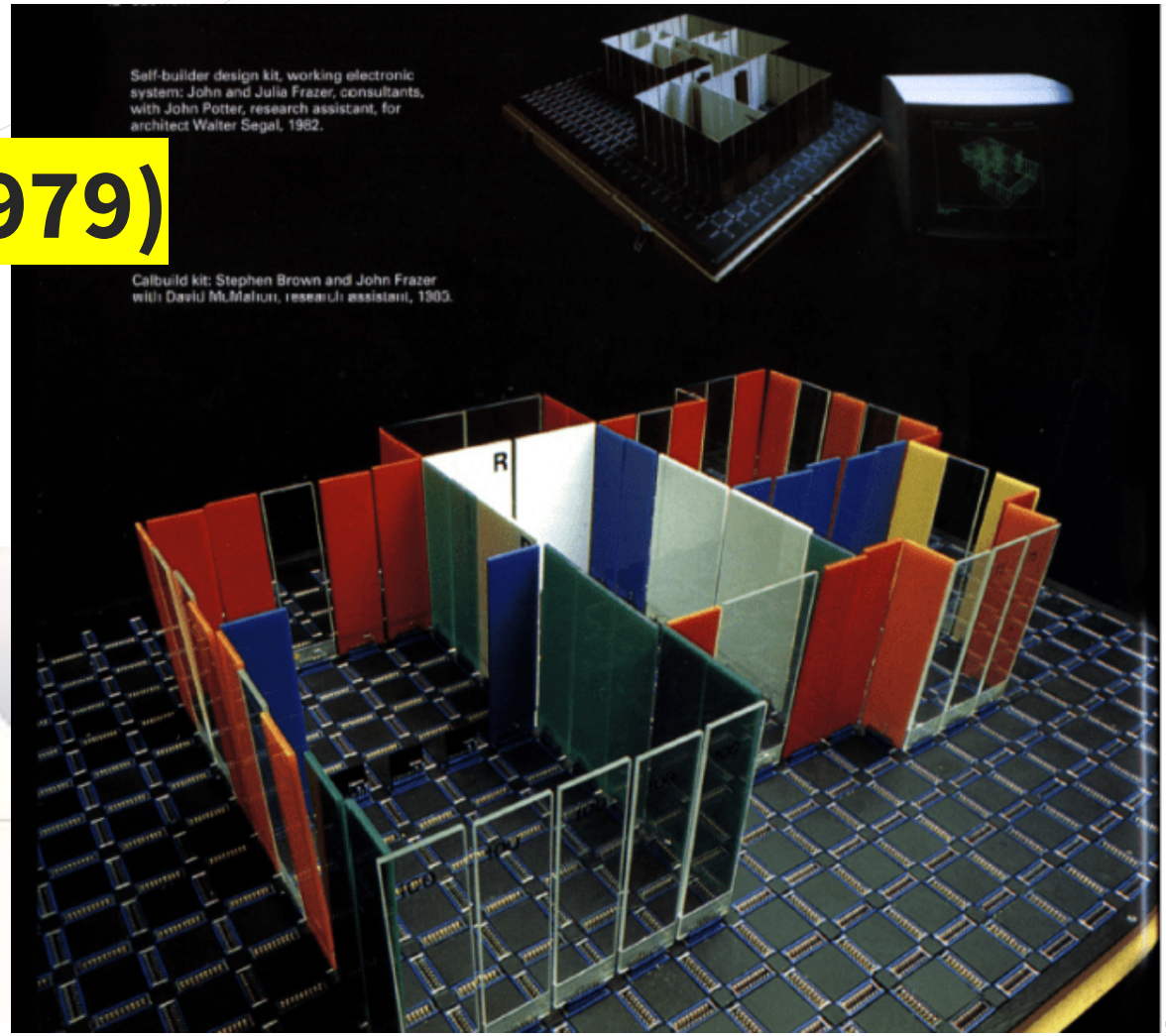
Sought to create conditions for shifting, changing personal interactions in a reconfigurable and responsive architecture project.

Notably first intelligent building project

http://www.interactivearchitecture.org/the-generator-project.html

The Generator (1976-1979)

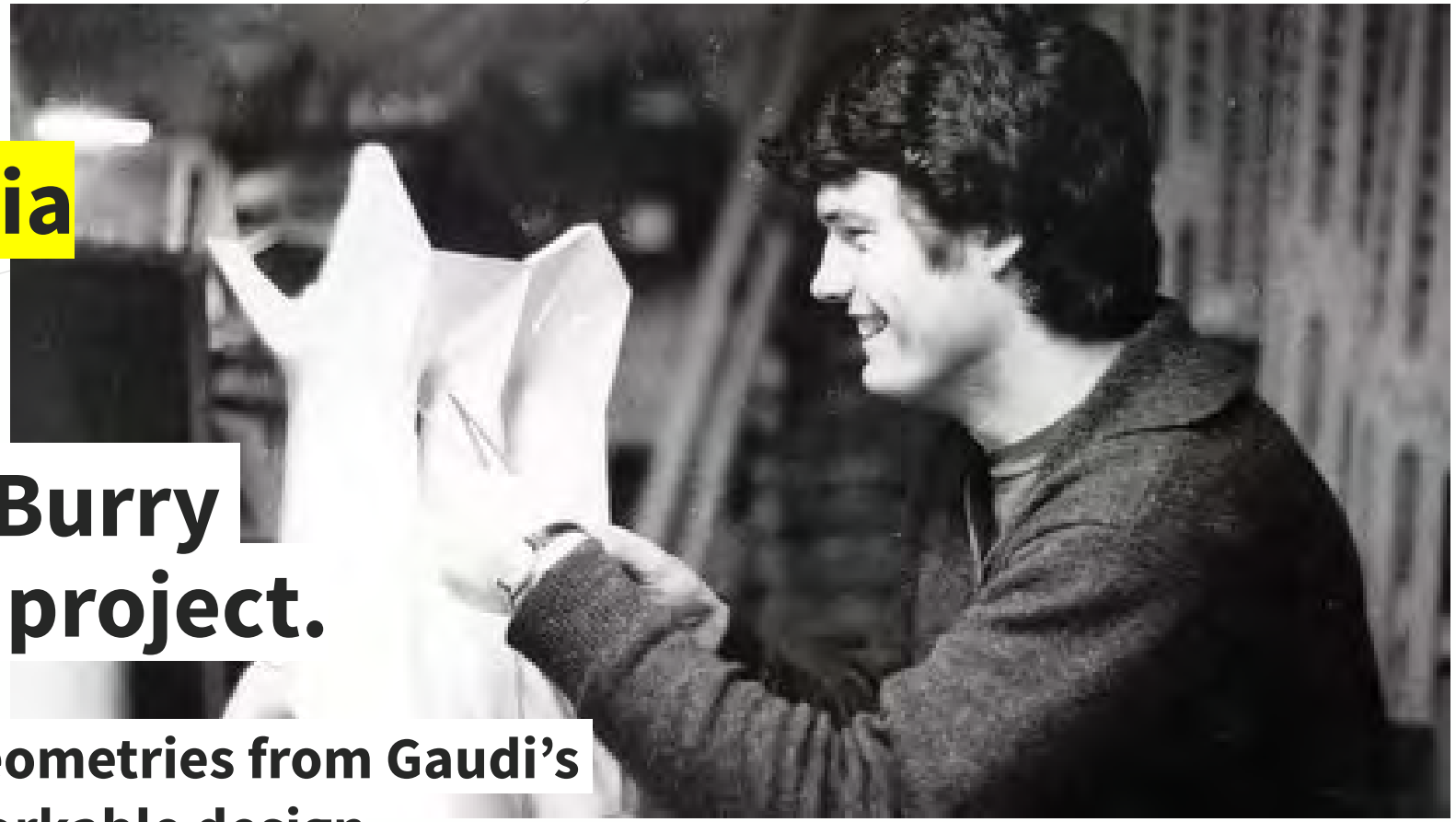
Cedric Price
John and Julia Frazer
(unbuilt)



http://www.interactivearchitecture.org/the-generator-project.html

c1970

Sagrada Familia
Antoni Gaudi



In 1979, Mark Burry continued the project.

Translated complex geometries from Gaudi's plaster models into workable design

https://mcburry.net/gaudi-unseen/

Circa 1980

About

With the economic downturn in mid-1970s and 1980s, architects had to recalibrate the way they practiced. Utilisation of tools borrowed from shipbuilding, aeronautical and automobile industries transformed design practice.

c1980

AutoCAD 1.0 (Release 1)
1982

Sold on floppy disks

Source; Flickr

Cyberspace

“Neuromancer” by William Gibson (1984)

Cyberpunk: science fiction genre

Influences from other fields, with CAD exposure.

Architects were able to achieve 3D, complex, variable curves using spline instead of 2D lines

Architecture firms:
GregLynn FORM
FOA
NOX

Peter Eisenman
Biocenter (1987)
Frankfurt

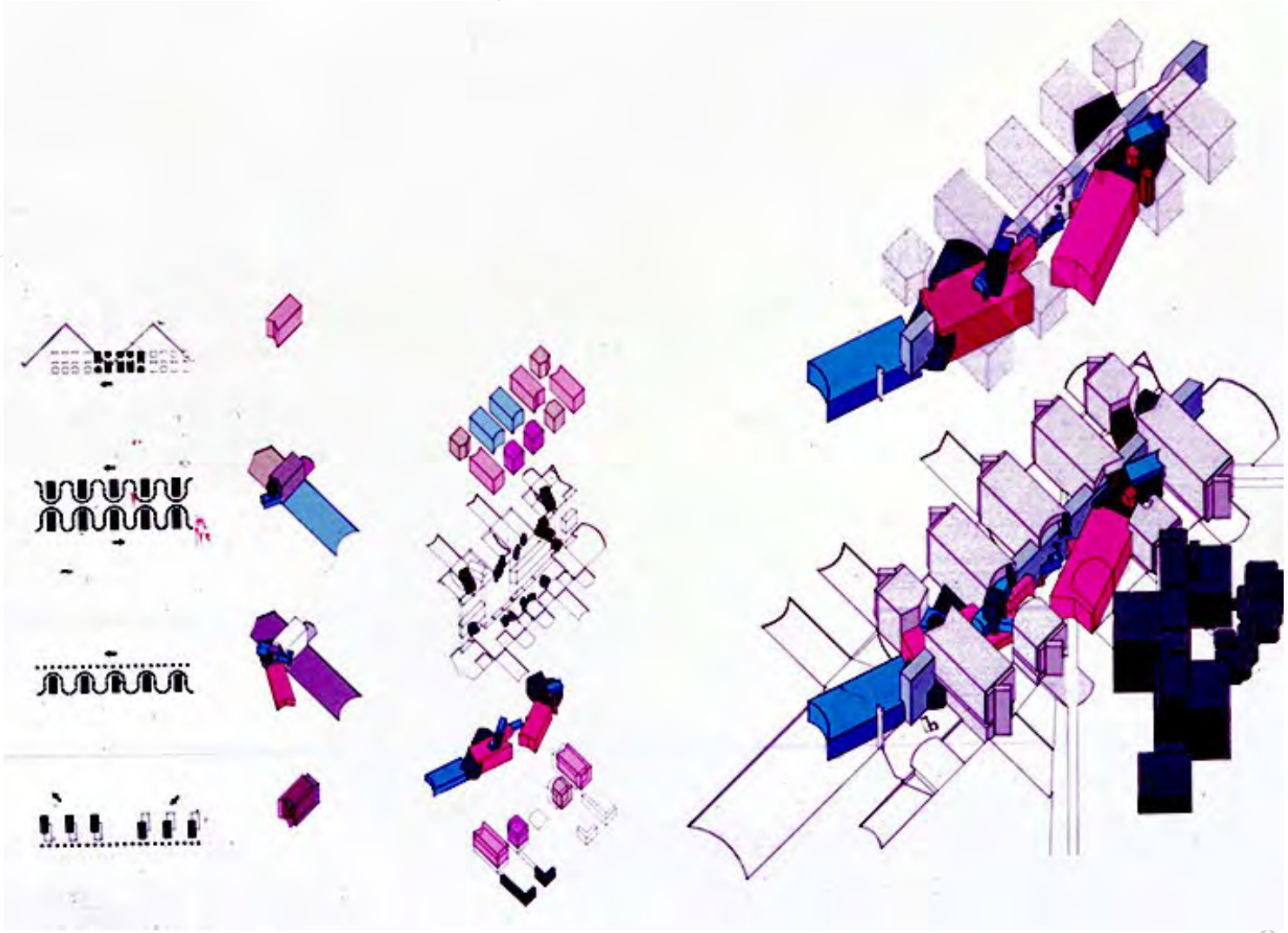
Characterised by manipulation of blocks and grids, generated through abstract steps of operations.

First projects to use computer to code design outputs.

c1980

Peter Eisenman
Biocenter (1987) Frankfurt

Symbolising DNA process of replication, transcription and translation.



https://eisenmanarchitects.com/Biocenter-1987

Frank Gehry

Lewis House (1985-1995)

Unbuilt

Physical model → captured in 3D model → physical model produced from 3D model →modified with analogue, intuitive model making → scanned using 3D scanner to further inform digital model*.

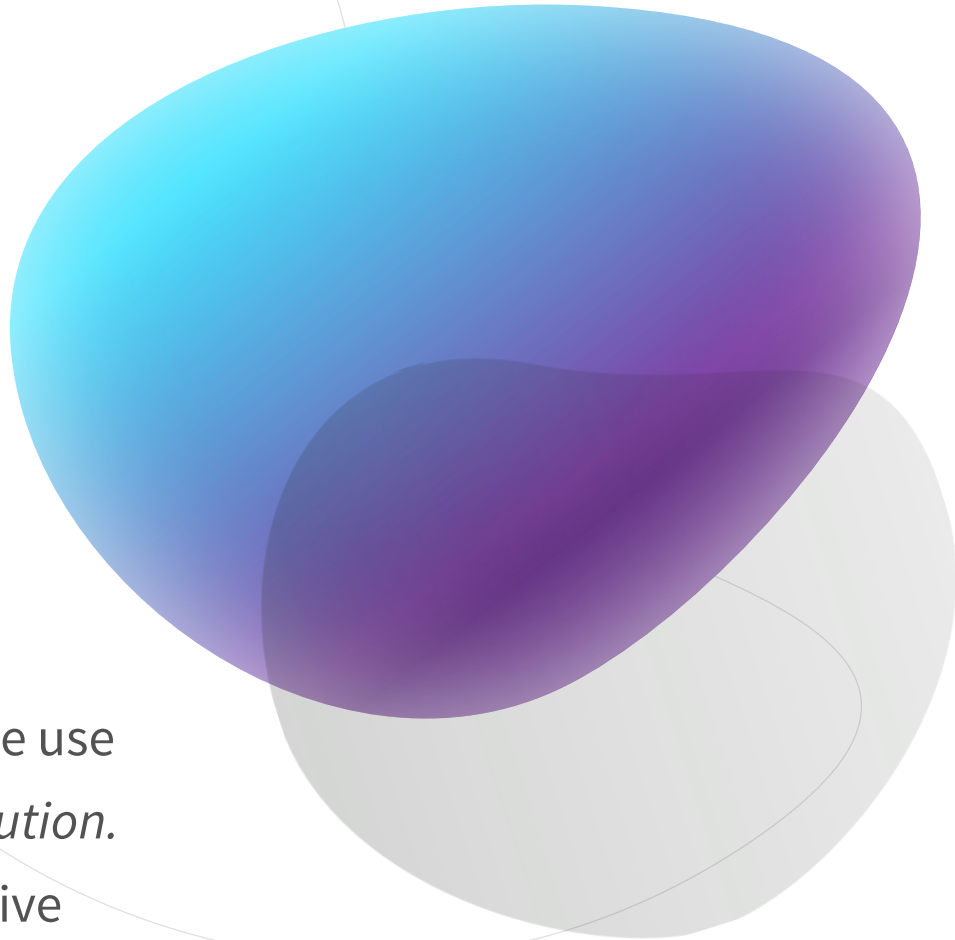
*Claypool, M. (2019). The Digital in Architecture: Then, Now and in the Future. SPACE10.

Frank Gehry

An interface in CATIA software developed by Gehry Technologies.

Now called Digital Project, BIM software.

Circa 1990



About

The 1990s showed an unprecedented growth of the use of digital design tools, what we called *digital revolution.* Advances in microprocessors resulting in progressive deduction of computer technology. And in turn become more accessible.

The first digital turn
According to Mario Carpo

Emergence of new digital tectonics parallel with development of **spline modellers.** It allows manipulation of curved lines directly on screen, using graphic interfaces.*

Digital design and fabrication

First generation of digitally intelligent designers had idea that, digital design and fabrication should do something else, something that industrial assembly lines do not do.*

Digital fabrication does not utilise mechanical matrixes, casts, stamps, molds or dies. No need to reuse them to reduce their cost. Making digital copies will not make them cheaper.

Each item can be different, at no additional cost → **Digital mass customisation**

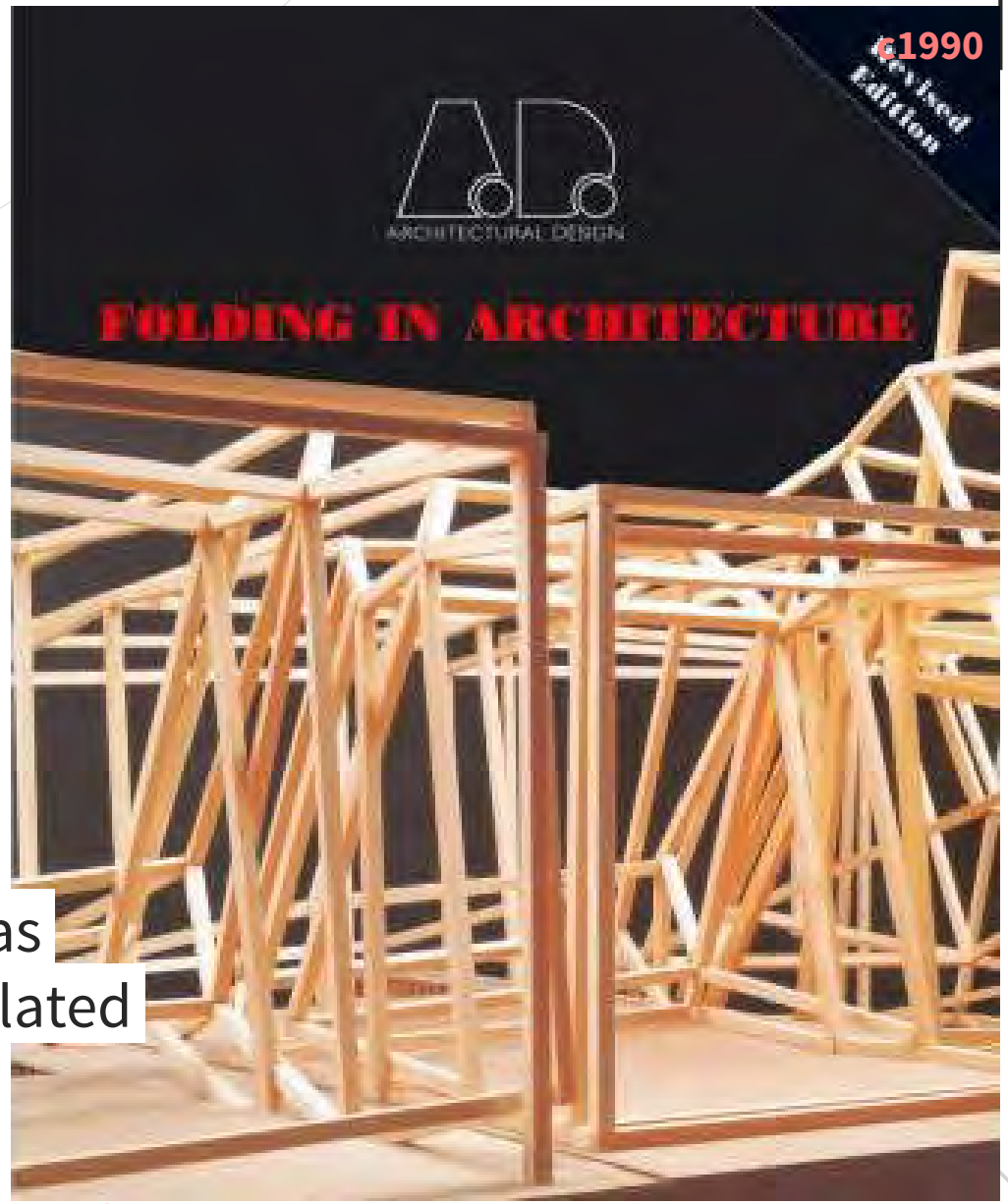
Carpo, M. (2017). *The second digital turn: design beyond intelligence*, MIT press.

Folding in Architecture*

Greg Lynn

Edited Architectural Design issue

First time that an entire issue of magazine was specially include architecture exploration, related to embodiment of new digital technologies

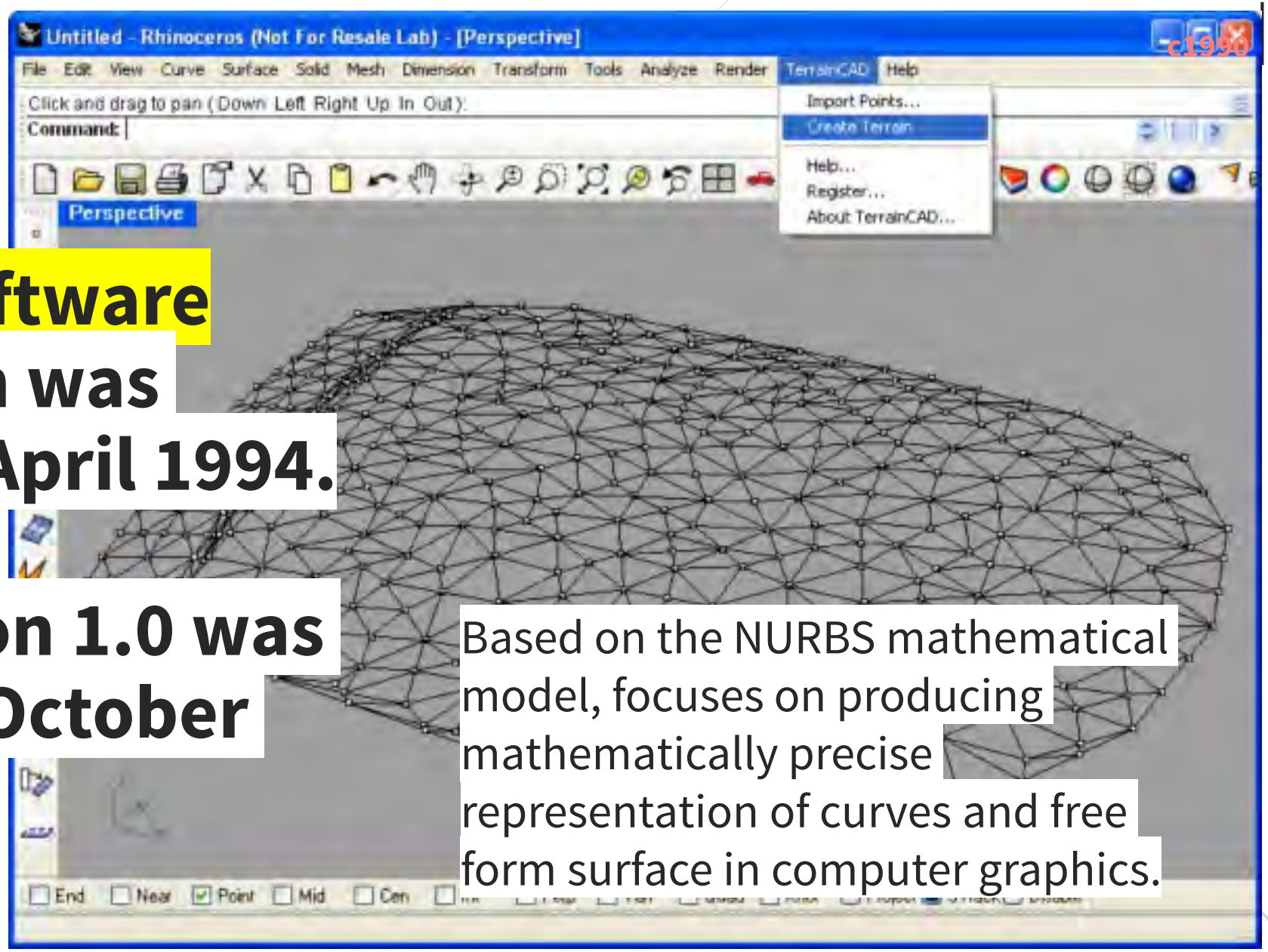


Lynn, G. (1993). *Folding in architecture*, Academy Editions Limited.

Rhino 3D software

Beta version was released in April 1994.

Rhino version 1.0 was released in October 1998



Based on the NURBS mathematical model, focuses on producing mathematically precise representation of curves and free form surface in computer graphics.

http://www.qweas.com/downloads/graphic/cad/screenshots-terraincad-for-rhino.html

The BLOb (Binary Large Objects) style 1995

Greg Lynn

Style of spline or of digital streamlining

Curving and non-Euclidean geometries
Digitally-generated realisations of flows and forces, what Lynn refers as *animate form.*

Maher, A., Woods, P. & Burry, M. (2003). Building Blobs: Embedding research in practice.

The BLOb (Binary Large Objects) style 1997-2001

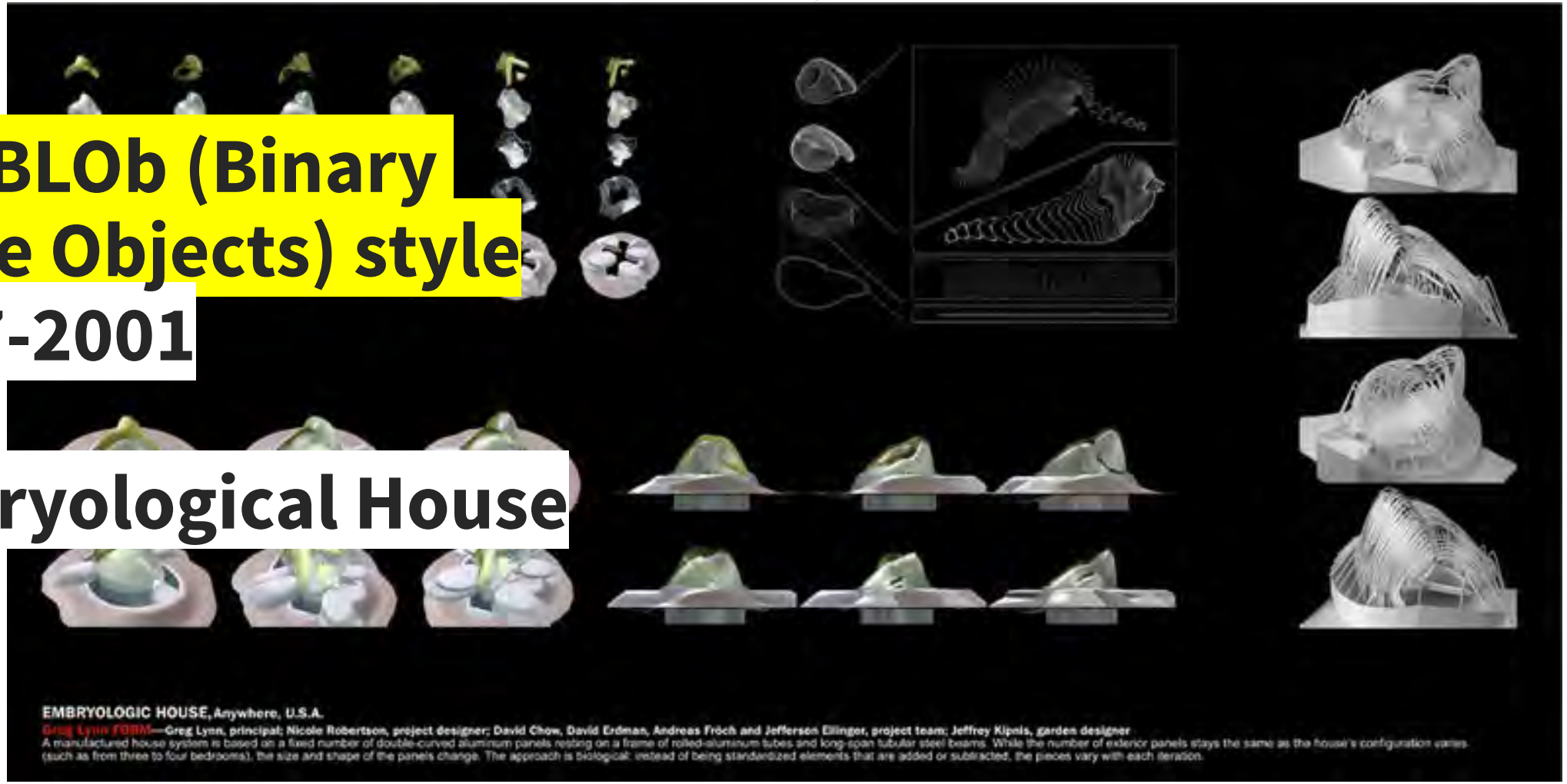
Embryological House

Moving from modernist idea of a form based on modules to form based (with potentially unlimited iterations) derived from basic form or primitive.

The House was developed using animation software (Microstation and Maya) and digitally-generated physical model. It was most completely designed in digital form.

The BLOb (Binary Large Objects) style
1997-2001

Embryological House



https://www.docam.ca/conservation/embryological-house/GL3ArchSig.html

c1990

The BLOb (Binary Large Objects) style

Fresh Water Pavilion By Nox Architects 1998

Gugghenheim Museum, Bilbao
Frank Gehry (1997)

Ground breaking digital tools and its socioeconomic factor, museum's expressive architectural form contributed to regeneration of the area. **The Bilbao Effect.**

It is celebrated as **turning point in architecture**, due to the fact that it was not possible to build without the use of CAD (computer-aided design) software, Digital Project.

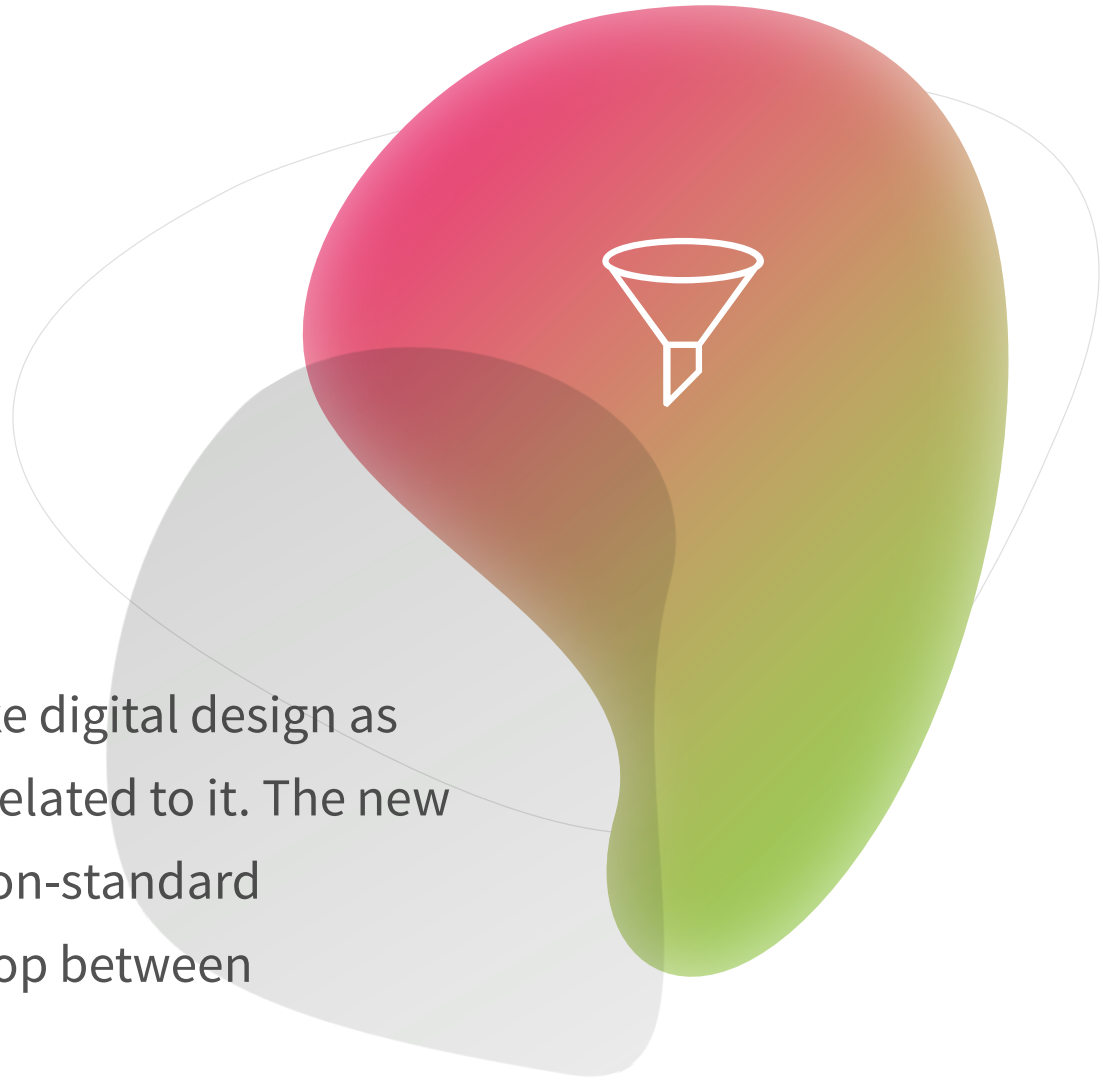
Gugghenheim Museum, Bilbao

Frank Gehry (1997)

Frank Gehry is considered as a pioneer in **“technological constructions”,** a technology that’s widely used as parametric design tools and BIM today.

Photo by Jorge Fernández Salas on Unsplash

Circa 2000



About

The 2000s marks the urge to make digital design as discipline and building theories related to it. The new concept is based on two ideas: non-standard architecture and the feedback loop between architecture and digitality.

“

“In the 1980s and 1990s, the computer maintained a cult status; It divided the architecture between **believers and skeptics**, a world of prophets, disciples and enthusiastic converts (...) Today the computer is not a new technology that **must be celebrated or deconstructed**, it is a simple fact ".

Stan Allen (2009) cited in Arteta (2017)

Augmenting reality

Digital tools enabled architecture to embody fluidity, temporality, movement and change.

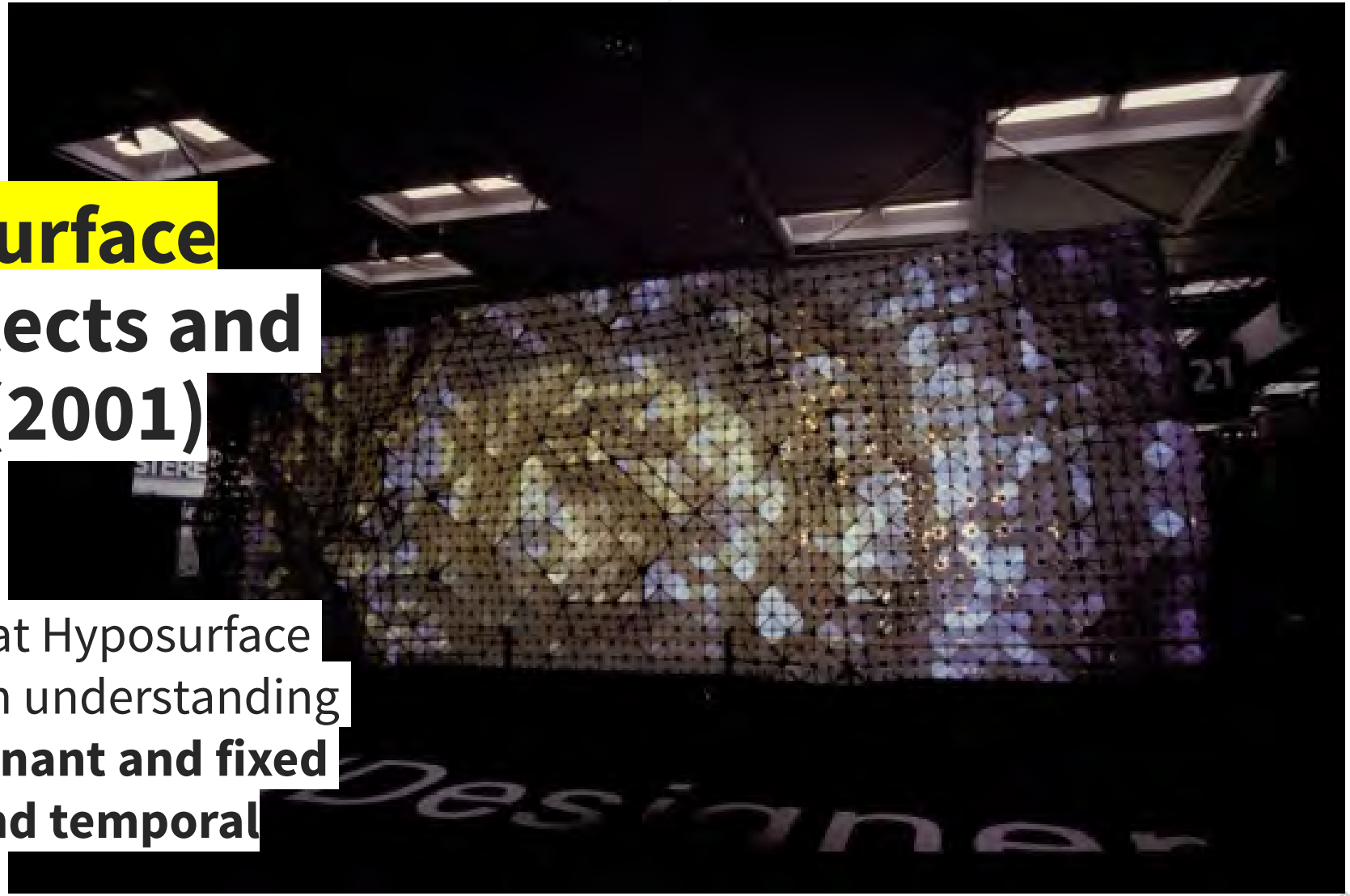
It transform how people move within their built environment. Architects explored adaptive physical architectural elements.

Aegis Hyposurface
dECOi architects and Mark Burry (2001)

First interactive walls consisted of almost 900 pneumatic pistons to control the movement of metal components on the wall**. Movement in real time** responses to **electronic stimuli** from environment (movement, sound, light, etc).

https://mcburry.net/aegis-hyposurface/

Aegis Hyposurface
dECOi architects and Mark Burry (2001)



Mark Burry wrote that Hyposurface represented a shift in understanding space, from **determinant and fixed** to **indeterminate and temporal**

https://mcburry.net/aegis-hyposurface/

Digital Fabrication

A shift from consumerism to prosumerism Small-scale digital fabrication machines

Digital fabrication technologies such as CNC-milling machines, laser cutter and 3D printers challenged the mechanism of consumer-based market.*

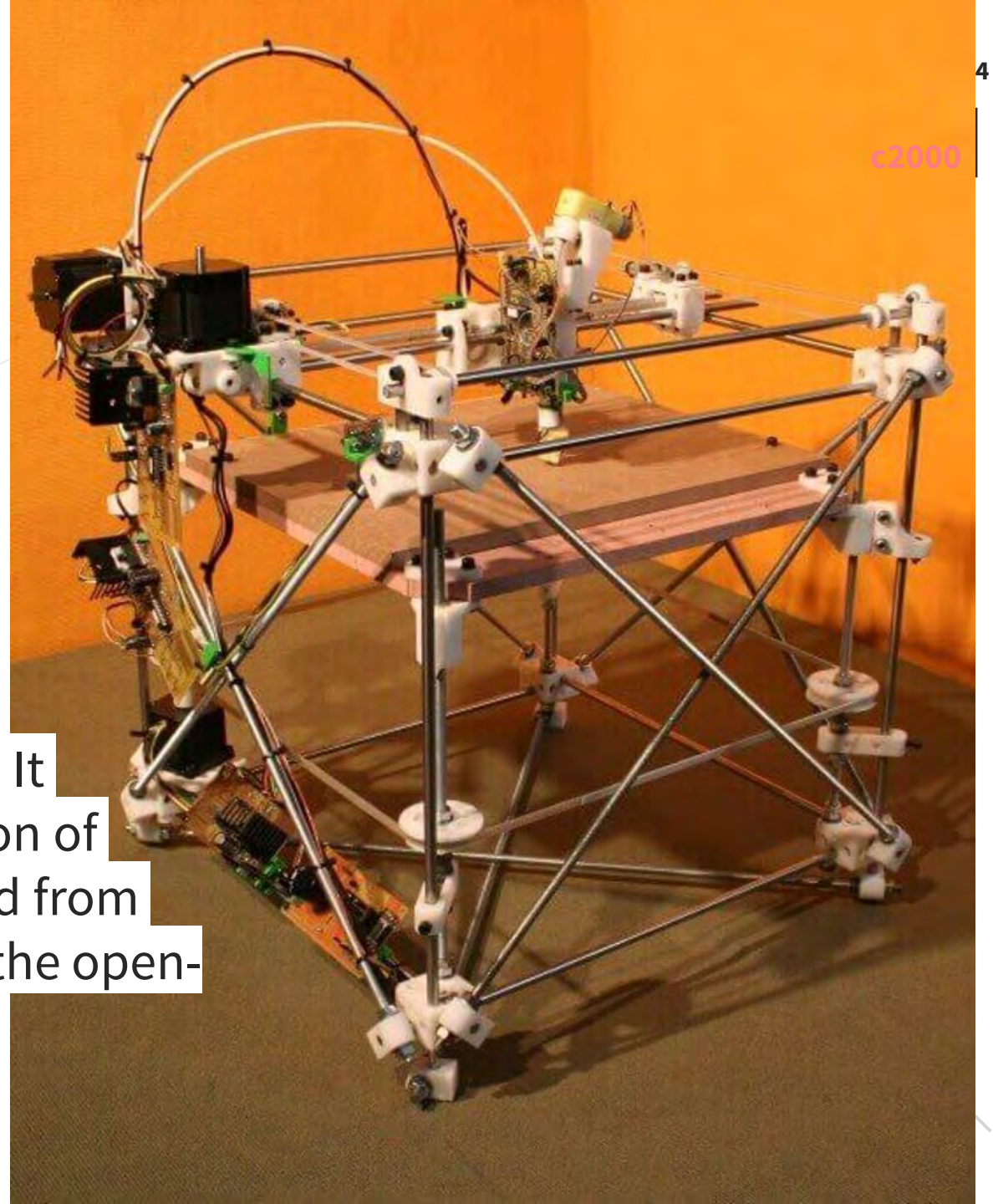
Claypool, M. (2019). The Digital in Architecture: Then, Now and in the Future. SPACE10

Digital Fabrication

Computer power increases exponentially, became more affordable and therefore more accessible.

c2000

Darwin
2004
Adrian Bowyer



First open-source desktop 3D printer. It exemplified the idea of digital fabrication of prosumer. The main idea was originated from *cybernetics* of John von Neumann and the open-source community.

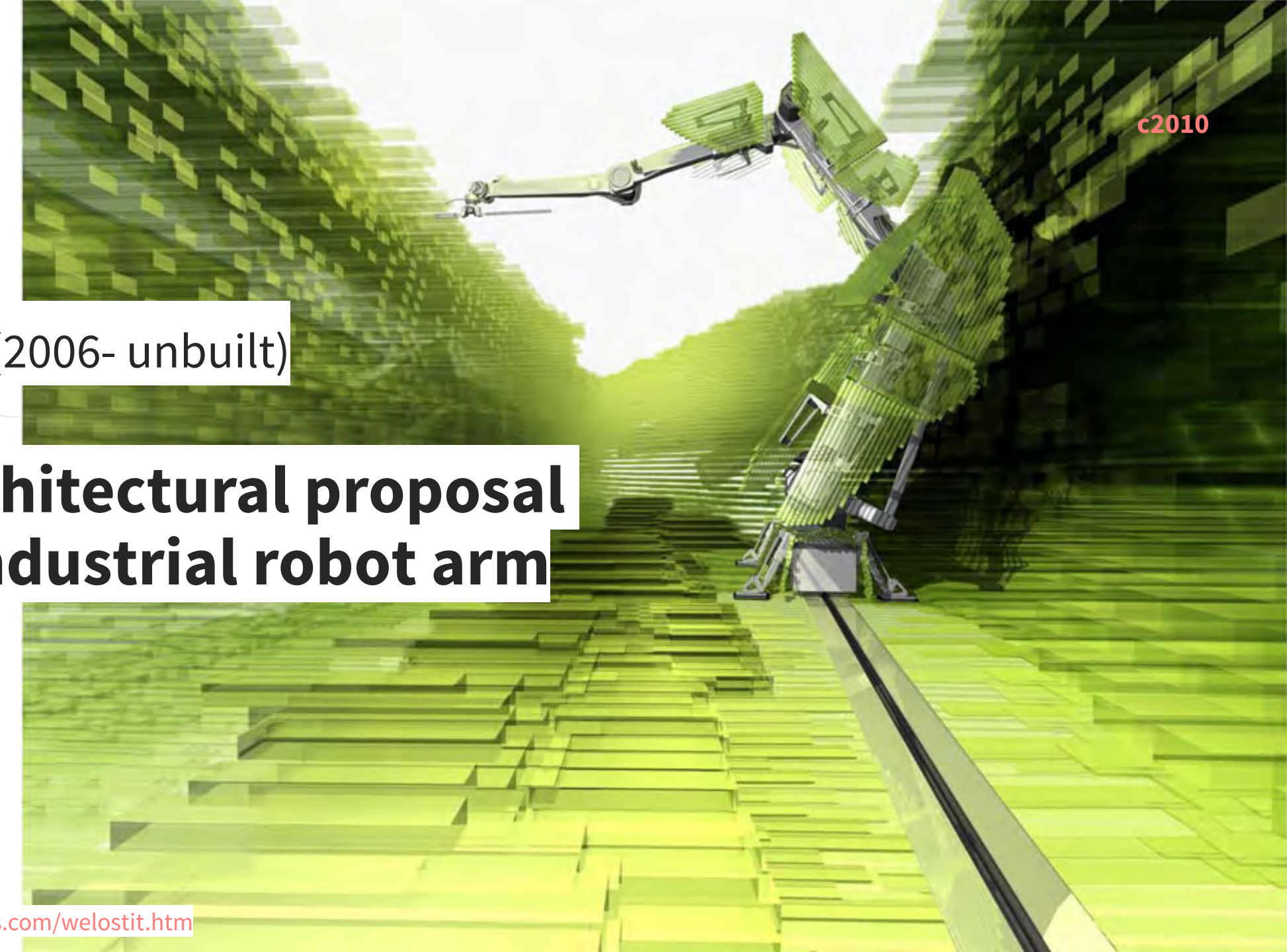
https://all3dp.com/history-of-the-reprap-project/

Olzweg (2006- unbuilt)

First architectural proposal to use industrial robot arm

Olzweg, the robotic arm would have been placed in the courtyard on a moving platform, perpetually construct a space made out of recycled glass by sliding them in and out the place.

https://new-territories.com/welostit.htm



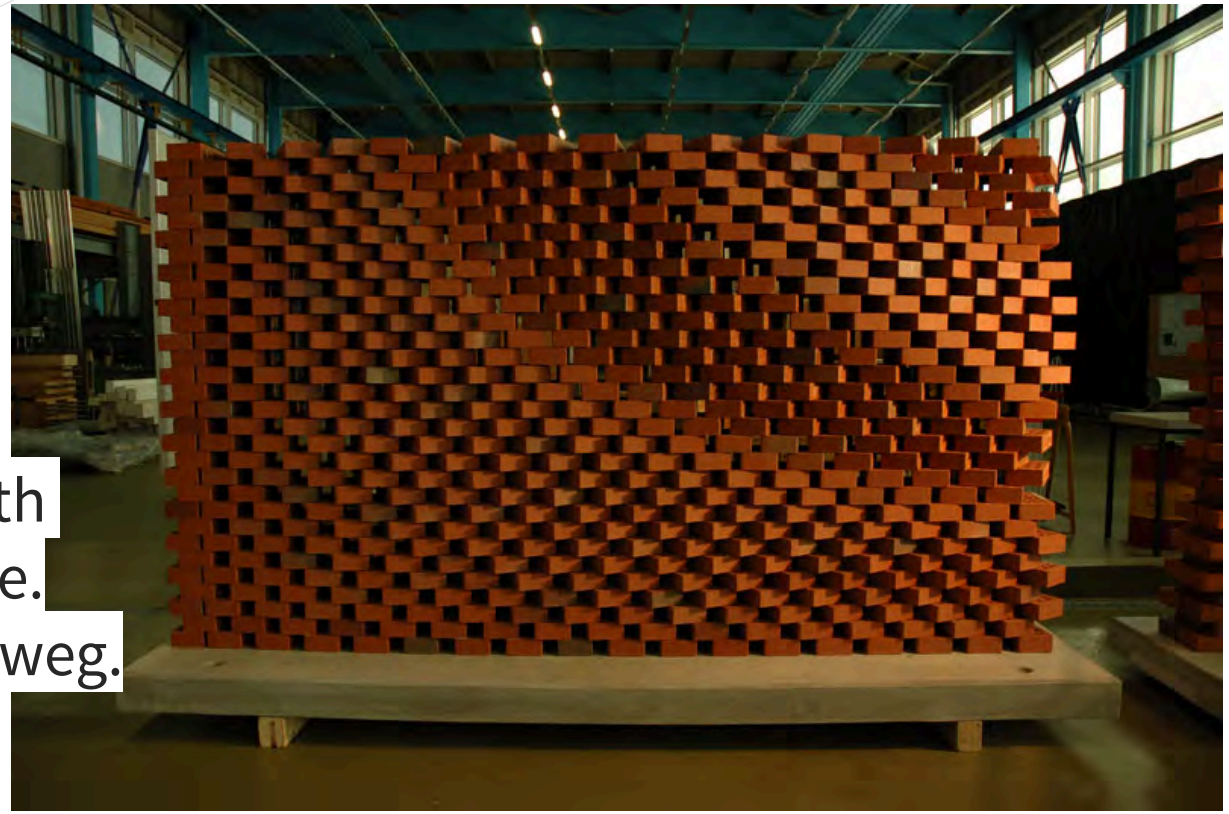
Olzweg (2006- unbuilt)

First architectural proposal to use industrial robot arm

https://new-territories.com/welostit.htm

The Programmed Wall
ETH Zurich
2006

Industrial robot positioned over 400 bricks by using constructive logic, with specific position and rotation in space. The robot is placed similarly with Olzweg.



https://gramaziokohler.arch.ethz.ch/web/e/lehre/81.html

The Programmed Wall

ETH Zurich

2006

https://gramaziokohler.arch.ethz.ch/web/e/lehre/81.html

fablab

Location: 1500 registered ‘fab labs’ in the world

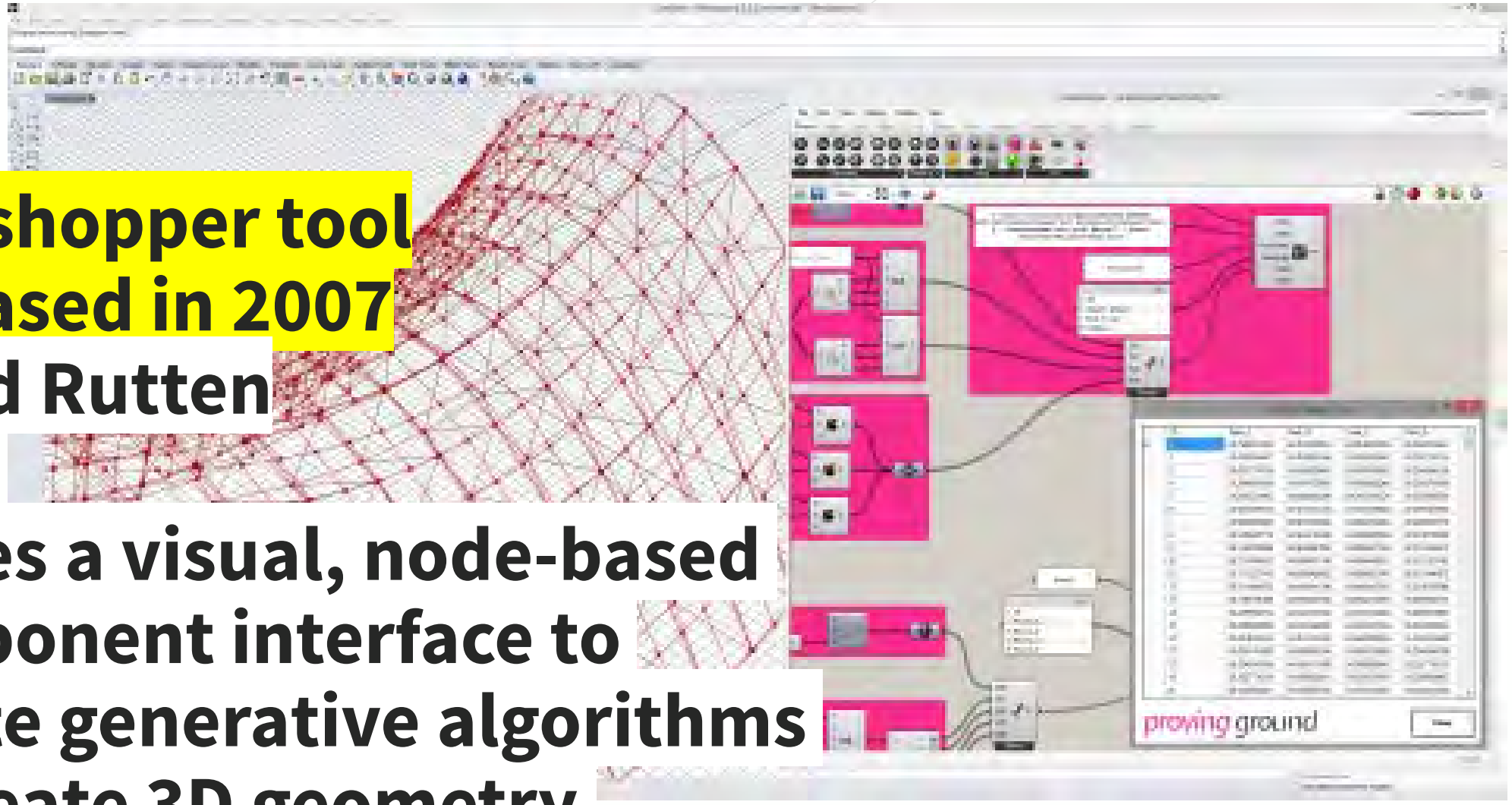
https://fabfoundation.org/

Formed in 2009. A Fab Lab, or **digital fabrication laboratory** which provides access to the environment, the skills, the materials and the advanced technology to allow anyone anywhere to make (almost) anything.

fablab

Location: 1500 registered ‘fab labs’ in the world

https://fabfoundation.org/



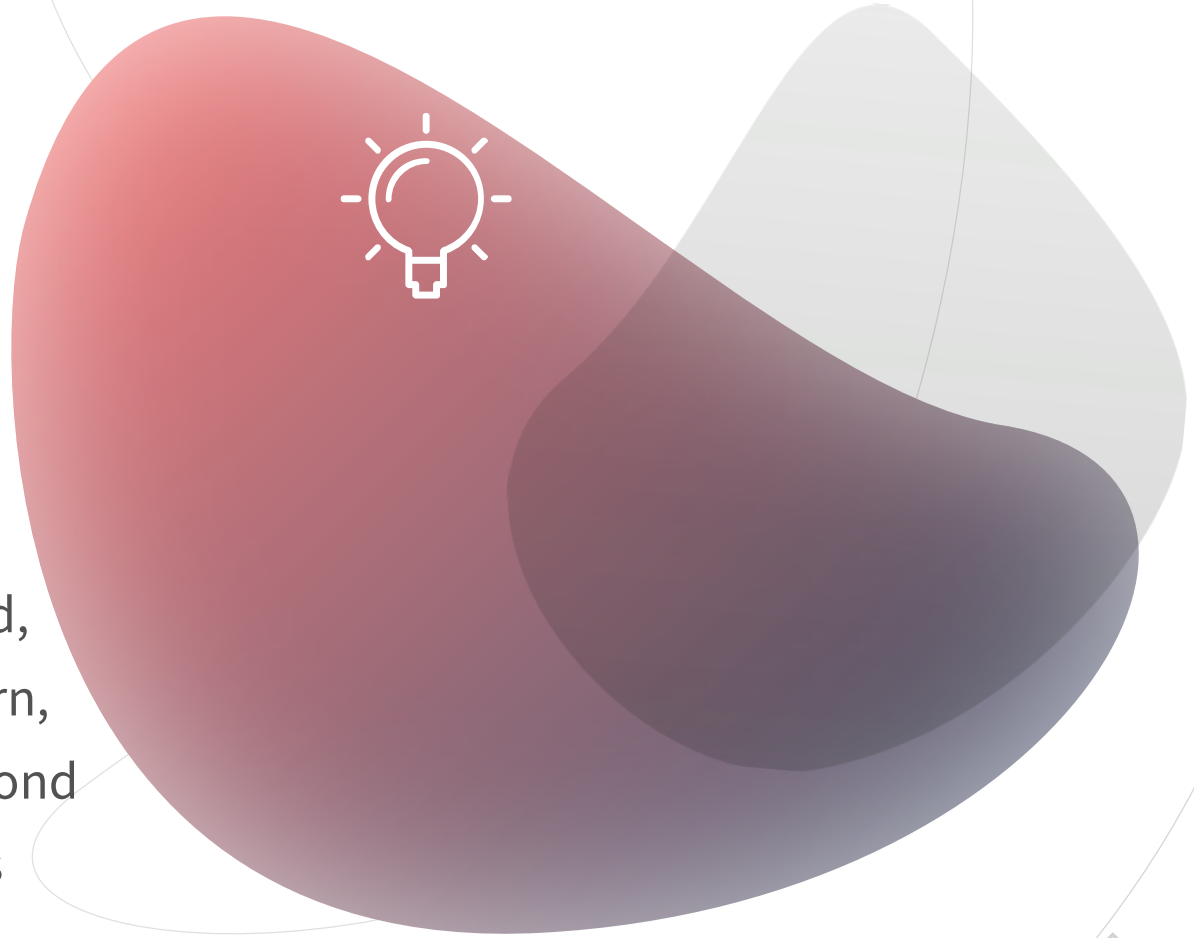
Grasshopper tool Released in 2007

David Rutten

It uses a visual, node-based component interface to create generative algorithms to create 3D geometry.

https://www.food4rhino.com/app/lunchbox

Circa 2010



About

The 2010s is when second digital turn started, according to Mario Carpo. During the first turn, it changed the way architects make. The second turn dissipate separations of ways architects think, draw and make.

Fourth Industrial Revolution (4IT)

The term was coined by Klaus Schwab, published a book in 2016 entitled “The Fourth Industrial Revolution”.

Technological is underway that is blurring the lines between: physical, digital and biological spheres

Big Data revolution

The effects on architecture industry can be:

1. Clients demand more data from architects
2. Clients demand data from buildings
3. Data changes process as much as it changes the output →architecture practice needs to be re-thought.

https://www.architectmagazine.com/technology/how-big-data-is-transforming-architecture_o

‘Cyber-physical’ approach 2015

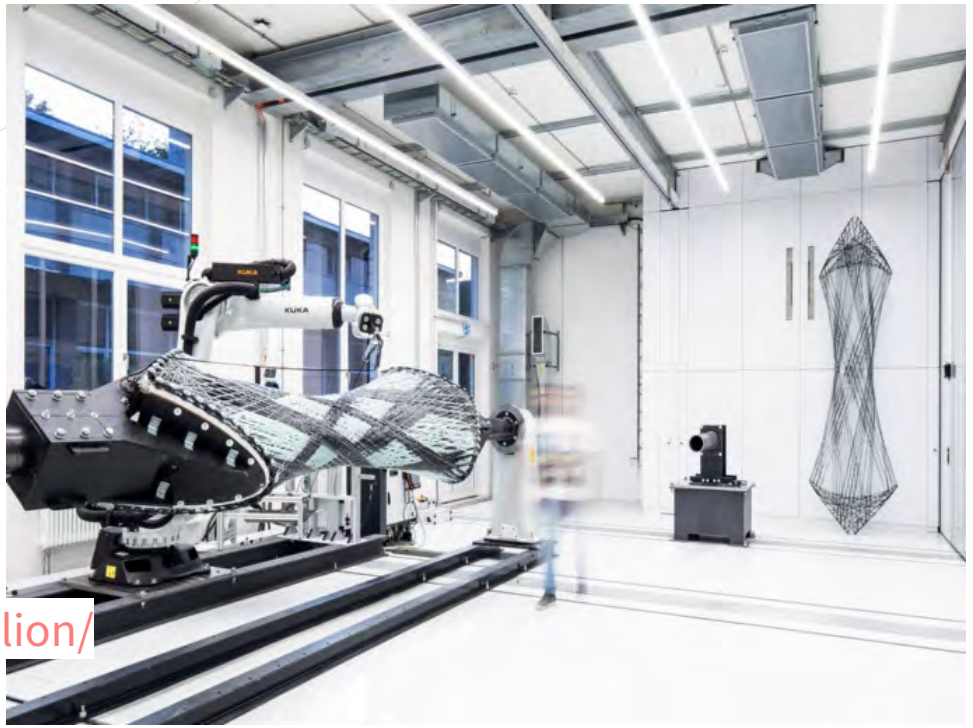
Menges, A. (2015). The New Cyber-Physical Making in Architecture: Computational Construction. *Architectural Design,* 85.

Relationship between virtual and physical data is interlinked using robotic technologies as well as sensor technologies.

‘Cyber-physical’ approach

BUGA Fibre Pavilion 2016 ICD Stuttgart

https://www.icd.uni-stuttgart.de/projects/buga-fiber-pavilion/



Combining cutting edge computational technologies + biomimetic principles = enabling development of truly novel and genuinely digital systems.

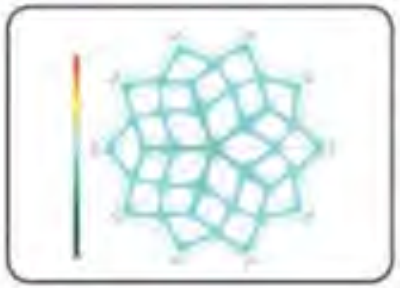
The pavilion was made from more than 150k meter of spatially arranged glass fibres and carbon fibres. The building components are produced by robotic approach.

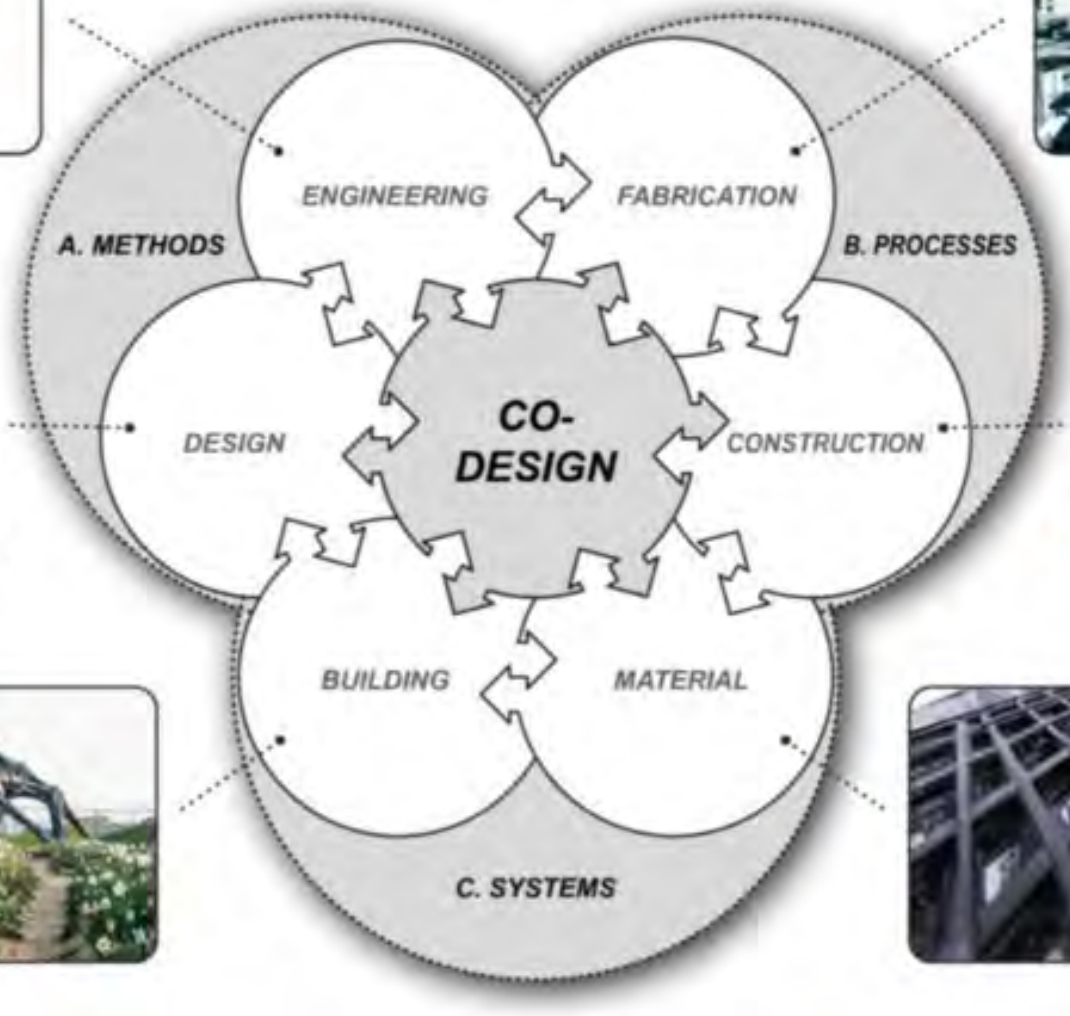
‘Cyber-physical’ approach
BUGA Fibre Pavilion 2016
ICD Stuttgart

https://www.icd.uni-stuttgart.de/projects/buga-fiber-pavilion/

‘Cyber-physical’ approach

BUGA Fibre Pavilion 2016 ICD Stuttgart





Co-design approach: Architectural design, structural engineering and robotic fabrication are developed in continuous computational feedback.

https://www.icd.uni-stuttgart.de/projects/buga-fiber-pavilion/

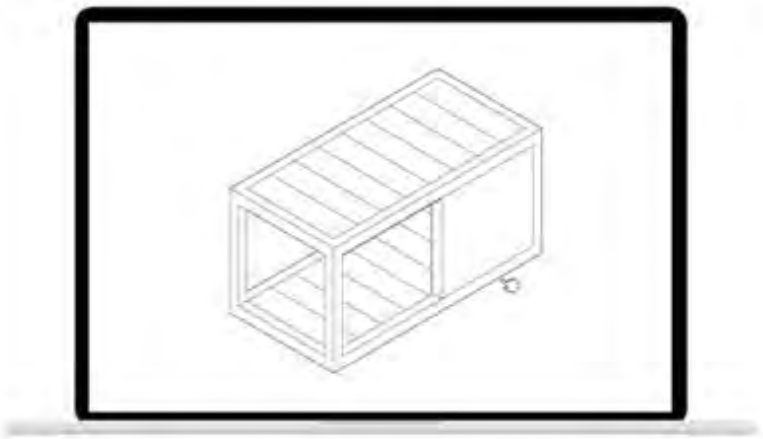
WikiHouse
(2011)

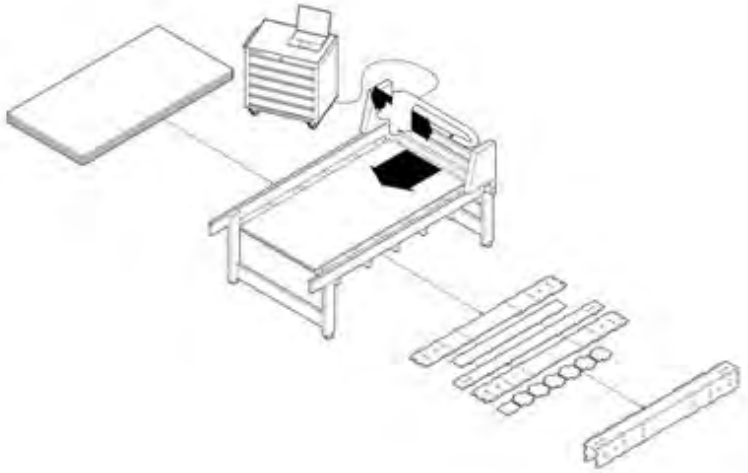
It is a digitally-manufactured building system.

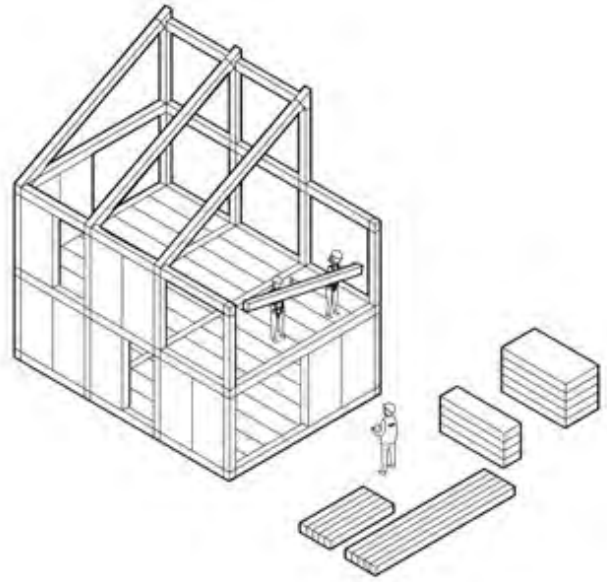
Aims to make it simple for anyone to design, manufacture and assemble customised homes.

https://www.wikihouse.cc/

WikiHouse (2011)







1 Digital design

WikiHouse is an adaptable system of standardised parts. This means each house can be unique without costing more. One size doesn't need to fit all

2 Local fabrication

WikiHouse doesn't need a large, expensive factory. Components are manufactured by a network of local microfactories using digital fabrication tools.

3 Rapid assembly

Homes can be rapidly assembled to millimetre precision, like a flat-pack. Almost anyone can do it; including small businesses and self-builders.

https://www.wikihouse.cc/

‘Discrete’ approach

Discreteness
The core of it is the wish to “redefine the entire production chain of architecture by accelerating the notion of discreteness in both computation and the physical assembly of buildings”
Self-similar, serialised and repeatable kit of parts
Voxel

Retsin, G. (2019). *Discrete: Reappraising the Digital in Architecture*, John Wiley & Sons.

‘Discrete’ approach

Self-similar, serialised and repeatable kit of parts

Eliminating ‘economy of scale’

Digital mass customisation allows us to mass-produce variations at no extra cost.

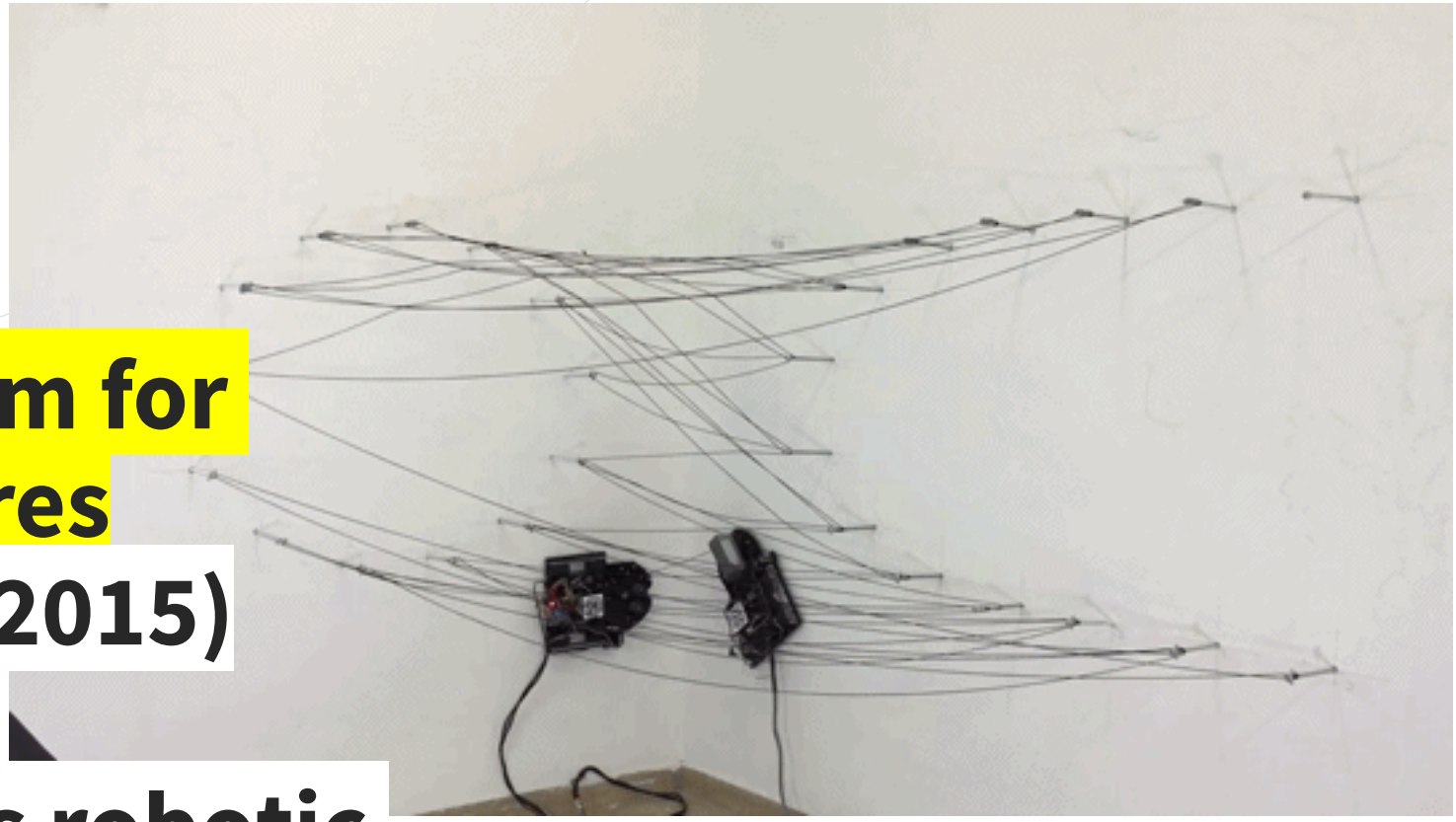
Thus eliminating economies of scale from a digital design and production workflow.

Key concepts in the field:

- Digital architecture
- Digital tools
- Algorithmic design
- Parametric design
- Generative design

Mobile Robotic Fabrication System for Filament Structures

Maria Yablonina (2015)



Semi autonomous robotic collaboration

Mobile Robotic Fabrication System for Filament Structures

Maria Yablonina (2015)

https://www.mariayablonina.com/mobile-robotic-fabrication-system

Criticism of parametric design:

It is not sensitive to contextual issues, no sympathy of local culture.

Complexity of forms demand the use of overly expensive and inefficient production methods.

Current concerns

Most construction remain analogue, reliant on manual labour.*

Although we have been practicing digital tools since 1960s.

Japan as pioneer in automated construction technologies.

Claypool, M. (2019). The Digital in Architecture: Then, Now and in the Future. SPACE10.

Harnessing drone technology for construction (deposit materials) and site visit.

AR (Augmented Reality) to deal with imprecision.

Claypool, M. (2019). The Digital in Architecture: Then, Now and in the Future. SPACE10.

Ongoing debate in areas of:

Mobility
Labour
Customisation

Architect Alessandro Bava writes:

01 'How could these innovations in computing be used to better understand a building's environmental performance, or the best way to design urban planning interventions, or production and construction processes?

02 How could artificial intelligence including machine learning enable architects to design novel kinds of architecture that can better respond to the changing world around it?

03 How can digital tools enable architects and designers to create better architecture for more people?'

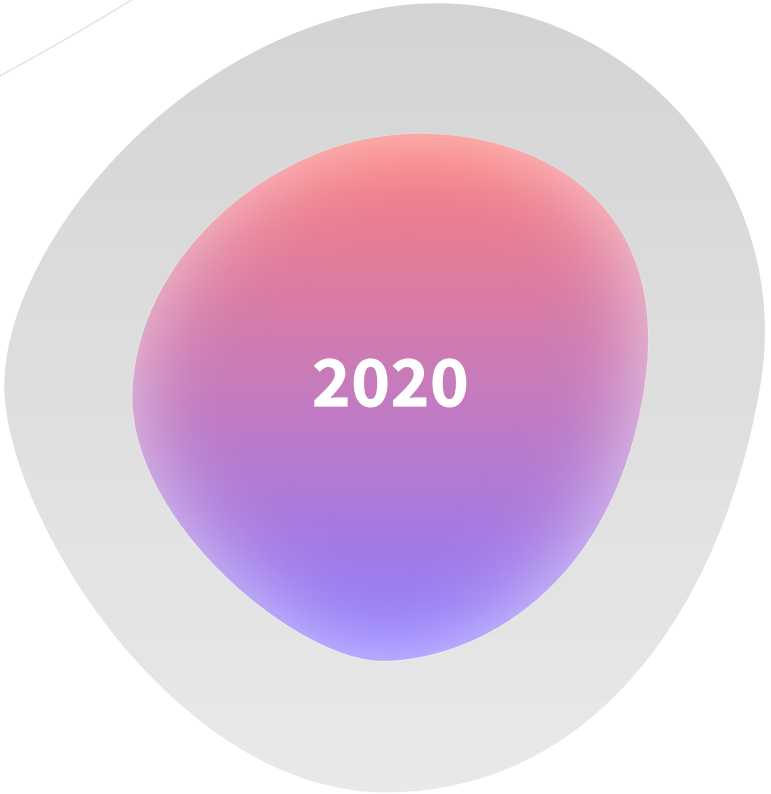
Reflections in 2020

Re Big Data

How do we gain the data?
How do we use the data?
How to we increase validity of data?
How can we communicate data with other skateholders?

Re Others

How do we make better architecture for people with the use of digital tools?
How do we maximise potentials of technology for the benefit of mankind?



Re-iterating aims and objectives

Have we achieved these?

- To expand historical background of this design field.
- To enumerate current debates.
- To elicit key events related to computational design.
- To enumerate key concepts related to development of the fields, in relation with the timeline.