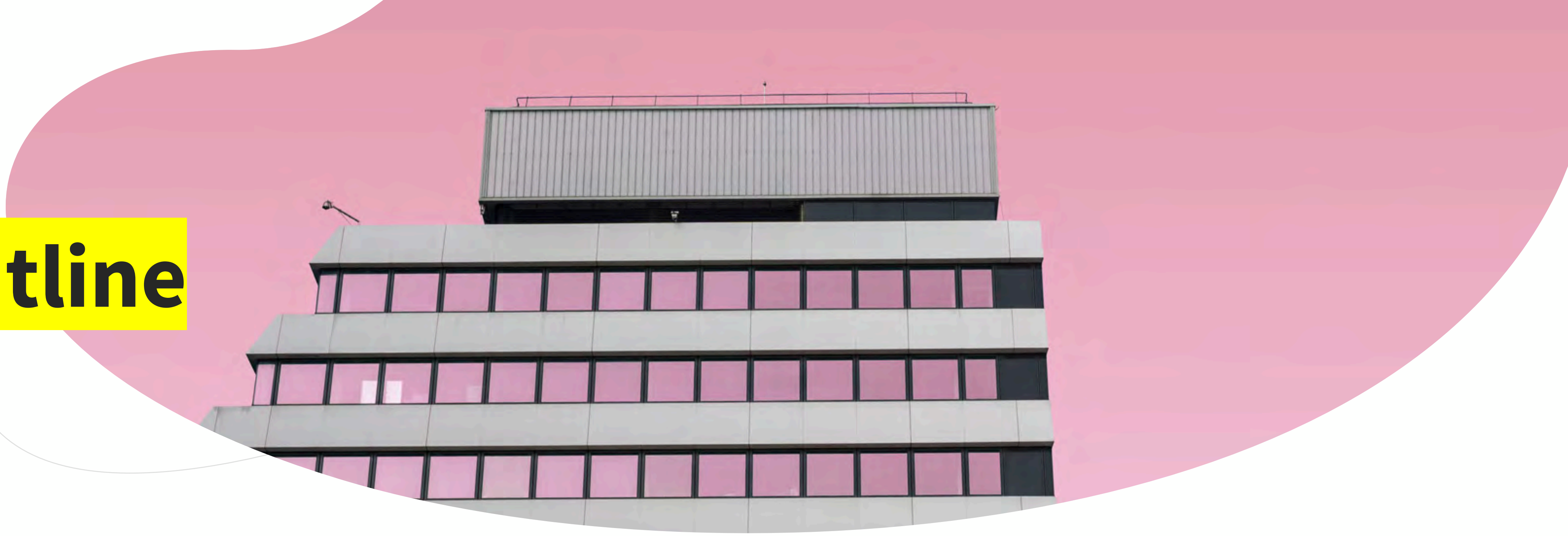
Week 13
Artificial Intelligence in Architecture

This week we will explore AI applications in architecture and looking at Generative Design.

Photo by Adam Birkett on Unsplash

Outline



01

Artificial Intelligence (AI)

Ranging from a historical perspective of AI dated in 1954, to the state-of-art of AI applications.

02

AI in architecture

Exploring how AI is adapted to the field of architecture and computational design.

03

Generative Design

Generative design techniques, implementation and potentials.

Photo by Pierre Châtel-Innocenti on Unsplash

Aims and objectives

- To contextualise definitions and concepts of AI
- To illustrate historical accounts of AI
- To contextualise AI in the field of architecture
- To elicit the state-of-art of AI in architecture, along with future recommendations
- To expand on Generative Design in computational design thinking

Learning outcomes

Students will be able to..

01 Gain understanding on the background knowledge of AI.

02 Enumerate influential figures in AI and AI in architecture.

03 Elicit Generative Design and its potential in computational design.

(module)

Overarching skills

Software skills
Rhino, Grasshopper, etc

Research skills
Designing through extensive research

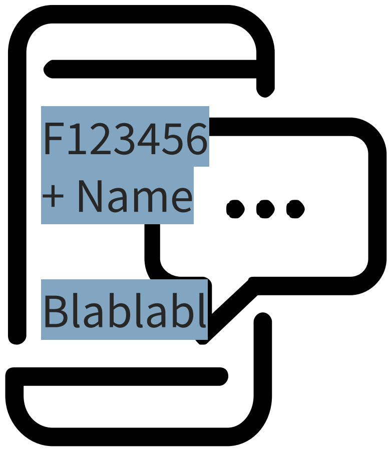
Personal interest
Exploring a preferred scope of design to be developed further

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

Discussion



Read Cudzik and Radziszewski (2018) discussion on three adopted AI methods. Share your thoughts on the fact that these methods will result in more intuitive design tools.

You can find the paper in supporting materials

https://miatedjosaputro.com/2020/05/19/week-13-discussion/

Artificial Intelligence

Photo by Марьян Блан | @marjanblan on Unsplash

Definitions of AI, organised in 4 categories

Stuart, R. & Peter, N. (2016). Artificial intelligence-a modern approach 3rd ed. Berkeley.

Thinking Humanly "The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	**Thinking Rationally** "The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	**Acting Rationally** "Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Definitions of AI, organised in 4 categories

Stuart, R. & Peter, N. (2016). Artificial intelligence-a modern approach 3rd ed. Berkeley.

Concerning *thought processes* and *reasoning*

Thinking Humanly: The cognitive modelling approach. Ways to determine how humans think: 1. Introspection 2. Psychological experiments 3. Brain imaging	**Thinking Rationally:** The “laws of through” approach. Syllogism Logic Logicist
Acting Humanly “The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990) “The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)	**Acting Rationally** “Computational Intelligence is the study of the design of intelligent agents.” (Poole *et al.*, 1998) “AI …is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Definitions of AI, organised in 4 categories

Stuart, R. & Peter, N. (2016). Artificial intelligence-a modern approach 3rd ed. Berkeley.

Thinking Humanly	Thinking Rationally
"The exciting new effort to make computers think … *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solv-	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)

Concerning *behaviour*

Acting Humanly: (Bellman, 1978)

The **Turing Test (#1-4)** approach .

The computer would need to possess the following capabilities:

1. Natural language processing
2. Knowledge representation
3. Automated reasoning
4. Machine learning

Total **Turing Test,** computer would need to possess:

1. Computer vision
2. Robotics

Acting Rationally:

The **rational agent** approach.

Rational agents are expected to act such as: operate autonomously, perceive their environment, persist over a prolonged time period, adapt to change, and create and pursue goals.

havior in artifacts." (Nilsson, 1998)

definitions of artificial intelligence, organized into four categories.

Emergence of AI

Neapolitan, R. E. & Jiang, X. (2018). *Artificial intelligence: With an introduction to machine learning*, CRC Press.

Initial effort involved modelling the neurons in the brain, initiated by:

1943

McCulloch and Pits

1949

Donald Hebb

1950

Alan Turing developed an empirical test of artificial intelligence.

1956

John McCarthy coined the term *Artificial Intelligence* in the 2-month workshop at Dartmouth University.

Development of AI

Stuart, R. & Peter, N. (2016). Artificial intelligence-a modern approach 3rd ed. Berkeley.

1956-1969

Early enthusiasm, great expectations

Newell and Simon GPS (General Problem Solver) was designed to start to imitate human problem-solving protocol.
In 1958 Marvin Minsky collaborated with McCarthy

1966-1973

A dose of reality

Difficulties of early systems when tried out on wider selections of problems and on more difficult problems. Scaling up problems.

1969-1979

Knowledge-based system

DENDRAL (1969): first successful knowledge-intensive systems, its expertise derived from large number of special-purpose rules.

1980-present

AI becomes an industry

Development of AI

Stuart, R. & Peter, N. (2016). Artificial intelligence-a modern approach 3rd ed. Berkeley.

1986-present

The return of neural networks

1987-present

AI adopts the scientific method

It is now more common to build on existing theories rather than propose new ones.

1995-present

The emergence of intelligent agents

One of the most important environment for intelligent agents are the internet.

2001-present

Availability of very large data set

Influential figures of AI:

1. John McCarthy
2. Marvin Minsky
3. Alan Turing
4. Allen Newell
5. Herbert A. Simon
6. J.C.R. Licklider

1927-2011
One of the founding fathers of Artificial Intelligence. He invented Lisp in 1960, a family of programming languages.

Influential figures of AI:

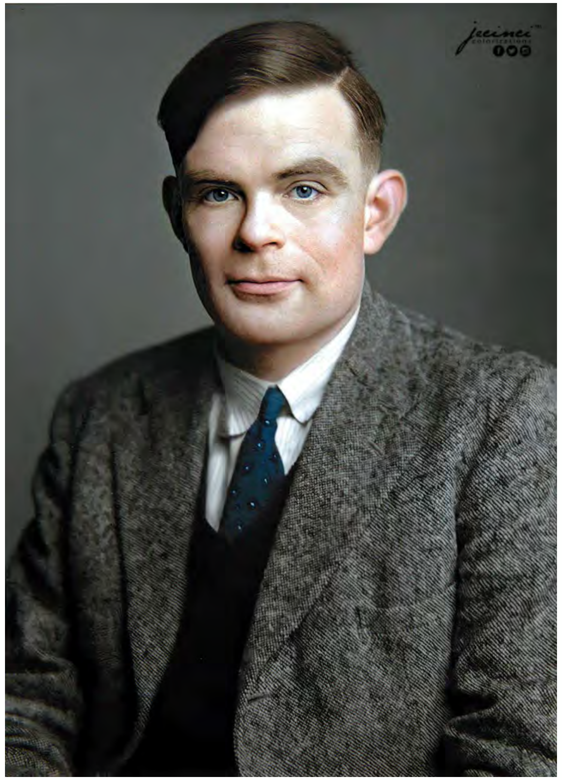
1. John McCarthy
2. Marvin Minsky
3. Alan Turing
4. Allen Newell
5. Herbert A. Simon
6. J.C.R. Licklider

1927-2016

Founder of MIT Artificial Intelligence Project. He believed that AI might eventually offer a way to solve some of humanity's biggest problems.

Influential figures of AI:

1. John McCarthy
2. Marvin Minsky
3. Alan Turing
4. Allen Newell
5. Herbert A. Simon
6. J.C.R. Licklider



1912-1954

In 1950 he was already grappling with the question whether machines can think. Turing Test remains a useful way to chart progress of AI.

Influential figures of AI:

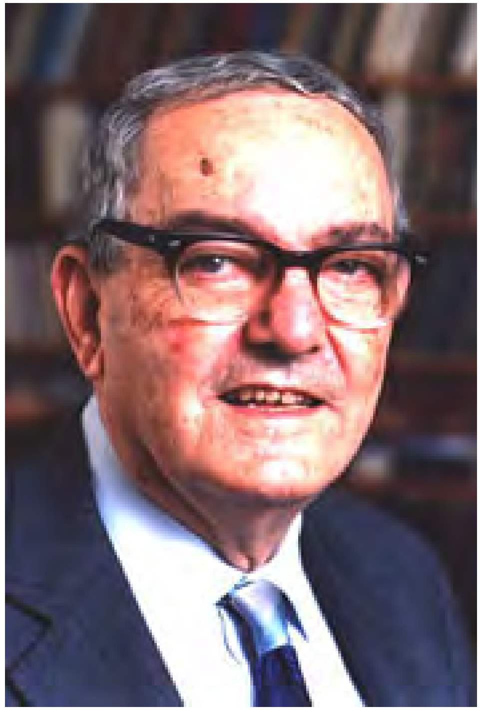
1. John McCarthy
2. Marvin Minsky
3. Alan Turing
4. Allen Newell
5. Herbert A. Simon
6. J.C.R. Licklider

1927-1992

His central goal was to understand the cognitive architecture of the human mind and how it enables human to solve problems.

Influential figures of AI:

1. John McCarthy
2. Marvin Minsky
3. Alan Turing
4. Allen Newell
5. Herbert A. Simon
6. J.C.R. Licklider

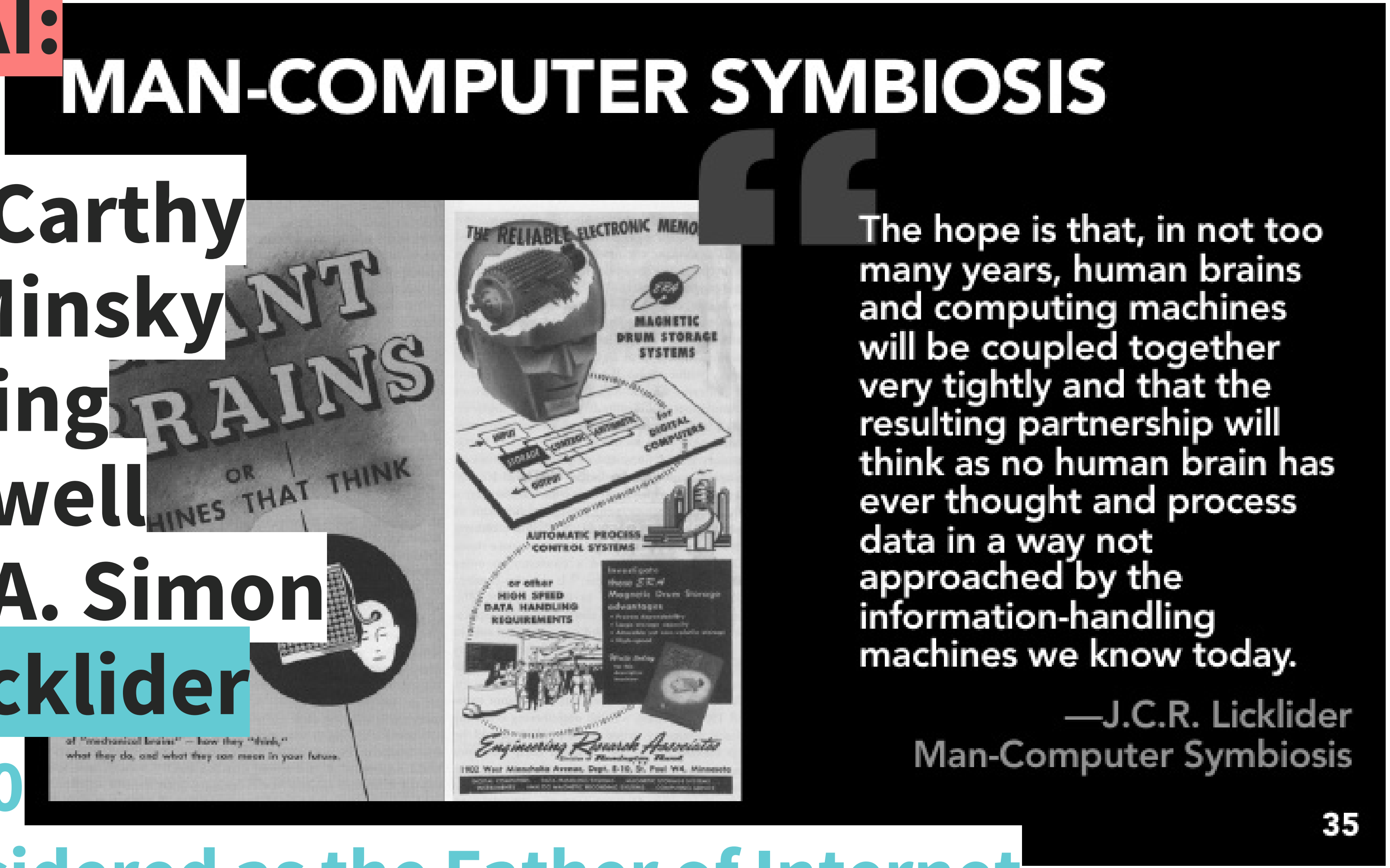


1916-2001

He is best known for his work on the theory of corporate decision making known as “behaviourism”.

Influential figures of AI:

1. John McCarthy
2. Marvin Minsky
3. Alan Turing
4. Allen Newell
5. Herbert A. Simon
6. J.C.R. Licklider



1915-1990

He is considered as the Father of Internet.

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

Important concepts in AI: Intelligent Agents

Stuart, R. & Peter, N. (2016). Artificial intelligence-a modern approach 3rd ed. Berkeley.

AI can be seen as a study of **rational agent** and its **environment**.

An **agent** is anything that can be viewed as perceiving its **environment** through sensors and acting upon that environment through **actuators**.

An **rational agent** acts as to maximise the expected value of performance measure, given the percept sequence.

Important concepts in AI: Properties of Task Environments

PEAS:
Performance
Environment
Actuators
Sensors

Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, staff	Display of questions, tests, diagnoses, treatments, referrals	Keyboard entry of symptoms, findings, patient's answers
Satellite image analysis system	Correct image categorization	Downlink from orbiting satellite	Display of scene categorization	Color pixel arrays
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts; bins	Jointed arm and hand	Camera, joint angle sensors
Refinery controller	Purity, yield, safety	Refinery, operators	Valves, pumps, heaters, displays	Temperature, pressure, chemical sensors
Interactive English tutor	Student's score on test	Set of students, testing agency	Display of exercises, suggestions, corrections	Keyboard entry

Figure 2.5 Examples of agent types and their PEAS descriptions.

Contemporary figures of AI:

1. Andrew Ng
2. Yoshua Bengio
3. Yann LeCunn
4. Demis Hassabis
5. Geoffrey Hinton
6. Fei-Fei Li

What can AI do now?

1. Robotic vehicles
2. Speech recognition
3. Autonomous planning and scheduling
4. Game playing
5. Logistics planning
6. Robotics
7. Machine Translation
8. *Any many more..*

AI application in COVID-19 in healthcare

Vaishya, R., Javaid, M., Khan, I. H. & Haleem, A. (2020). Artificial Intelligence (AI) applications for COVID-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 14**,** 337-339.

Main applications are:

1. Early detection and diagnosis of infection
2. Monitoring the treatment
3. Contact tracing of individuals
4. Projection of cases and mortality
5. Development of drugs and vaccines
6. Reducing healthcare workers' workload
7. Prevention of the disease

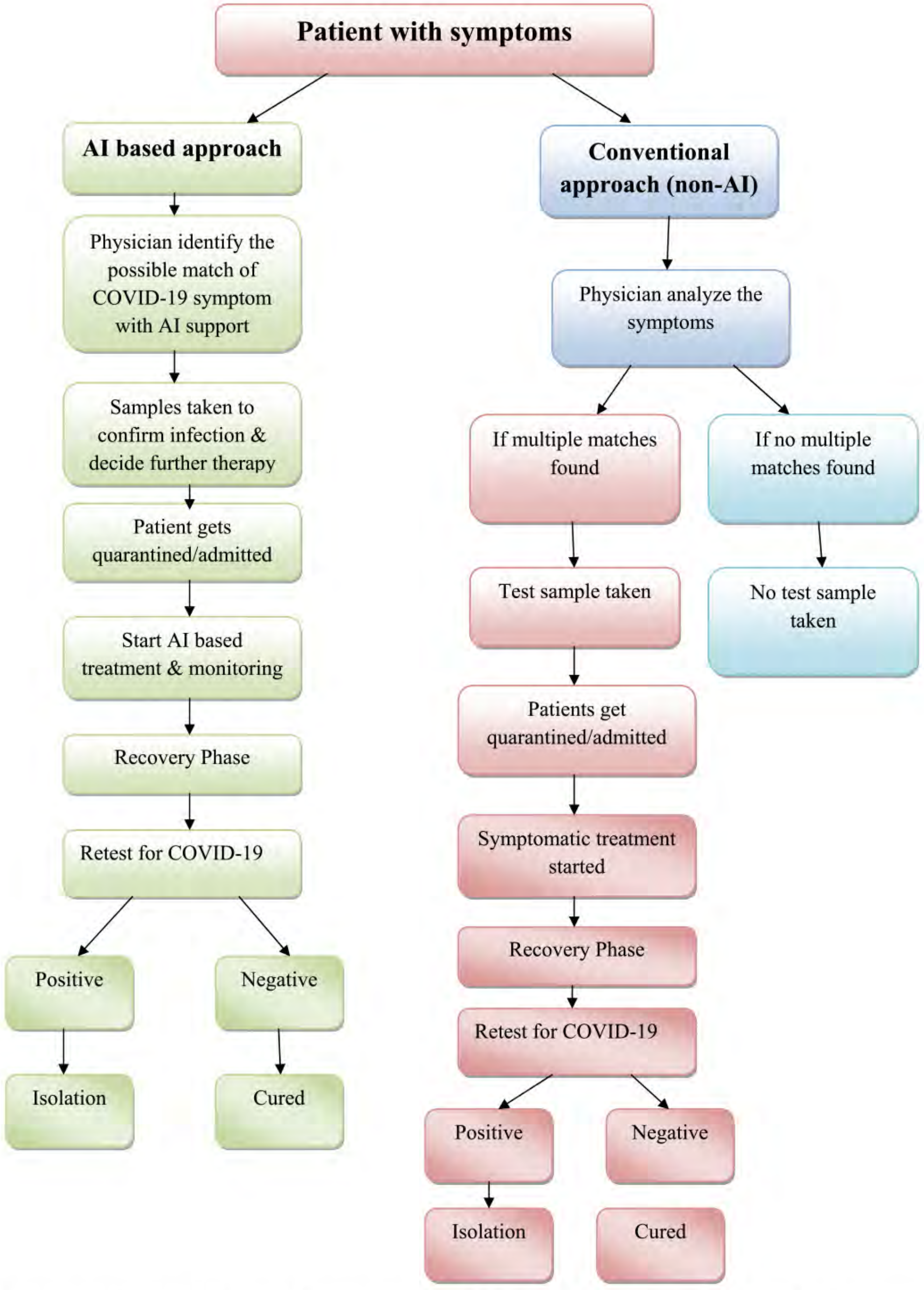


Fig. 1. General procedure of AI and non-AI based applications that help general physicians to identify the COVID-19 symptoms.

AI application in COVID-19 in other areas

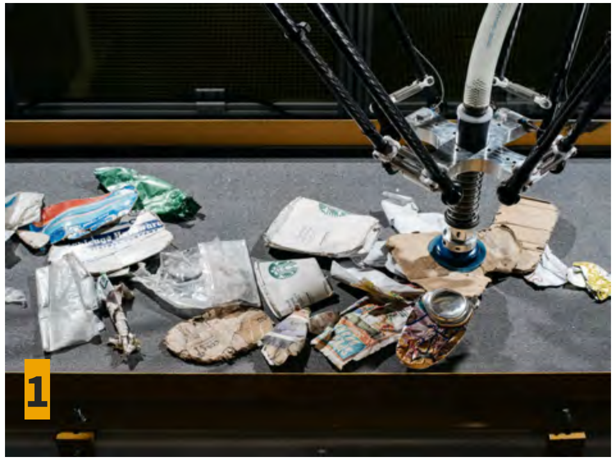
https://sloanreview.mit.edu/article/ai-robots-and-ethics-in-the-age-of-covid-19/

https://www.weforum.org/agenda/2020/05/covid19-coronavirus-artificial-intelligence-ai-response/

AI infused technologies

have presented potentials during pandemic, such as:

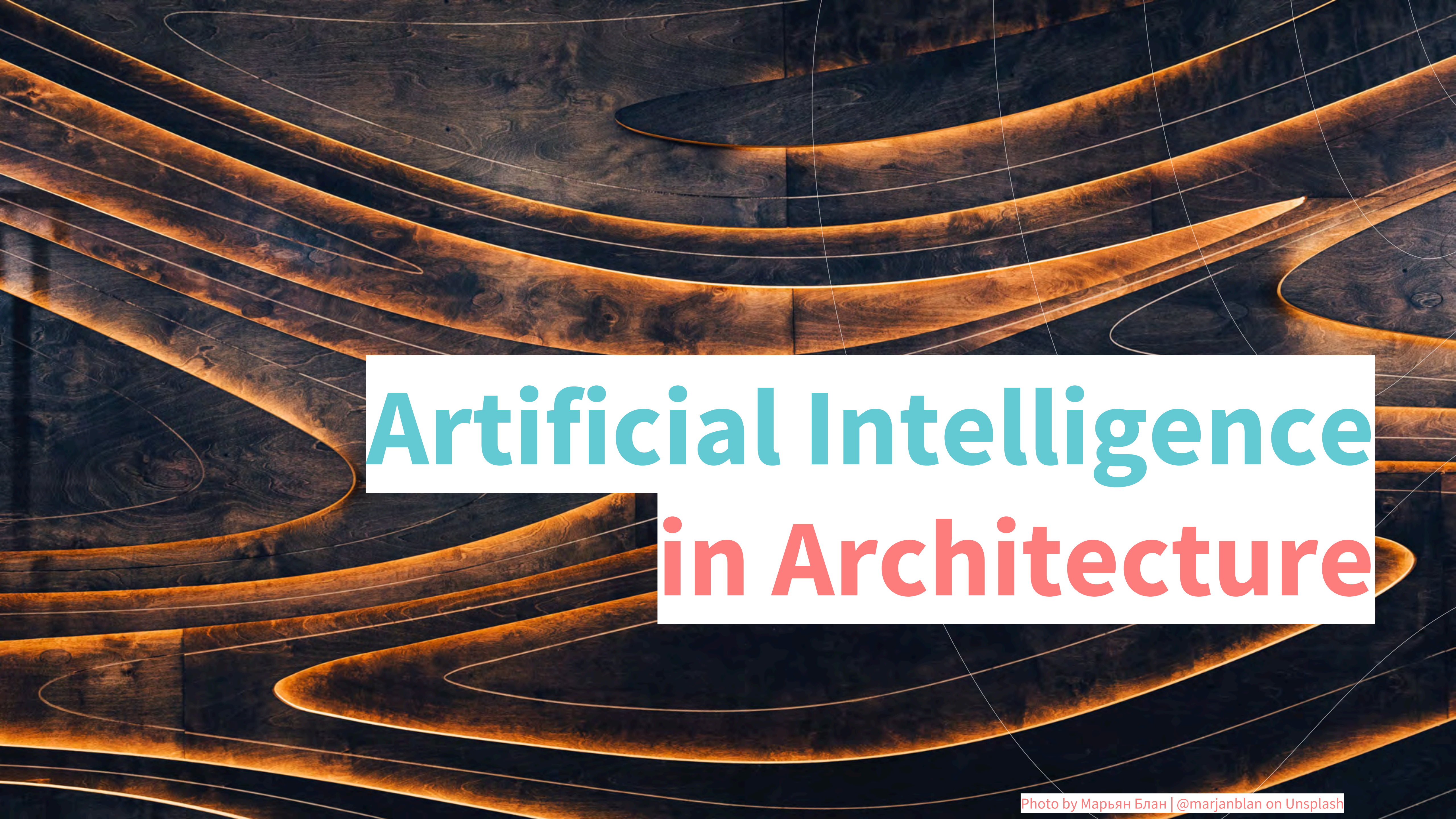
1. Labour-replacing robots in recycling industry, AMP Robotics.
2. Robotic telepresence platforms (college graduation experience in Japan).
3. Noisy fans in empty stadiums, baseball games in Taiwan.



(Selected) misconceptions of the proliferation of AI:

https://bdtechtalks.com/2018/11/28/ten-misconceptions-about-artificial-intelligence-dispelled/
https://www.business.com/articles/4-misconceptions-about-ai/

1. AI is actively looking to replace people (or architects)
2. AI can solve any problem
3. AI is infallible
4. AI will be the end of humanity



Artificial Intelligence in Architecture

Photo by Марьян Блан | @marjanblan on Unsplash

Virtual exhibition

(due to the pandemic)

"Architecture and AI"

at the Pavilion de l'Arsenal in Paris.

28 February- 5 May 2020

http://stanislaschaillou.com/arsenal/vtour/

"AI does bring a more holistic approach to understanding architecture and uncoding its complexity in terms of computer commands.."

Stanislas Chaillou
Architect and AI Researcher

"..the magic is really created when you combine architectural intuition and artificial intelligence and give the architect superpowers.."

Anders Kvale
Cofounder & President, SPACEMAKER

".. (AI) enable the architect to get a very fast feedback… and that's very important.. the faster the iterations are, the faster you can process new design, the more ideas you can explore.."

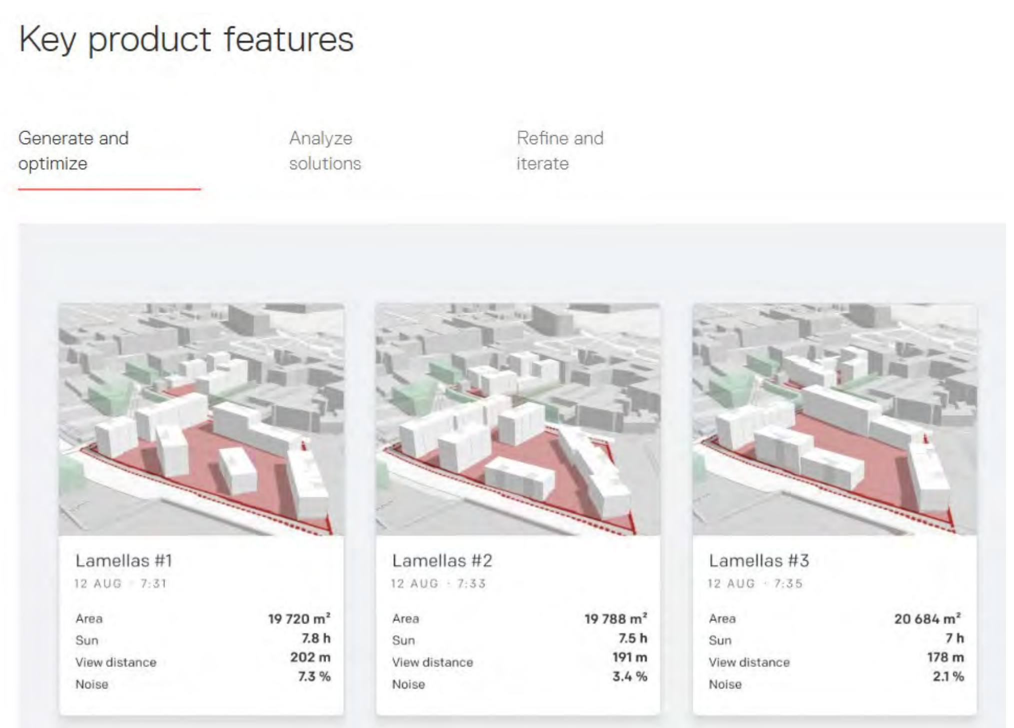
Bastian Dolla
Cofounder, HABX

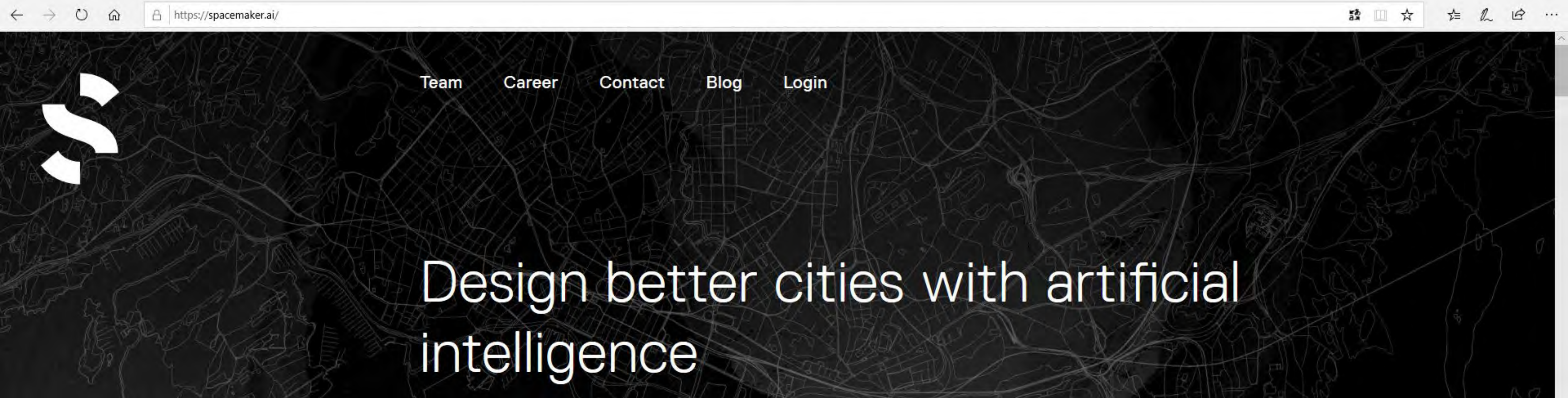
"..it necessitates the collaboration between architect and the machine.. It will allow the architects to be challenged in their many choices, but architects will not be replaced..

Nathalie Watine
Executive Vice-president, Innovation, Digital Transformation and Information systems, Bouygues Immobilier

https://vimeo.com/400297372

SPACEMAKER: Using AI to maximise potential of building site

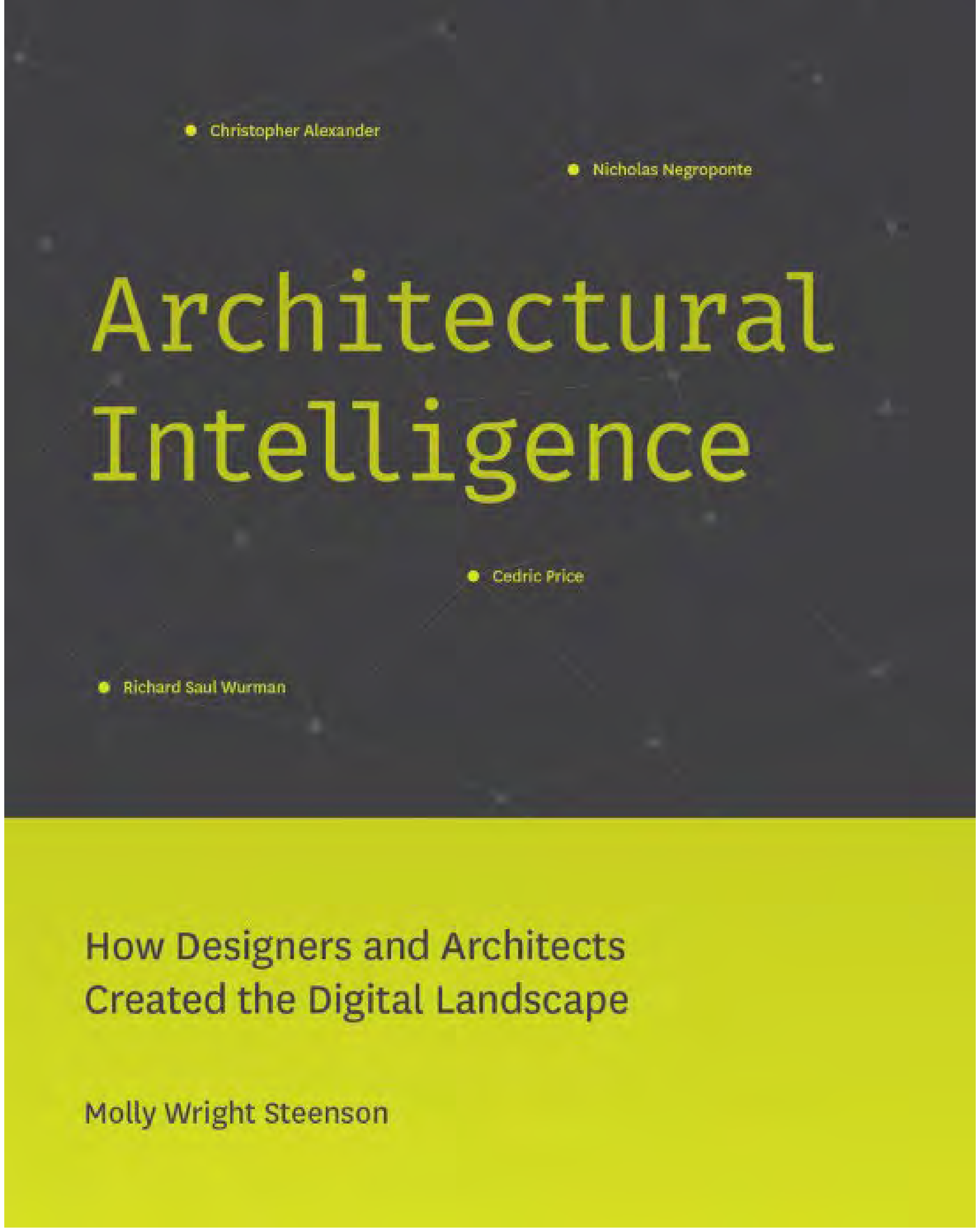




Historical viewpoints: technological paradigms of 4 architects:

1. Christopher Alexander
2. Richard Saul Wurman
3. Cedric Price
4. Nicholas Negroponte

Steenson, M. W. (2017). *Architectural Intelligence: How Designers and Architects Created the Digital Landscape*, mit Press.



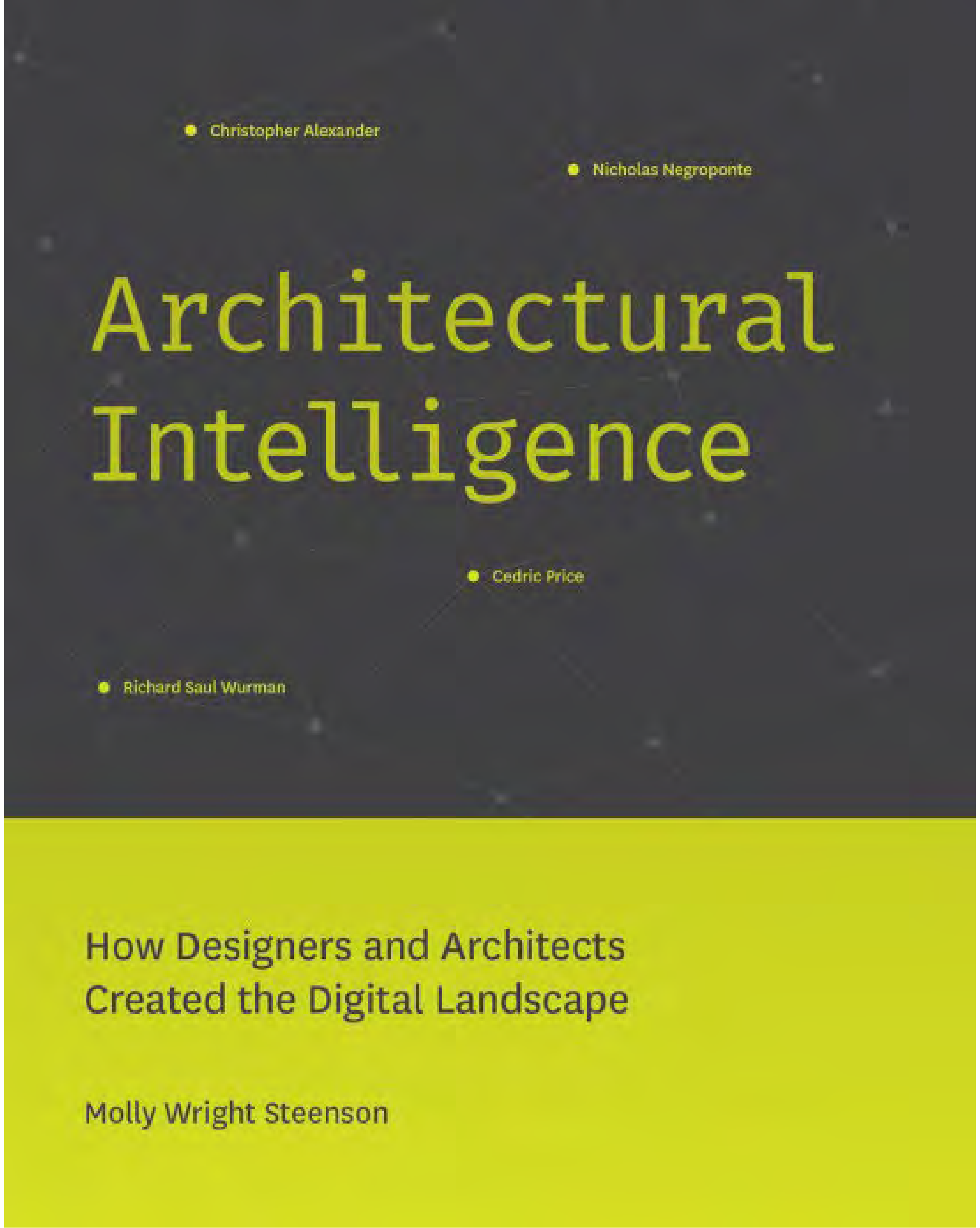
The discussions in the book are based on questions such as:

In what ways were these practices architectural, and how did they push the boundaries of architecture?

Similarly, how did their experiments with computing and technology push the bounds of the technological fields in which they were working?

What did computational, cybernetic, and artificial intelligence researchers and engineers stand to gain by engaging with architects and architectural problems?

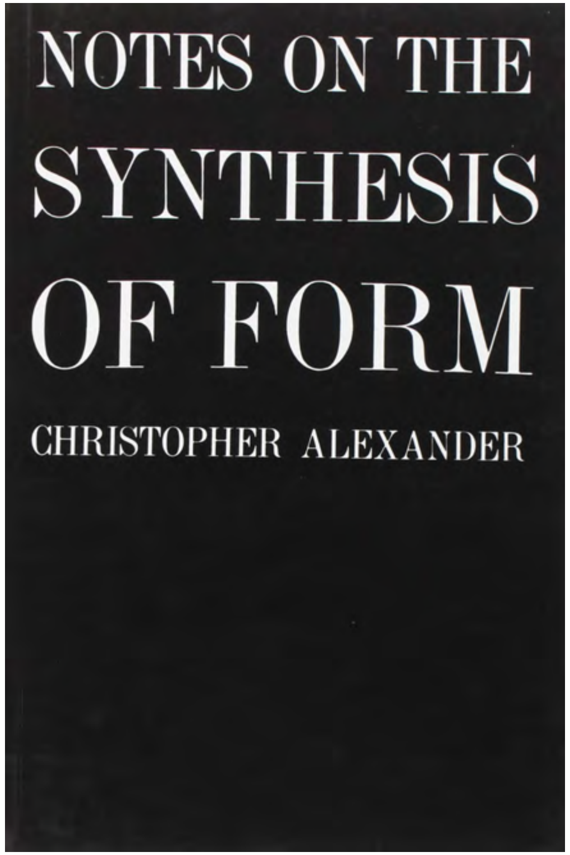
How did architecture became useful territory for the imagination of new digital worlds?

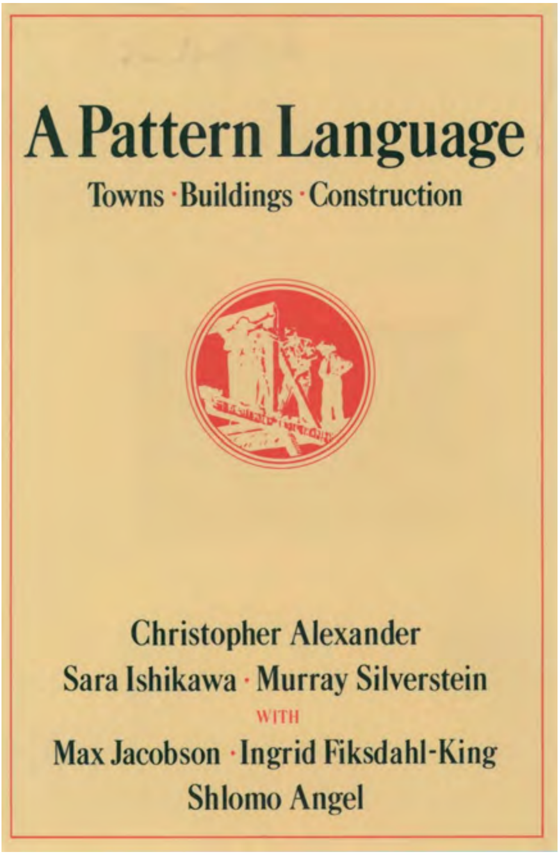


Historical viewpoints: technological paradigms of 4 architects:

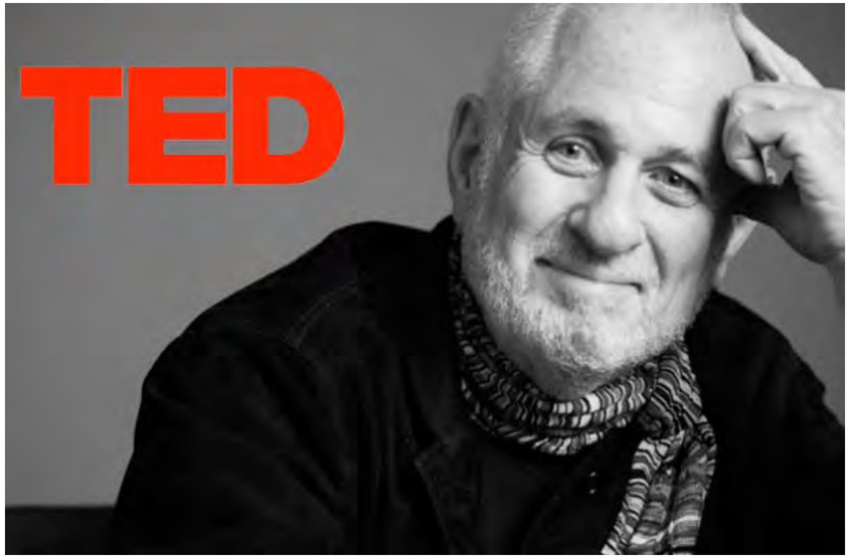
1. **Christopher Alexander**
2. Richard Saul Wurman
3. Cedric Price
4. Nicholas Negroponte

He and his colleagues developed an operating system for order, which is called pattern languages. His approach to pattern is vital to human-centered design.
He is regarded as the father of the ***pattern language*** movement.





Historical viewpoints: technological paradigms of 4 architects:



1. Christopher Alexander
2. Richard Saul Wurman
3. Cedric Price
4. Nicholas Negroponte

For Wurman, **information architecture** referred to the organisation of information on the page, in a map, within a book, as a design language.

Wurman influenced a generation of software and web designers with the concept of **information architecture** by application on the structure and design of websites, software and mobile applications.

He is also best known for founding TED conferences.

Historical viewpoints: technological paradigms of 4 architects:

1. Christopher Alexander
2. Richard Saul Wurman
3. Cedric Price
4. Nicholas Negroponte

Price designed buildings that were determined by their flows of information. He incorporated **cybernetics feedback loops** in projects, which challenged relationships between: architects, users, sites and technology.

Most of his projects are unbuilt, yet they provoke fellow architects, students and got them to question what a building can be and how computation might change its notion.

c1960

Previously in Week 2..

“Intellectual experiment”

Fun Palace (1958-1964)

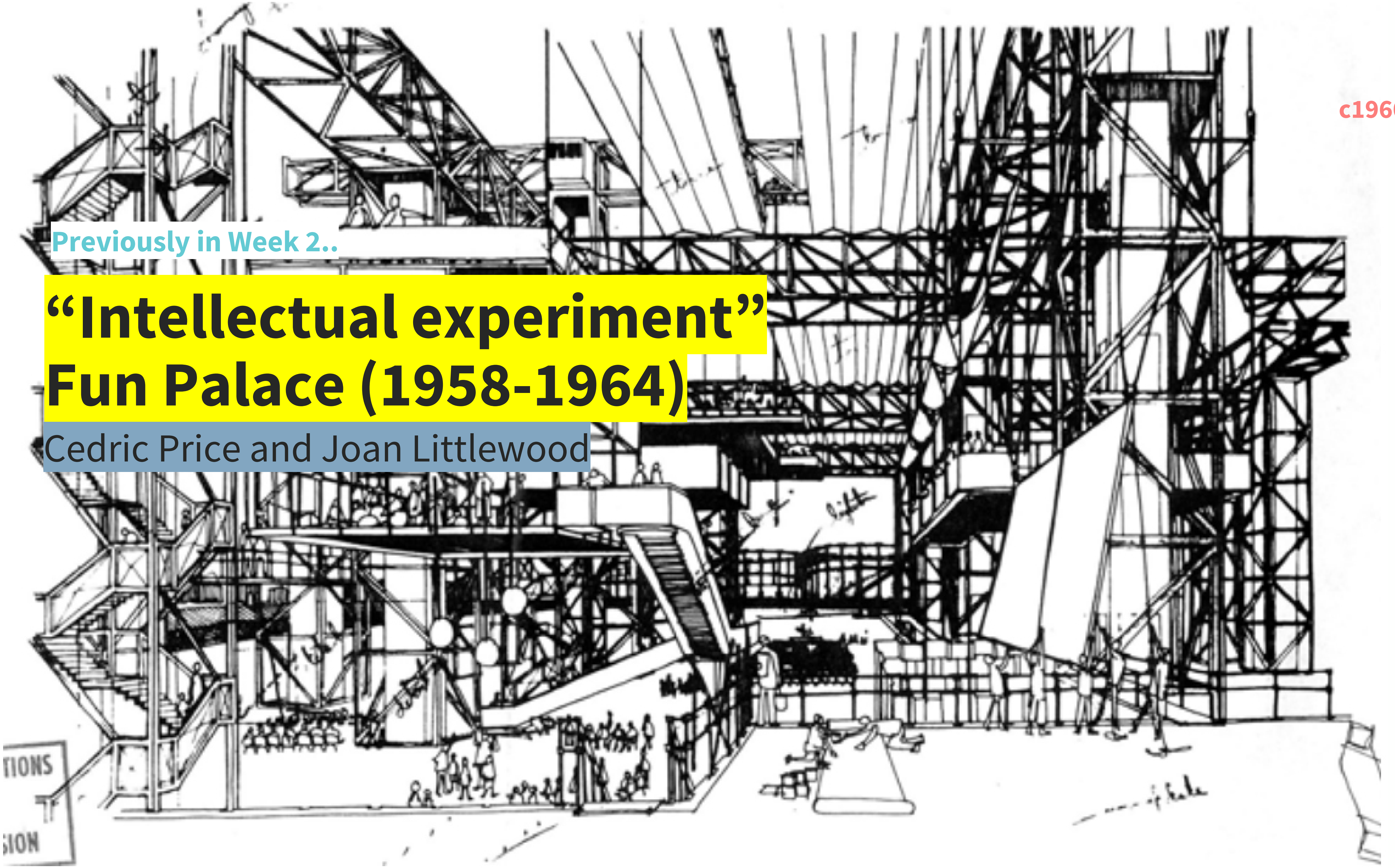
Cedric Price and Joan Littlewood

“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



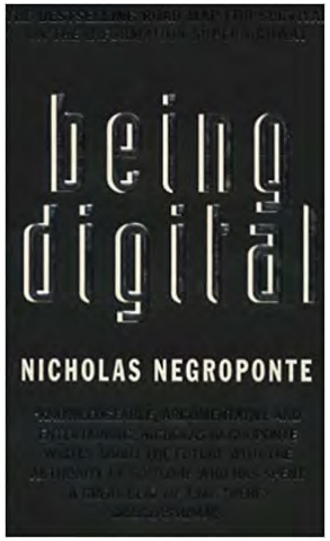
Previously in Week 2..

“Intellectual experiment”
Fun Palace (1958-1964)

Cedric Price and Joan Littlewood

Historical viewpoints: technological paradigms of 4 architects:

1. Christopher Alexander
2. Richard Saul Wurman
3. Cedric Price
4. **Nicholas Negroponte**



Negroponte, along with his colleague Leon Groisser, founded MIT's Architecture Machine Group (AMG) in 1967. It became the foundation of MIT Media Lab. The lab's research area includes AI, machine-learning, intelligent environments, virtual reality, remote sensing and drone surveillance.

His vision includes architecture machine that would turn the design process into a dialogue.

Current debates in AI in architecture:

The application of AI in architecture is still in infancy stage, prominent figures and design practice are pushing boundaries at what AI could bring to the field.

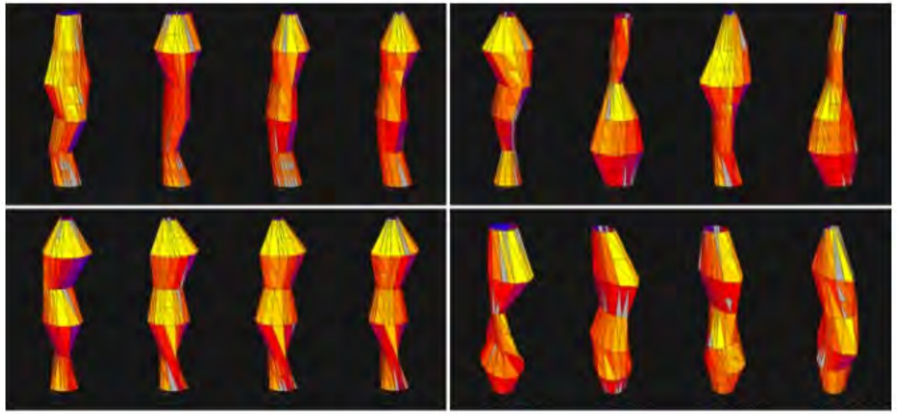
Three adopted methods from AI

Cudzik, J. & Radziszewski, K. (2018). Artificial Intelligence Aided Architectural Design.

1- Evolutionary algorithms

Inspired by biological evolution. It enables adjustment of input parameters, leading to optimised configuration in the reference of set goals. Example of this in architecture includes the use of in optimisation to reduce materials usage. Commonly known as **Genetic Algorithm (GA).**

Architectural evolutionary system based on Genetic Algorithms



Siyuan Jing

On February 17, 2016

Introduction:

Genetic Algorithms (GAs), a computational technique of evolution, recently have been used in architecture to solve the complicated functional and formal problems. The purpose of this paper is to discuss the advantages of GAs as an architectural design tool to use on the architectural evolutionary system. First, this paper will show the process of GAs to understand how they works. Next, several essential elements in GAs will be analyzed to demonstrate the connection between GAs and adaptive architecture. Several architecture design examples based on GAs will be used to evidence the argument. GA is one of many approaches for the optimization and evolution, and I think it is beneficial to the architectural area. Because GAs could not only generate numerous adaptive methods as the adaptive solutions, but also be able to keep the evaluating criteria dynamic with the surroundings to achieve the long-term optimization.

Keywords:

Adaptive architecture, Genetic Algorithms, architectural optimization, evaluating criteria

Read more on GA (can be downloaded from supplementary materials):

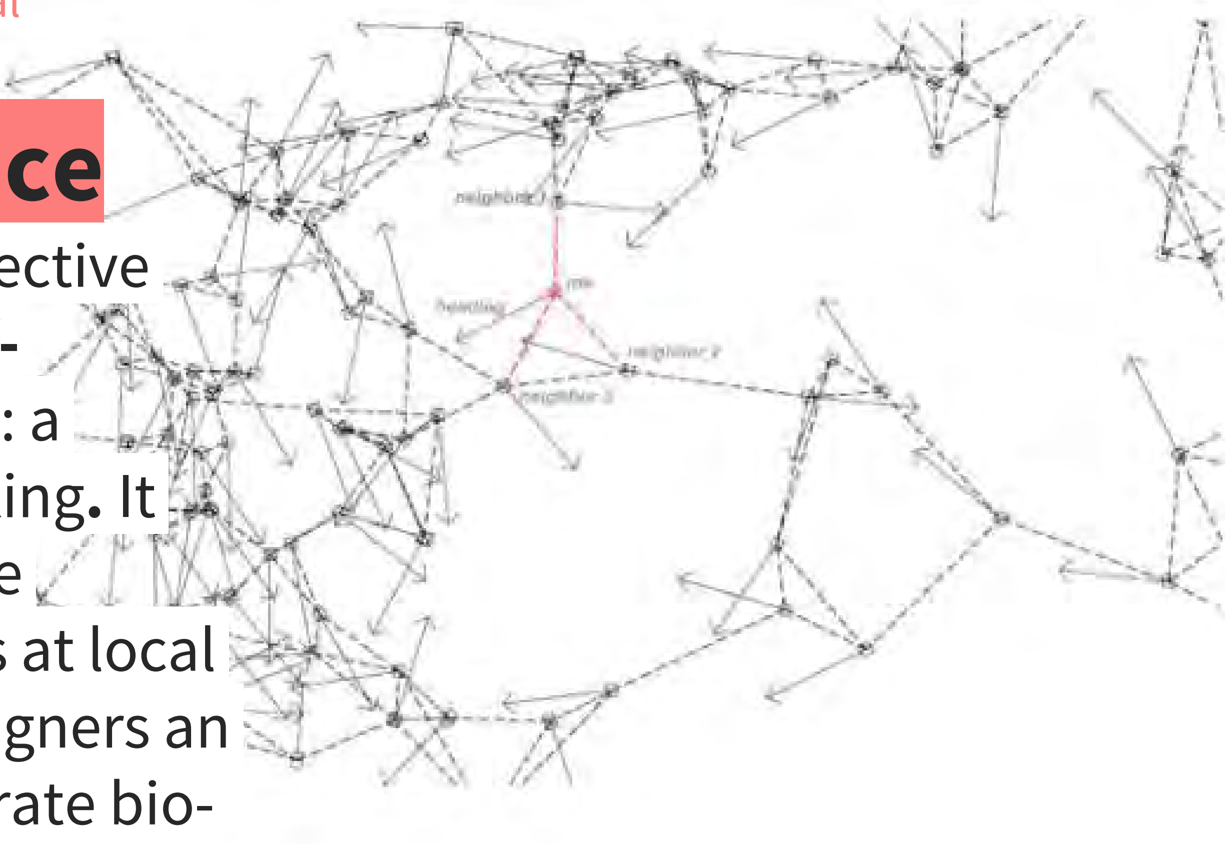
- www.interactivearchitecture.org/architectural-evolutionary-system-based-on-genetic-algorithms.html
- Latifi, M., Mahdavinezhad, M. J. & Diba, D. (2016). Understanding Genetic Algorithms In Architecture.

Three adopted methods from AI

Cudzik, J. & Radziszewski, K. (2018). Artificial Intelligence Aided Architectural Design.

2- Swarm Intelligence

Behaviour-based solution. A collective behaviour of **decentralised**, **self-organised** systems. For example: a collective behaviour of bird flocking**.** It presents potential in macro-scale intelligent system of simple rules at local level, which in turn provides designers an efficient and simple tool to generate bio-inspired complex design.



The flock algorithm.
Miranda, P. & Coates, P. (2000). Swarm modelling. The use of Swarm Intelligence to generate architectural form.

Three adopted methods from AI

Cudzik, J. & Radziszewski, K. (2018). Artificial Intelligence Aided Architectural Design.

3- Neural Network

The system enables training the artificial neural networks based on the provided examples (**training set**), in the form of: input parameters and corresponding output values. According to Cudzik and Radziszewski (2018), possible wider application of NN might take place during all planning phase. In particular **repeatable and predictable** activities.


Imaginary Plans

The potential of 2D to 2D Style transfer in planning processes

Matias del Campo
Taubman College
for Architecture and Urban
Planning/ UMich

Sandra Manninger
Taubman College
for Architecture and Urban
Planning/ UMich

Alexandra Carlson
Michigan Robotics/ UMich

Results of 2D to 2D Style transfers

Del Campo, M., Sandra, M. & Carlson, A. (2019). Imaginary Plans. ACADIA 19: UBIQUITY AND AUTONOMY. 39th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA) 2019 The University of Texas at Austin School of Architecture, Austin, Texas.

Adopted methods from AI

Chen, D., Luo, D., Xu, W., Luo, C., Shen, L., Yan, X. & Wang, T. (2019). Re-perceive 3D printing with Artificial Intelligence.

Combining machine learning with intelligent construction

Re-perceive 3D printing with Artificial Intelligence

Dechen Chen[1], Dan Luo[2], Weiguo Xu[3], Chen Luo[4], Liren Shen[5], Xia Yan[6], Tianjun Wang[7]
[1,2,3,4,5,6,7] Tsinghua University
[2] luo_dana@126.com

How can machine learning be combined with intelligent construction, material testing and other related topics to develop a new method of fabrication? This paper presents a set of experiments on the dynamic control of the heat deflection of thermoplastics in searching for a new 3D printing method with the dynamic behaviour of PLA and with a comprehensive workflow utilizing mechanic automation, computer vision, and artificial intelligence. Additionally, this paper will discuss in-depth the performance of different types of neural networks used in the research and conclude with solid data on the potential connection between the structure of neural networks and the dynamic, complex material performance we are attempting to capture.

Keywords: *3D printing, AI, automation, material, fabrication*

Architects' challenges in AI-enabled architecture

https://towardsdatascience.com/the-advent-of-architectural-ai-706046960140

1. Architects have to pick up on adequate taxonomy. I.e. the right set of objectives for the machine
2. Architects must select, the vast field of AI, the proper tools and train them.

AI design practices:

Adapted from https://www.archdaily.com/936999/pioneers-6-practices-bringing-ai-into-architecture

1. Xkool
2. AI + Architecture
3. 3XN
4. Ai Build
5. XL Lab SWA Group
6. Sidewalk Labs
7. Jenny Sabin

Generative Design

Photo by Марьян Блан | @marjanblan on Unsplash

Previously in Week 5..

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.

https://thispersondoesnotexist.com/

https://thispersondoesnotexist.com/

Imagined by a GAN (generative adversarial network)
StyleGAN2 (Dec 2019) - Karras et al. and Nvidia
Don't panic. Learn how it works [1] [2] [3]
Help this AI continue to dream | Contact me
Code for training your own [original] [simple]
Art • Cats • Horses • Molecules | News | Friends | Offic
Another | Save

https://thispersondoesnotexist.com/

https://thispersondoesnotexist.com/

Imagined by a GAN (generative adversarial network)
StyleGAN2 (Dec 2019) - Karras et al. and Nvidia
Don't panic. Learn how it works [1] [2] [3]
Help this AI continue to dream | Contact me
Code for training your own [original] [simple]
Art • Cats • Horses • Molecules | News | Friends | Office
Another | Save

Generative Adversarial Networks

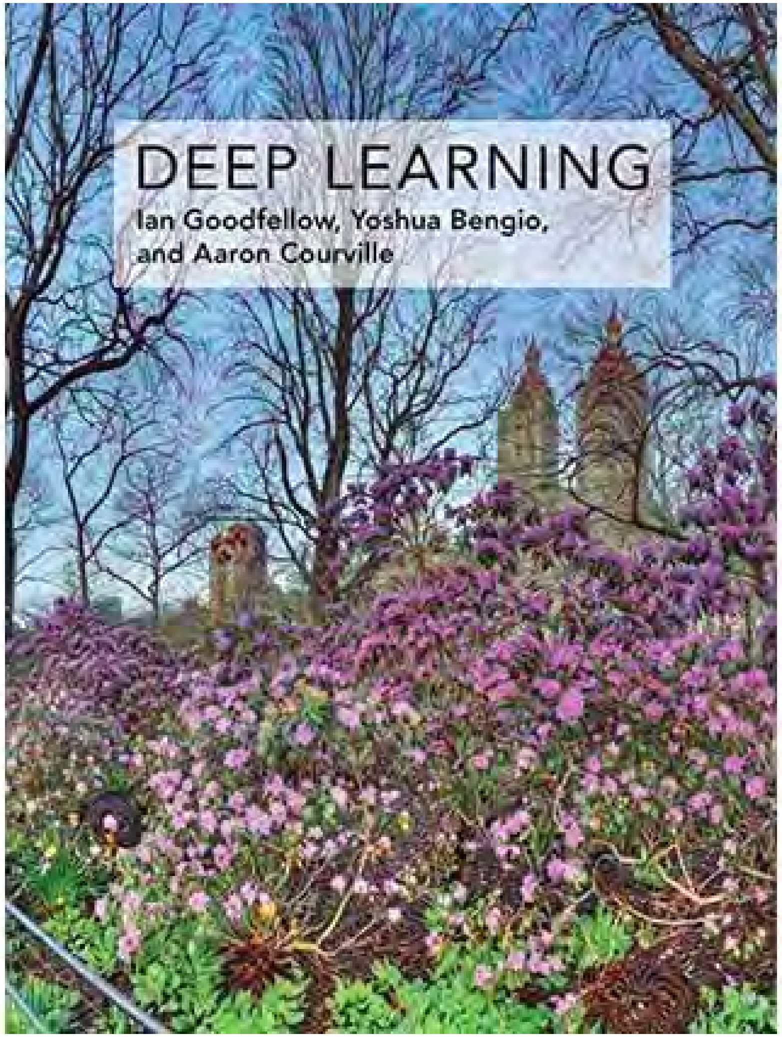
GAN was invented by Ian Goodfellow and his colleagues in 2014.

It is a class of machine learning.

Generative Adversarial Networks

Goodfellow, I., Bengio, Y. & Courville, A. (2016). *Deep learning*, MIT press.

Goodfellow's Introduction to GANs (2017): https://youtu.be/9JpdAg6uMXs



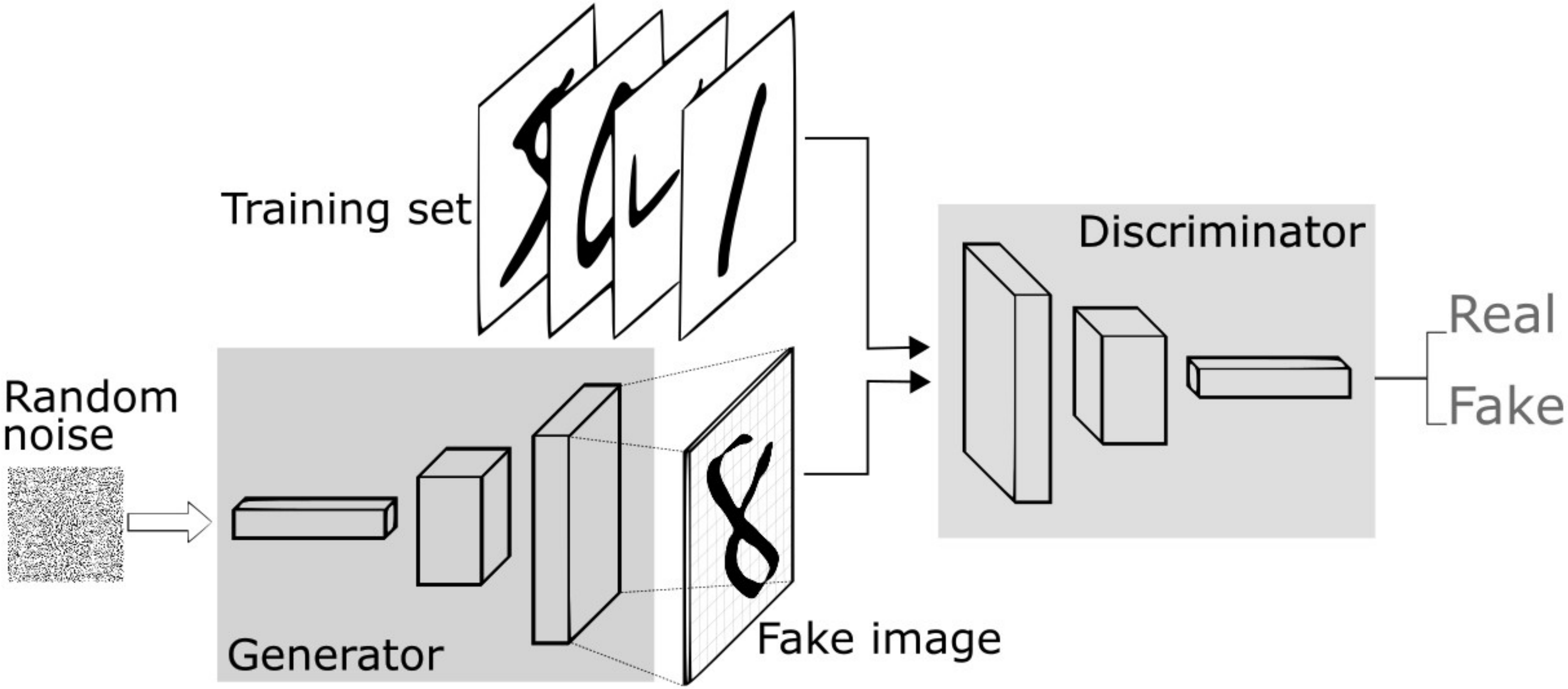
Generative Adversarial Networks

Adversarial Training:
“Training in a model in worst-case scenario, with inputs chosen by an adversary”

Generative Adversarial Networks

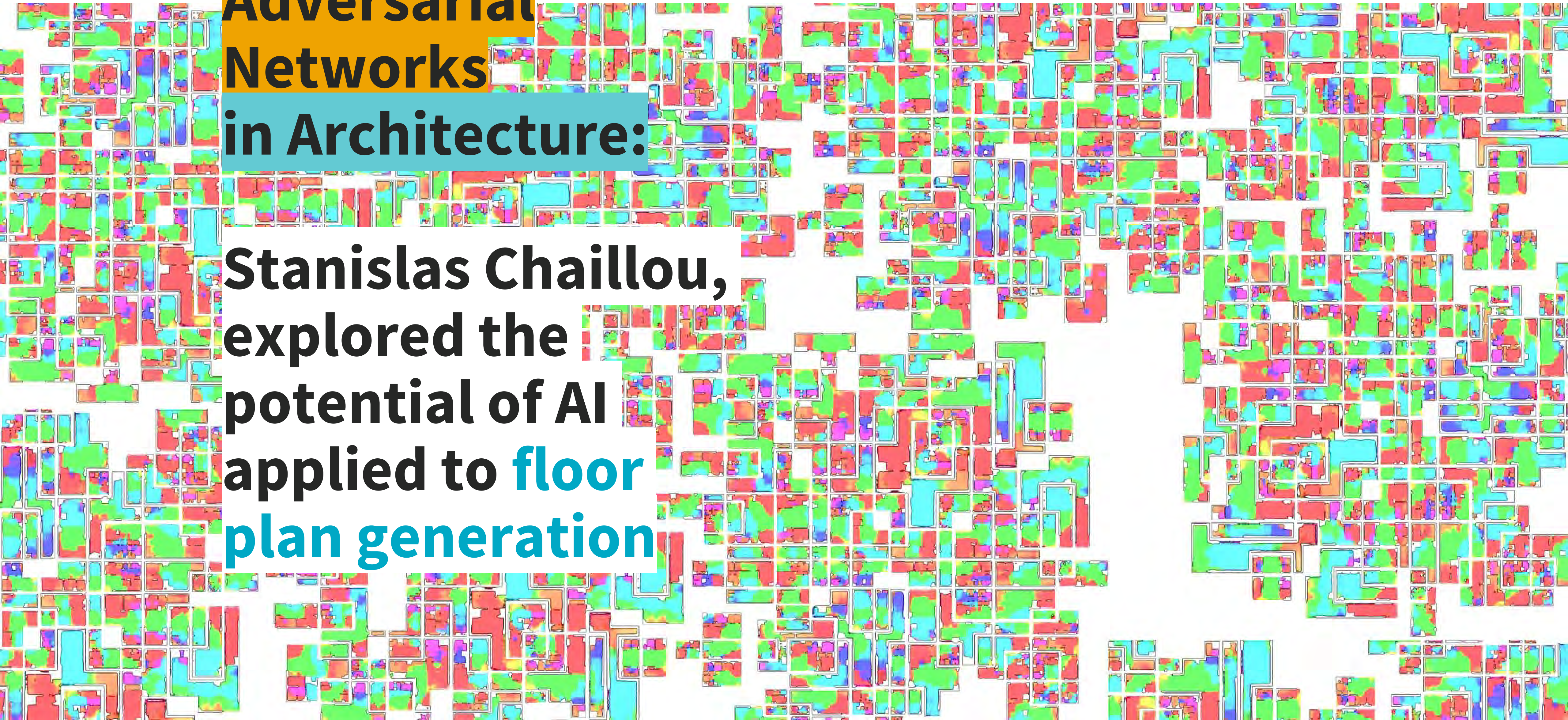
https://towardsdatascience.com/ai-architecture-f9d78c6958e0

The **Discriminator** is trained to recognise images from a set of data. With proper training, this model is able to distinguish between a real example, taken out of the data set, from a 'fake' image, foreign to the data set.
The **Generator**, is trained to create images resembling images from the same dataset.
As the **Generator** creates images, the **Discriminator** provides him with some feedback about the quality of its output. The **Generator** adapts, to produce even more realistic images.



Generative Adversarial Networks in Architecture:

https://towardsdatascience.com/ai-architecture-f9d78c6958e0



Stanislas Chaillou, explored the potential of AI applied to floor plan generation

Generative Adversarial Networks in Architecture:

https://towardsdatascience.com/ai-architecture-f9d78c6958e0

Stanislas Chaillou, explored the potential of AI applied to floor plan generation

Generative Adversarial Networks in Architecture:

https://towardsdatascience.com/ai-architecture-f9d78c6958e0

Multi-step pipeline emulating process taken by architects:

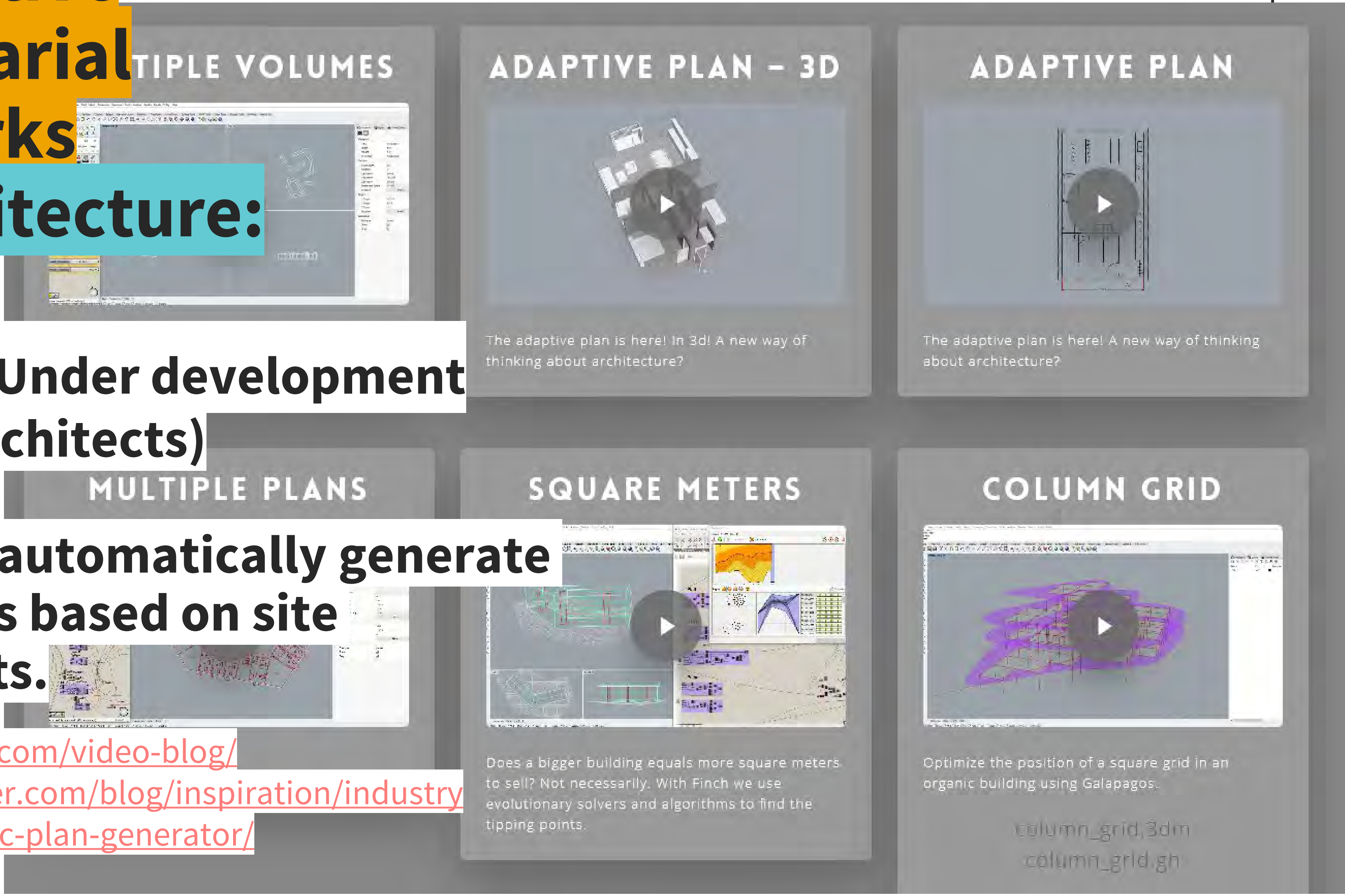
1. Building Footprint
2. Room Split & Fenestration
3. Furnishing

Generative Adversarial Networks in Architecture:

FINCH (Under development tool for architects)

It aims to automatically generate floor plans based on site constraints.

https://finch3d.com/video-blog/
https://architizer.com/blog/inspiration/industry/finch-automatic-plan-generator/



Generative Design in Urban Context:

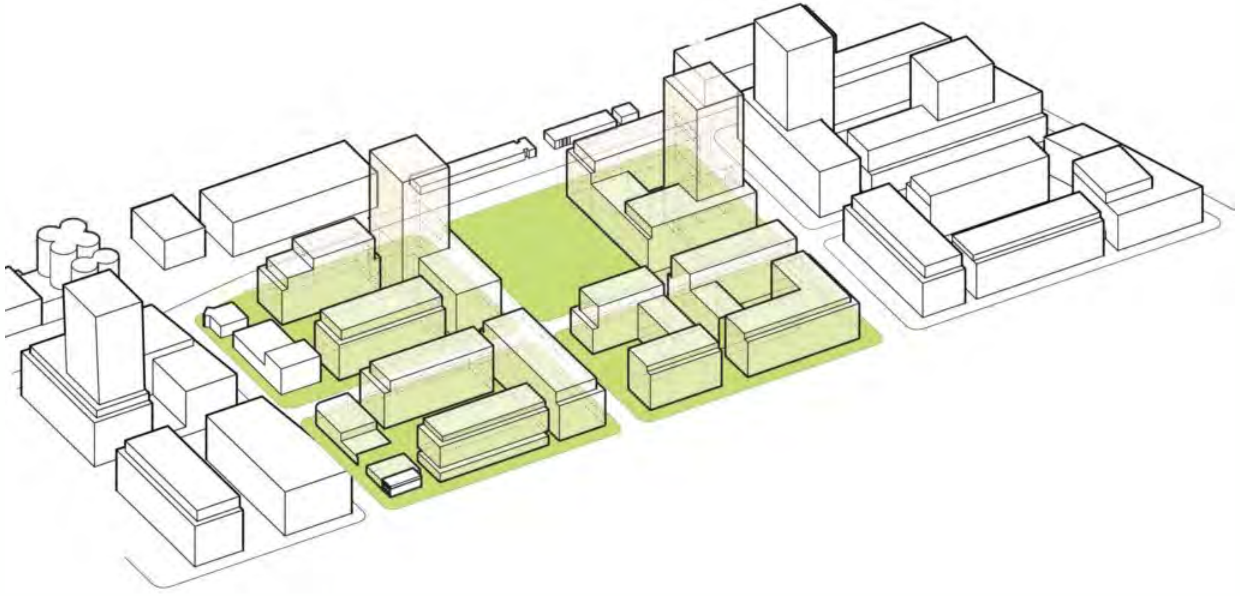
Sidewalk Labs

https://www.sidewalklabs.com/blog/a-first-step-toward-the-future-of-neighborhood-design/

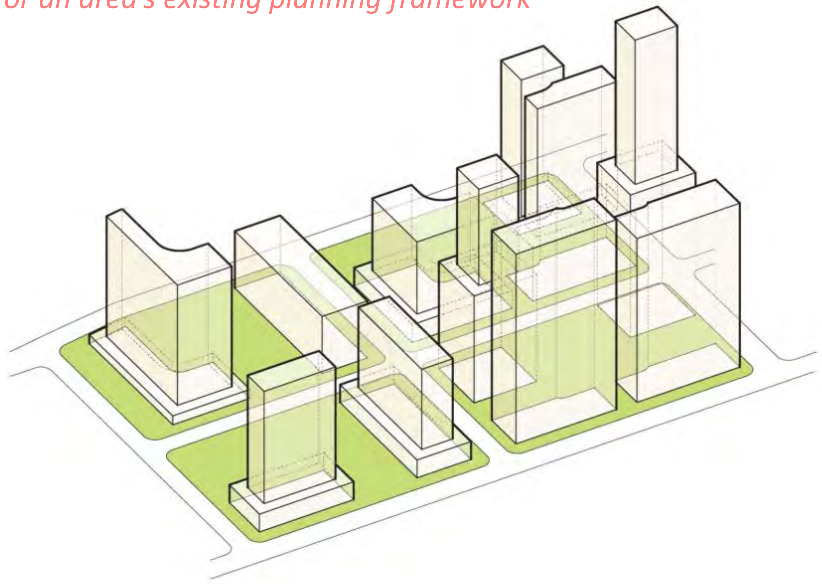
https://youtu.be/h7gq7OrbgxY

What Sidewalk Labs generative design tool offers compare to non-AI enabled architecture:

1. Using machine learning, **generating many comprehensive planning scenario.**
2. It can **evaluate the impact** of each scenario.



The baseline development or an area's existing planning framework



Generative design #01140

Generative Design: Five design techniques

1. Cellular Automata
2. Genetic Algorithms
3. L-systems
4. Shape grammars
5. Swarm Intelligence

Singh and Gu (2012) propose a framework of an integrated Generative Design system that can support these five techniques.

Singh, V. & Gu, N. (2012). Towards an integrated generative design framework. *Design Studies,* 33**,** 185-207.

What is the future of AI in Architecture?

https://www.archdaily.com/937523/how-artificial-intelligence-will-shape-design-by-2050

- AI will **continue** to shape how we live, work and play
- **Urban Intelligence** and **Big Data**
- **Transportatio**n, transit is being re-imagined on the street and in the air
- **Construction** will be hugely affected, towards human-free construction process
- The **Singularity** moment, the point at which exponential technological advancements cross the threshold of ‘strong AI’ and machines possesses a broad intelligence that exceeds human levels.

Re-iterated aims and objectives

- To contextualise definitions and concepts of AI
- To illustrate historical accounts of AI
- To contextualise AI in the field of architecture
- To elicit the state-of-art of AI in architecture, along with future recommendations
- To expand on Generative Design in computational design thinking