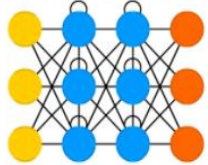# Generative AI for sustainable product design
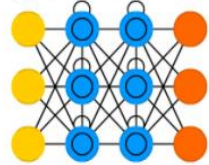
AIM-NET Networking event Spring 2023

Santiago Muiños Landin

The path towards Generative AI
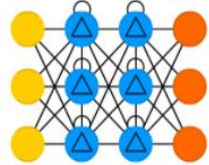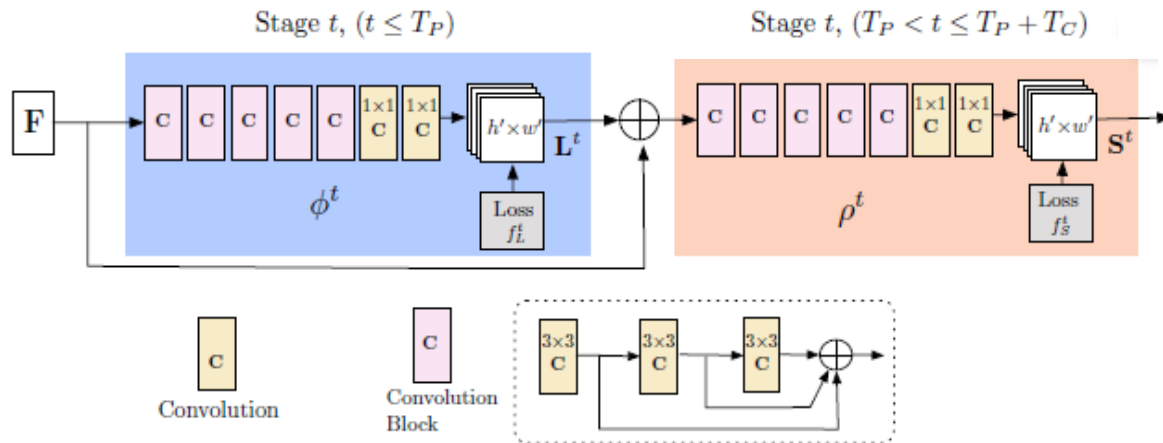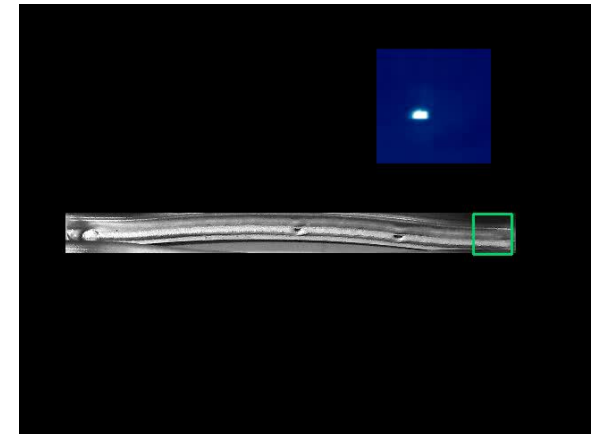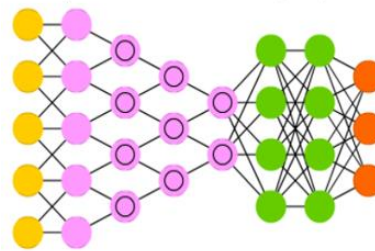
Data structure optimization
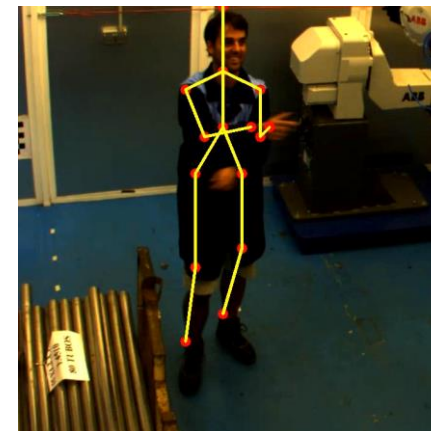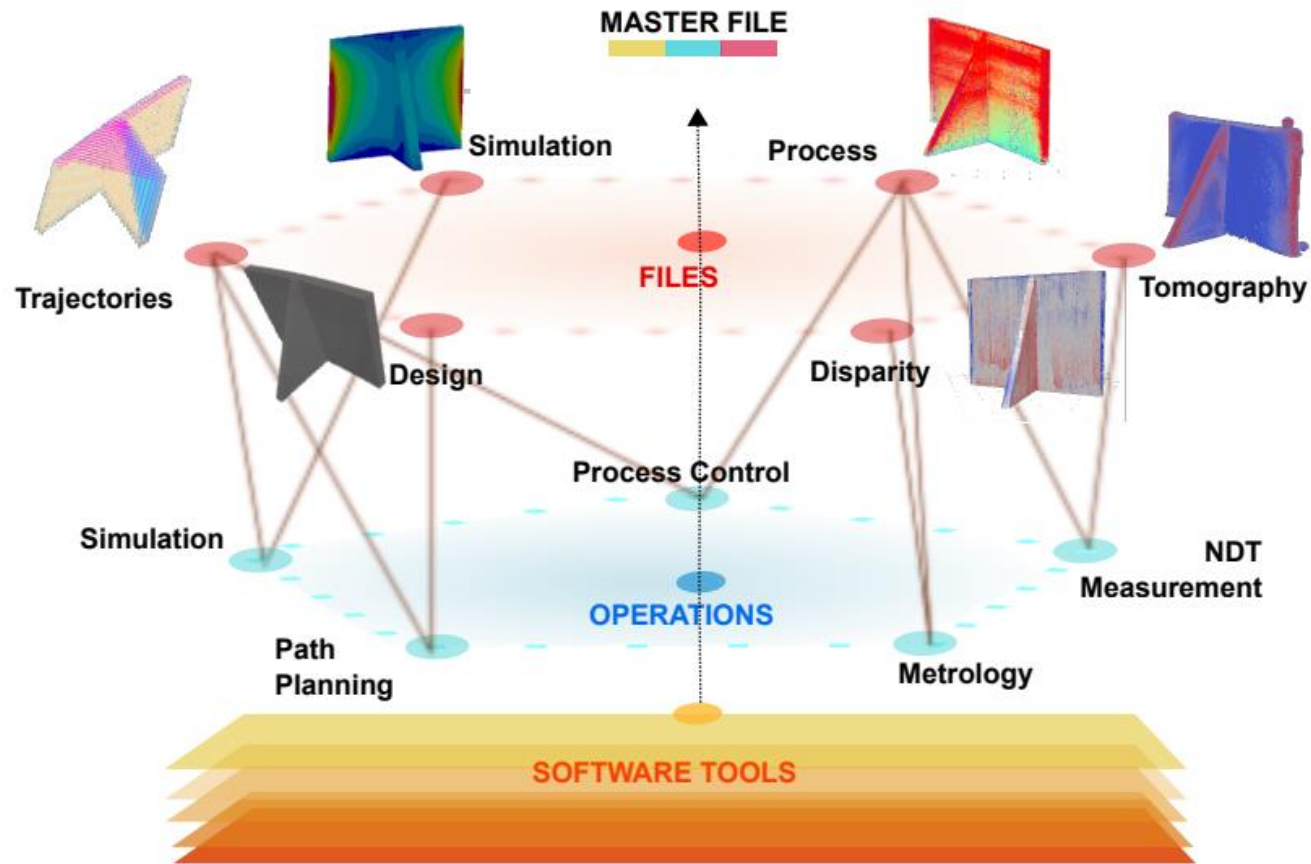

Gonzalez-Val et al. Towards the digitalization of Additive Manufacturing
Database and Expert Systems Applications 2022

Generative Models
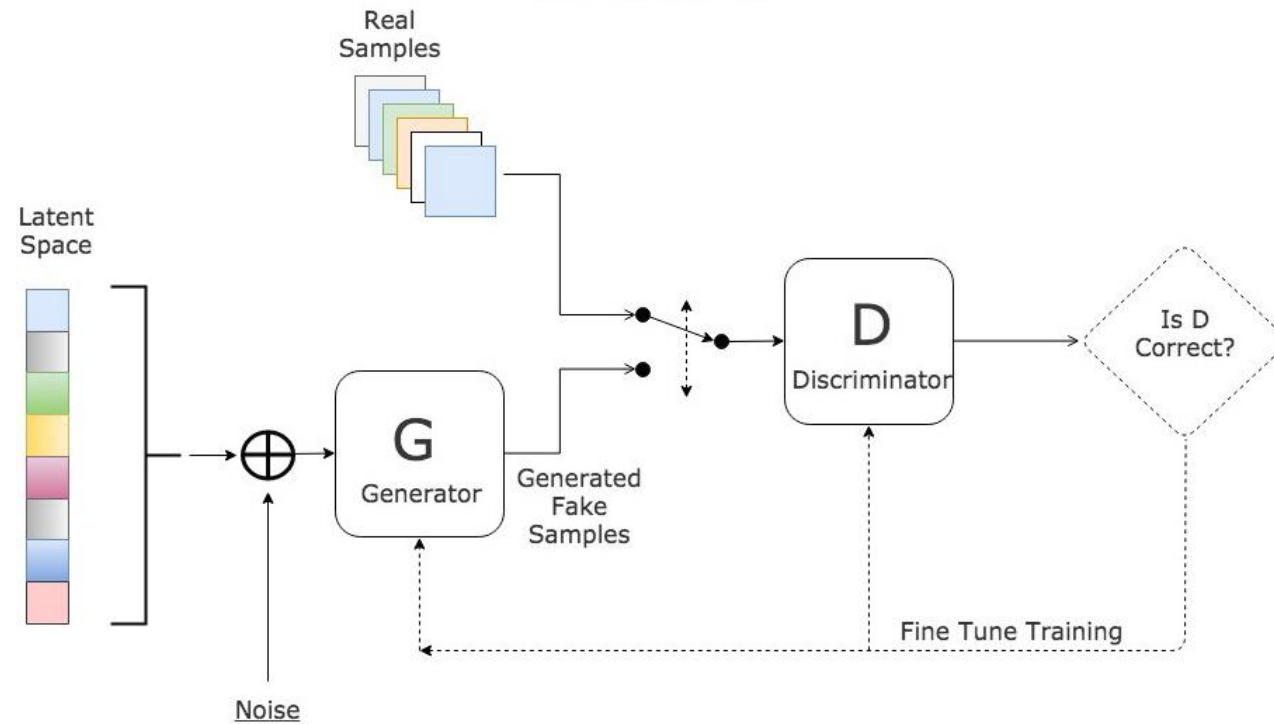
Goodfellow et al. Generative Adversarial Nets 2014

Generated realistic images of people that don't exist. Source: Progressive Growing of GANs for Improved Quality, Stability, and Variation, 2017

Synthetic Data Generation

- Visual inspection

- Magnetic particles

- High amount of data is required

- If different classes, they might be non equally distributed
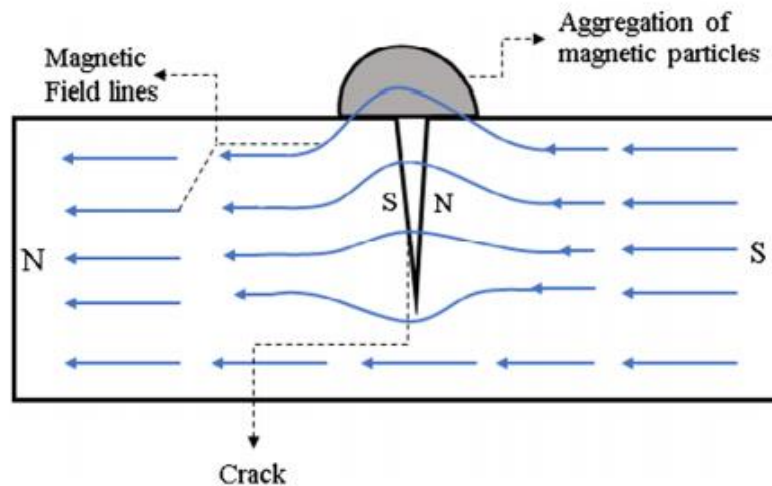
Botana et al. GAN-based data augmentation for crack detection 2020 (https://doi.org/10.5281/zenodo.7074639)
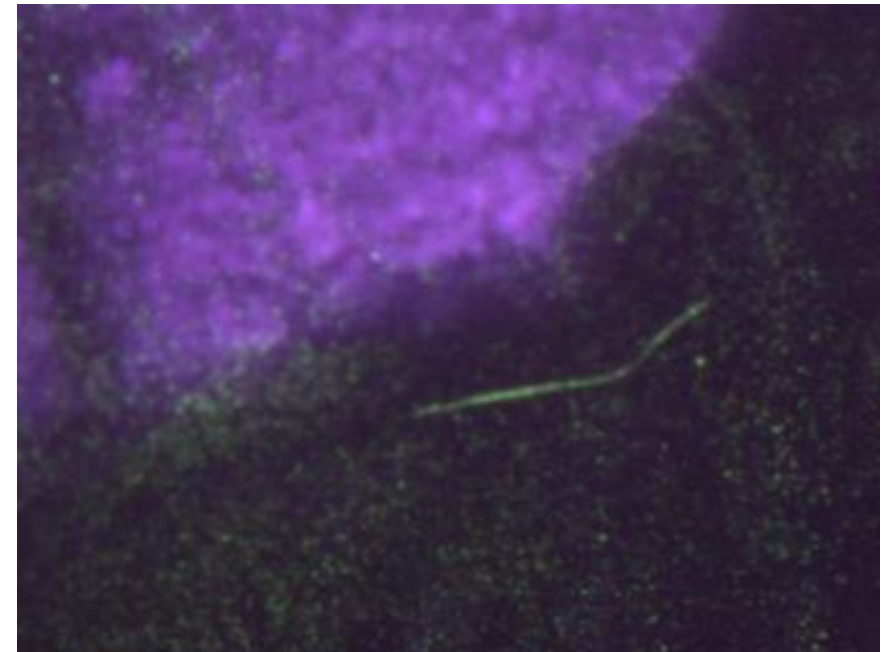
Design as a part of a complex system

Sustainable Product Design
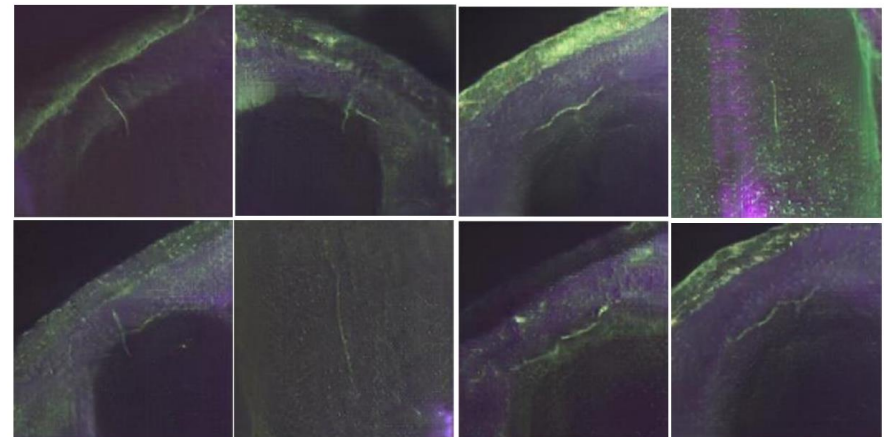

EMPATHIZE · IDEATE · TEST
DEFINE · PROTOTYPE · IMPLEMENT
UNDERSTAND · EXPLORE · MATERIALIZE

ACTION · EFFECT · FEEDBACK

Furniture design using Generative AI
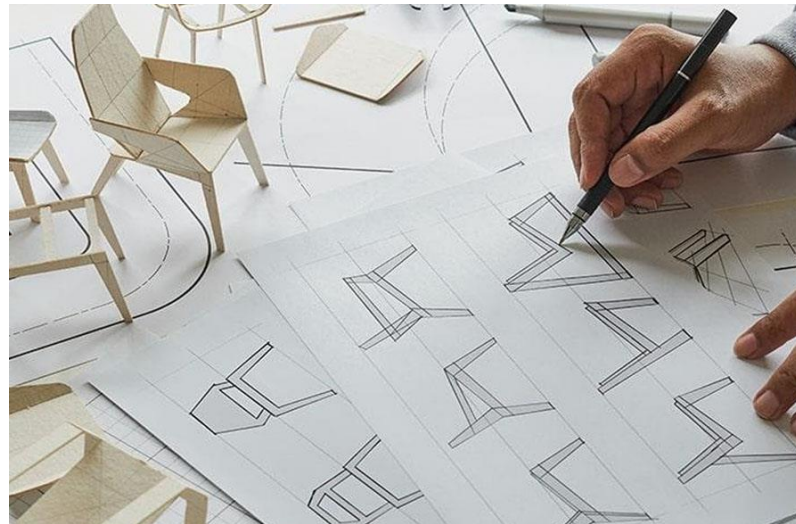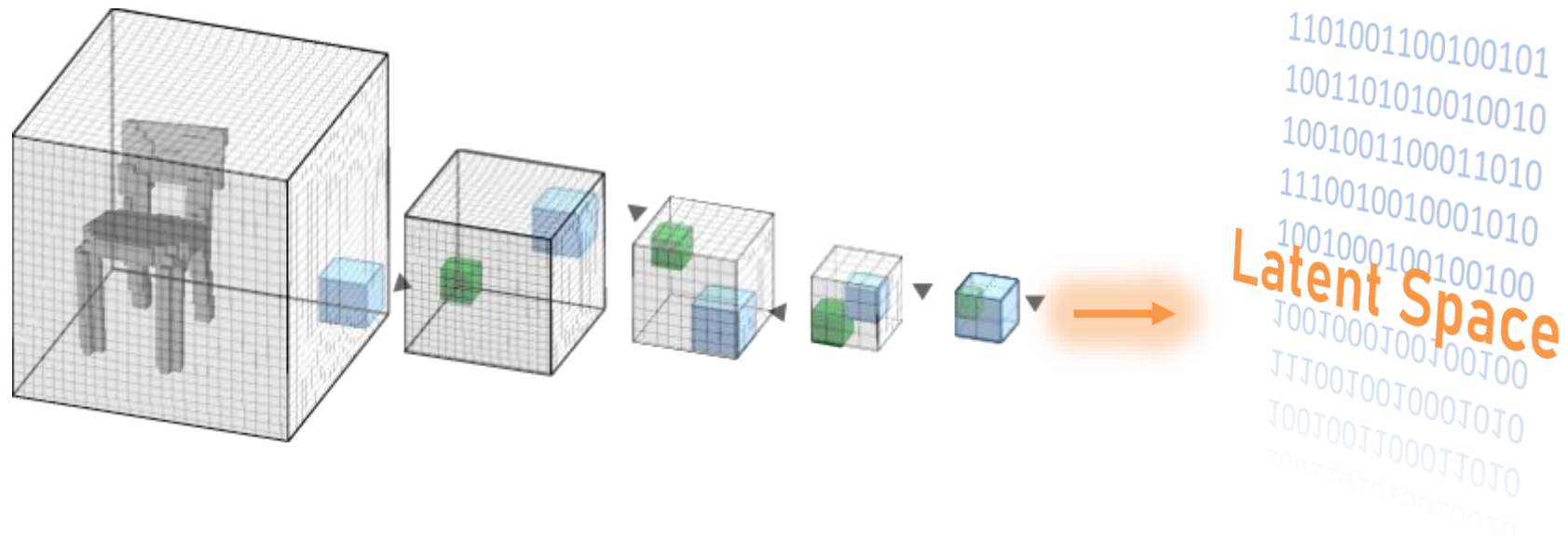
Encoded Information about design parameters

Non-linear relationships among design parameters are encoded

These relationships feed Artificial Creativity Algorithms

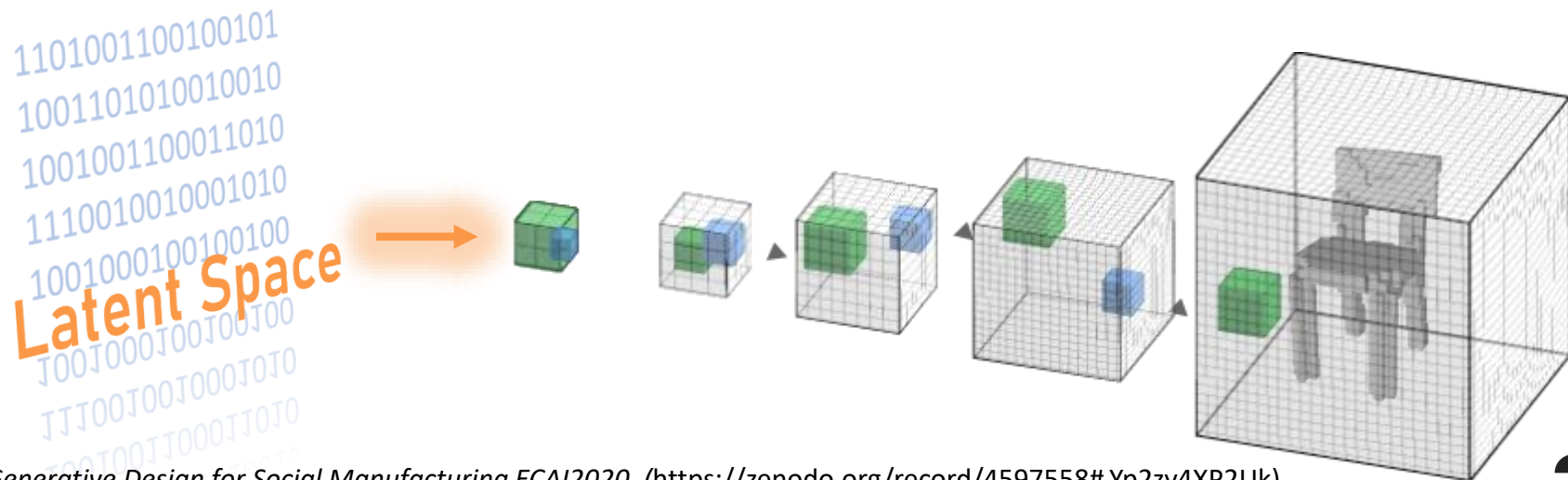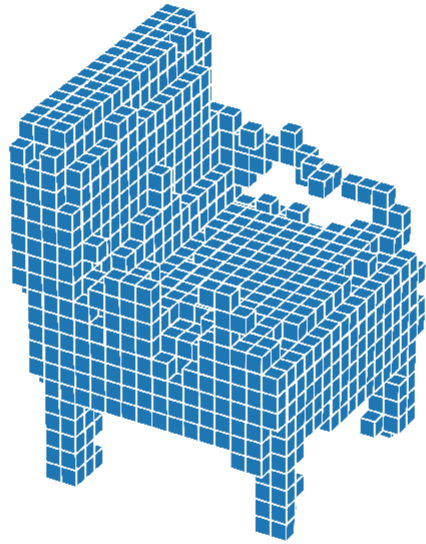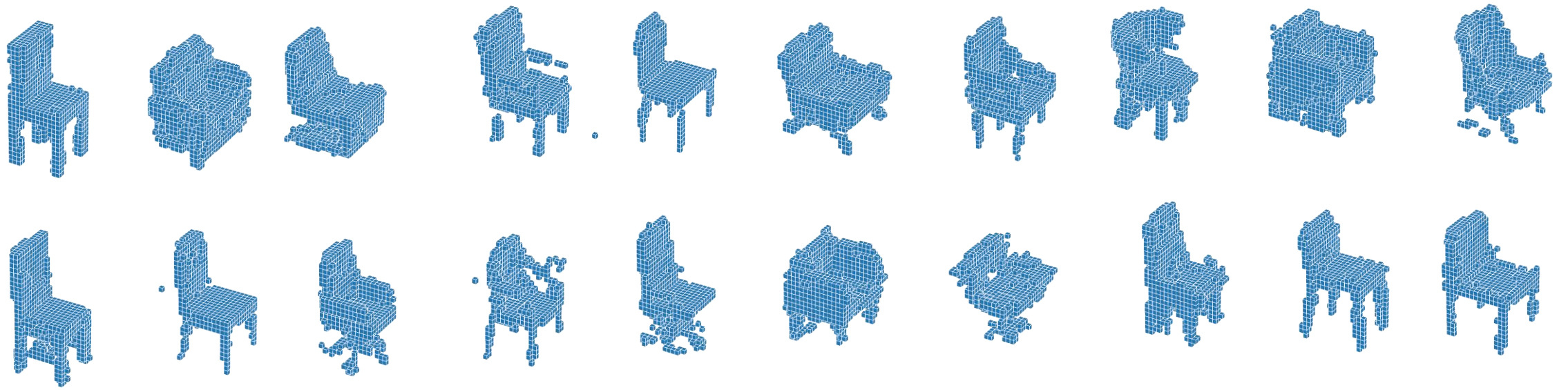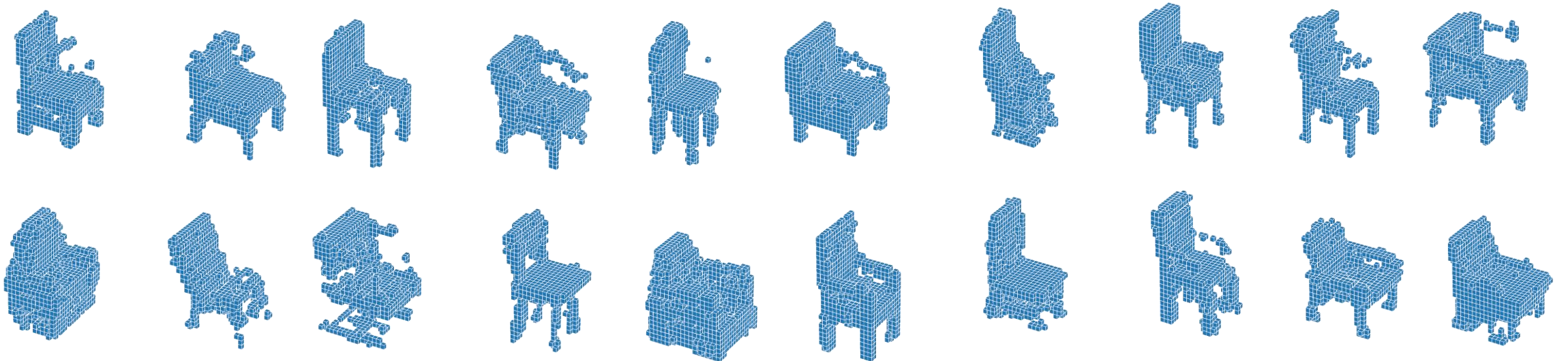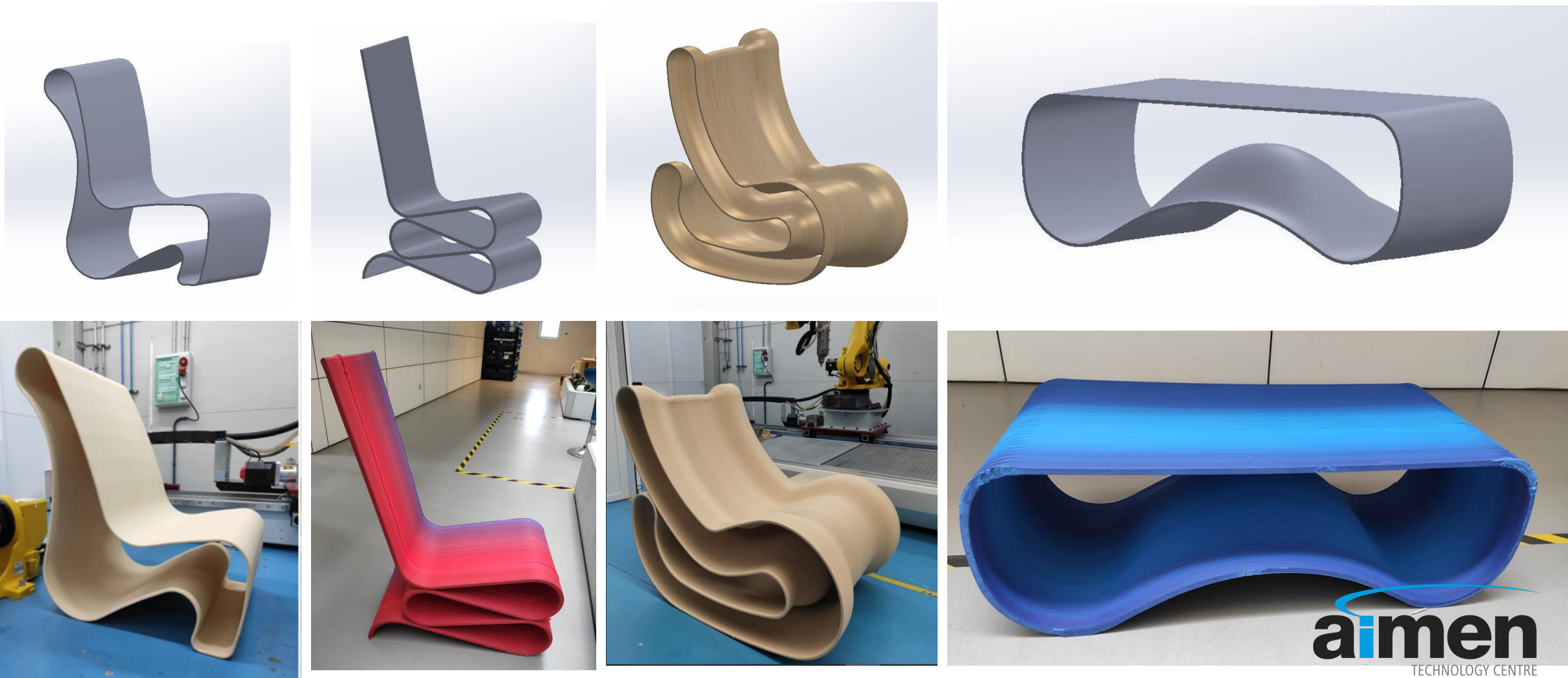In seconds, an endless amount of designs can be produced to be postprocesed and evaluated by a potential user
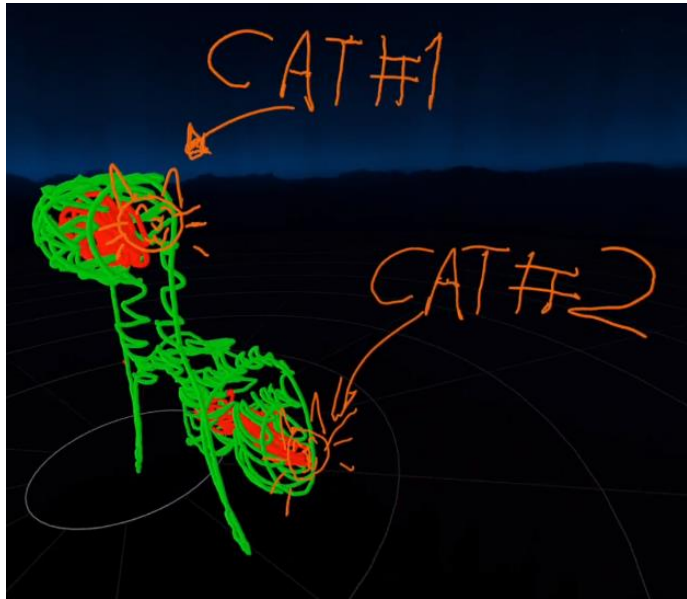
From digital to real

Boosting creativity

Different levels of abstraction. Texture design
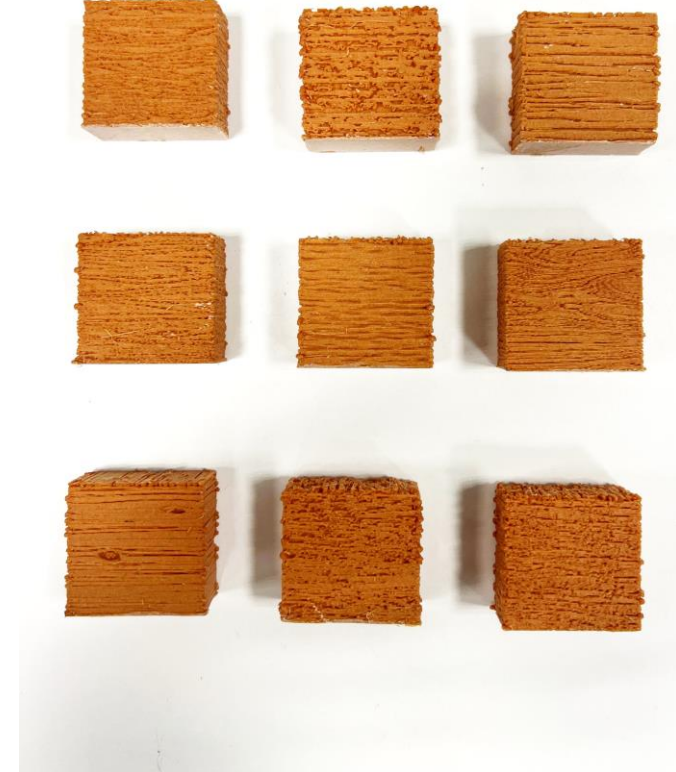
Towards Sustainable Product Design

Product Manufacturing can be widely optimized. From **process** itself to **material selection or design** to optimize different factors such as product **performance** or **product impact** from a **sustainable** perspective

From left to right: First UPM Formi (20% cellulose), second and third samples Smart Materials wood based (pine and coconut respectively).

Generative AI for Material Science

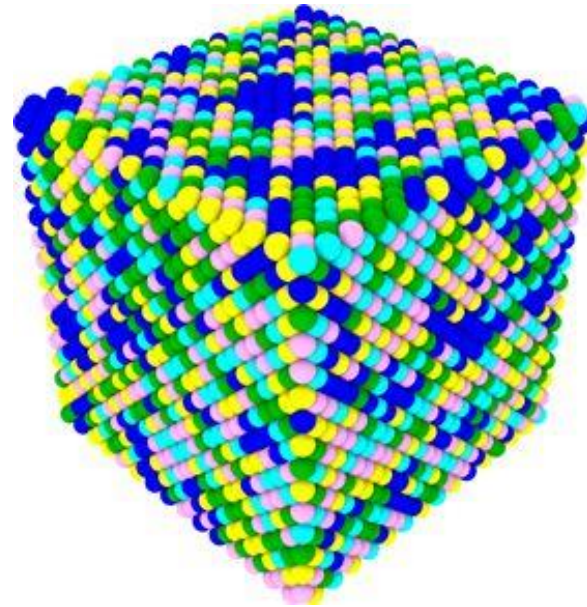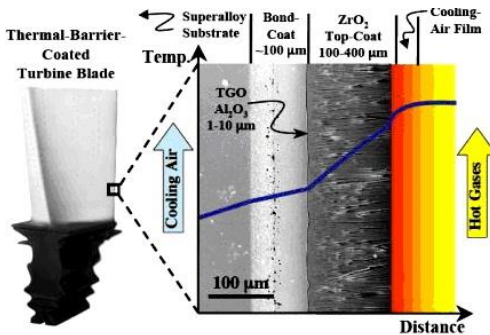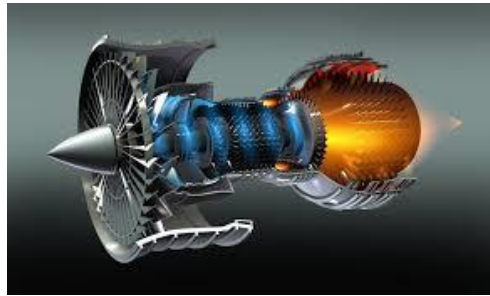# Generative AI for Material Science
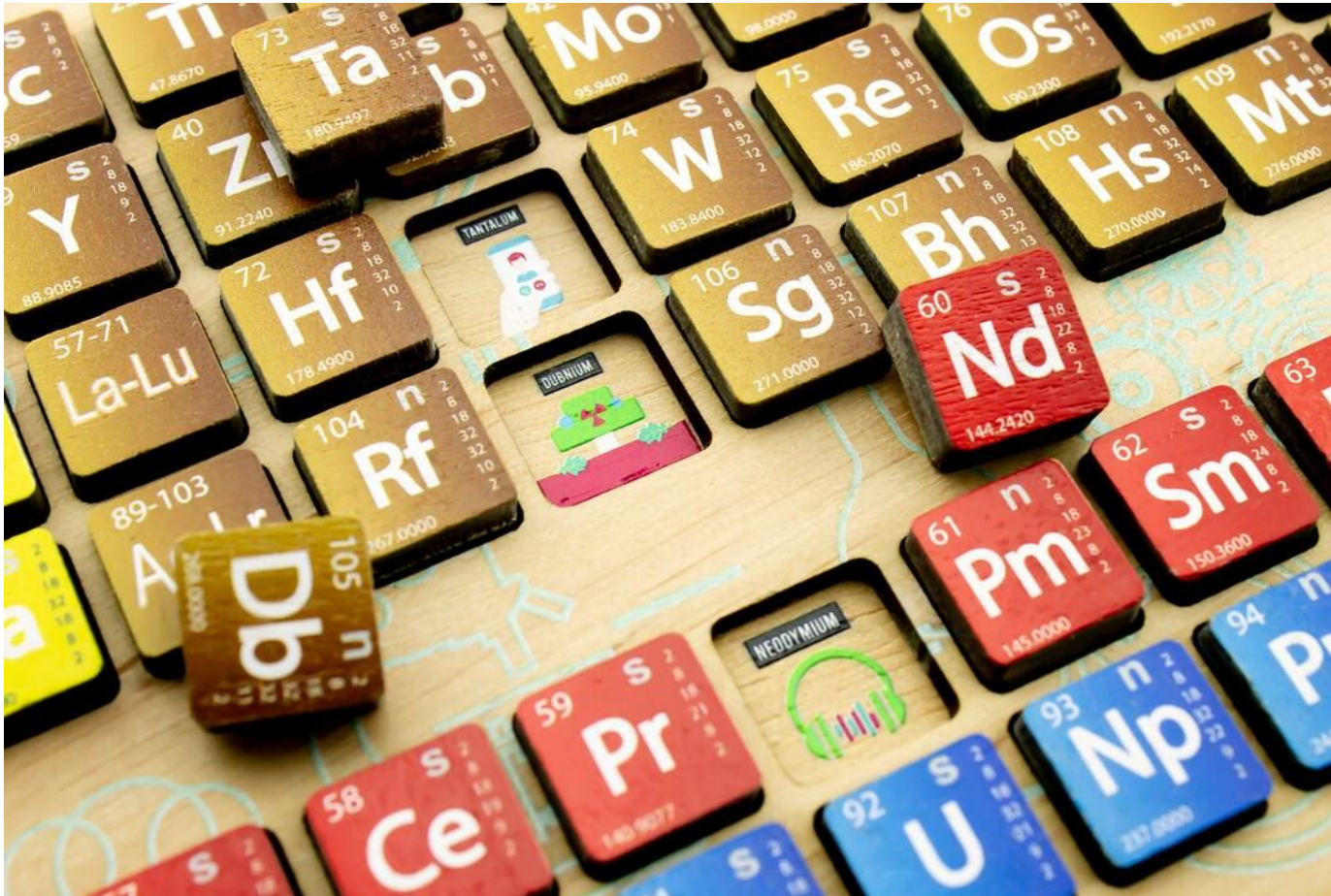

Thermal barrier coatings: energy/aerospace

Biocompatible, corrosion resistant alloys: medical implants

Photovoltaic materials: solar energy harvesting

Superhard, wear resistant coatings: machine tools
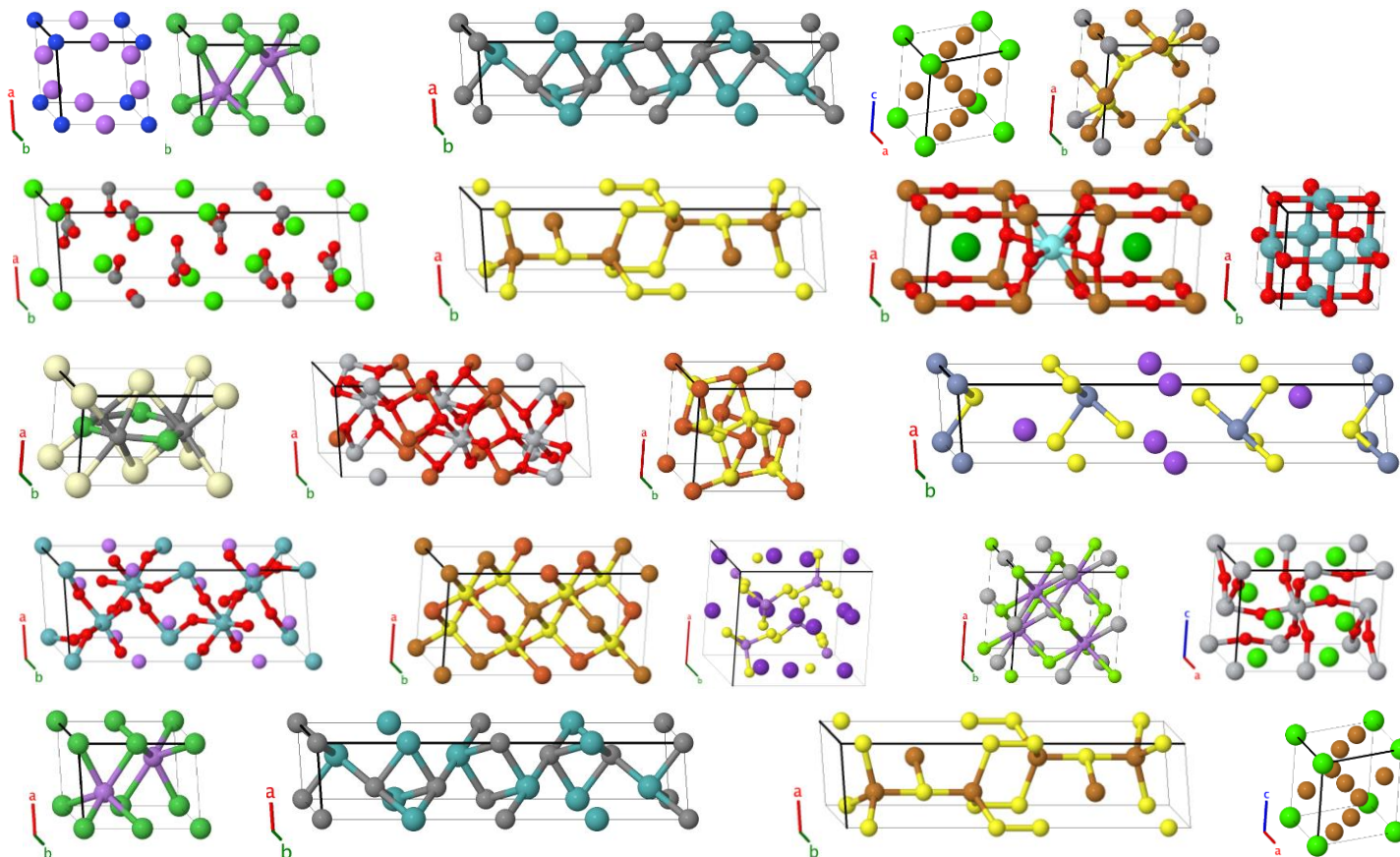
$$\binom{78}{2} = 3,003$$

$$\binom{78}{3} = 76,076$$

$$\binom{78}{4} = 1,426,425$$

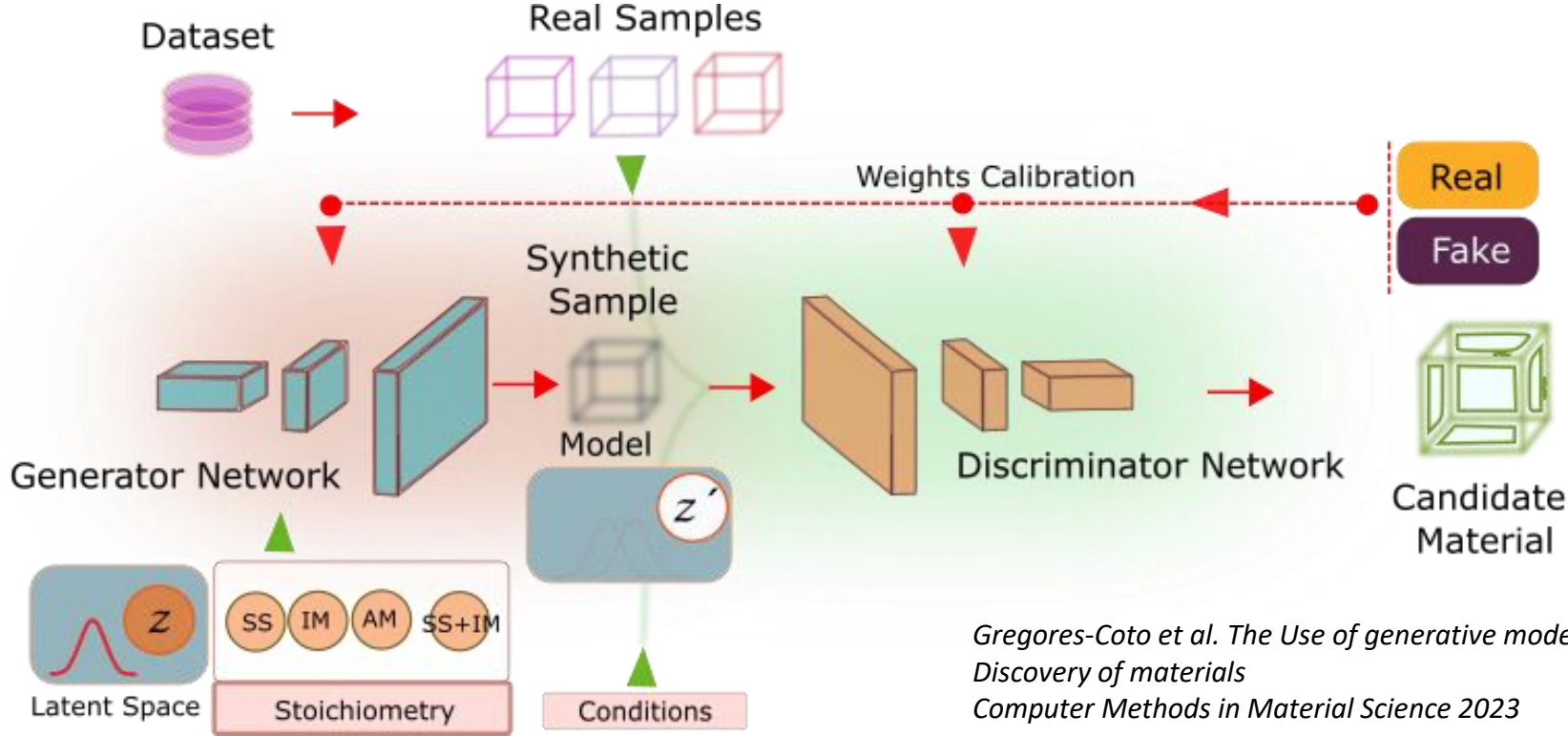$$\binom{78}{5} = 21,111,090$$

$$\binom{78}{6} = 256,851,595$$

10^{177}

M. J. Mehl *et al.*, Comput. Mater. Sci. **136**, S1-S828 (2017), D. Hicks et al., Comput. Mater. Sci. **161**, S1-S1011 (2019)
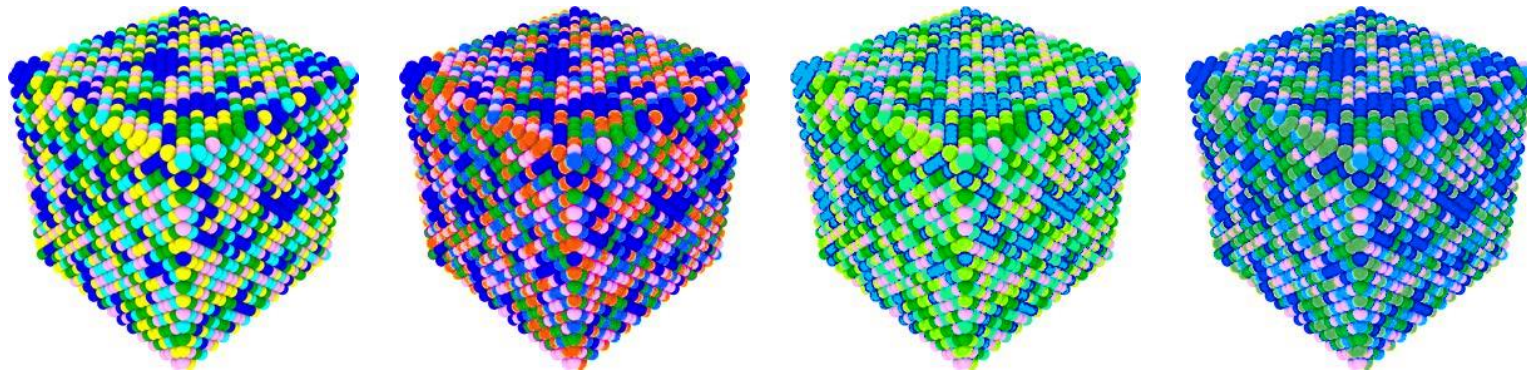
Speed up of material design

Gregores-Coto et al. The Use of generative models to speed up the Discovery of materials
Computer Methods in Material Science 2023
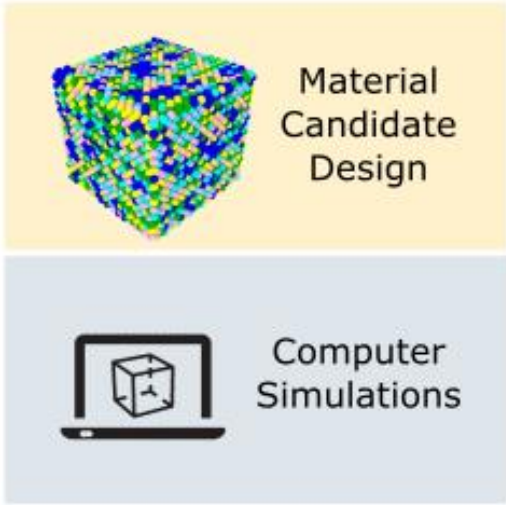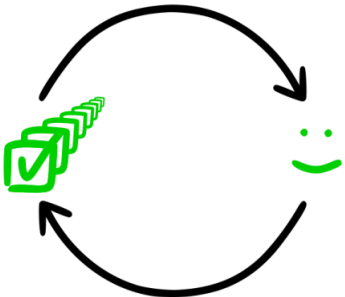
Design as a part of a Feedback Loop

Which one is the best?

Design as a part of a Feedback Loop

A **Reinforcement Learning Framework** is concatenated with the generative approach to define an **Objective oriented** material final design.
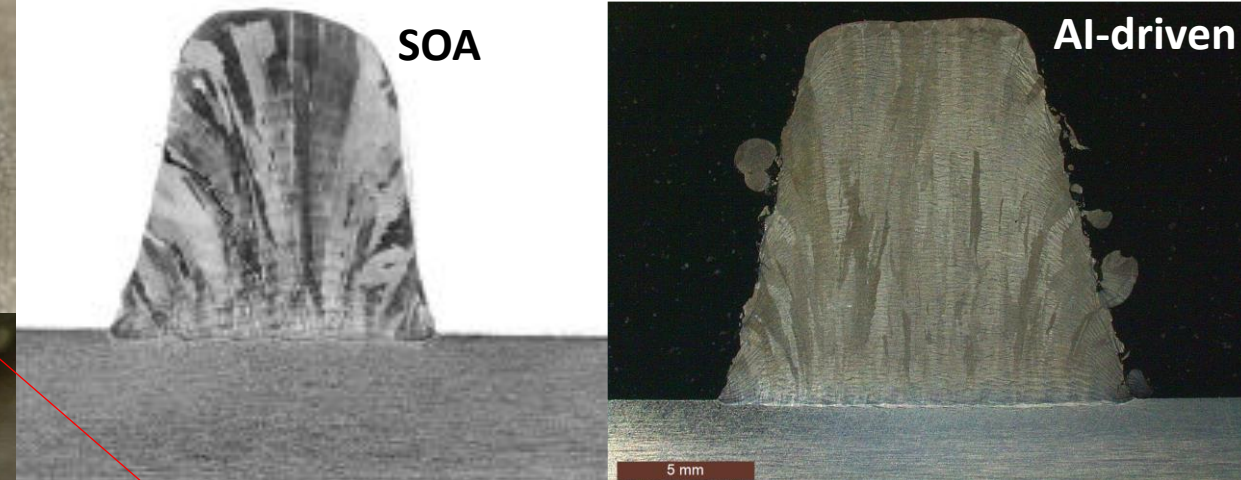

Material Candidate Design

Computer Simulations

Generative Design

+

Reinforcement Learning

→

Objective Oriented Generative Design Algortihms

→

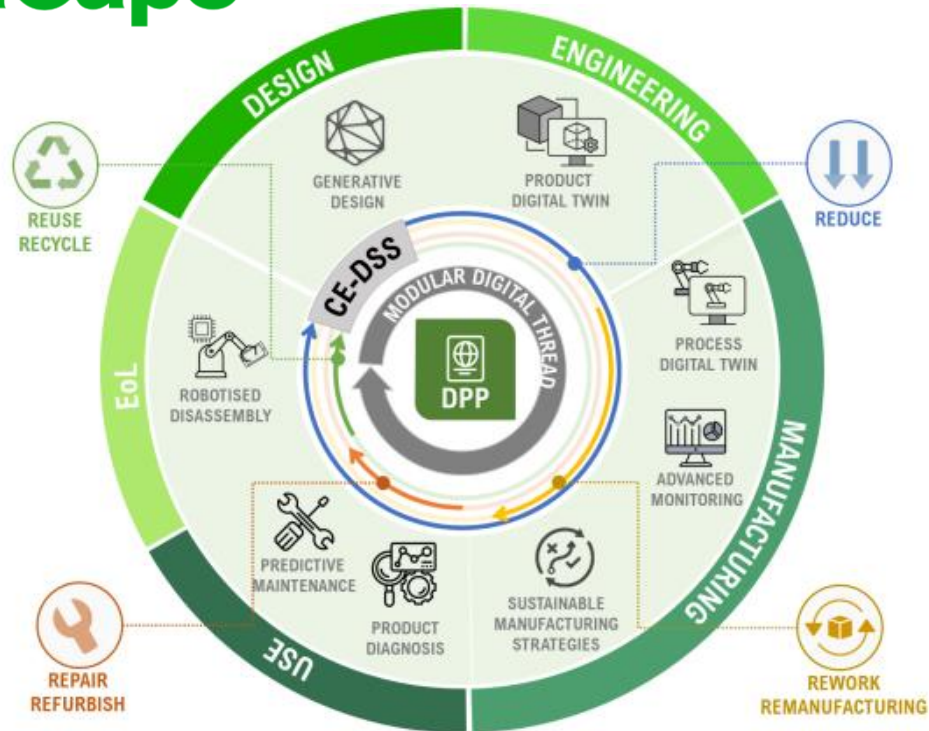Material Design Software

From digital to real

SOA

AI-driven

SOA

AI-driven
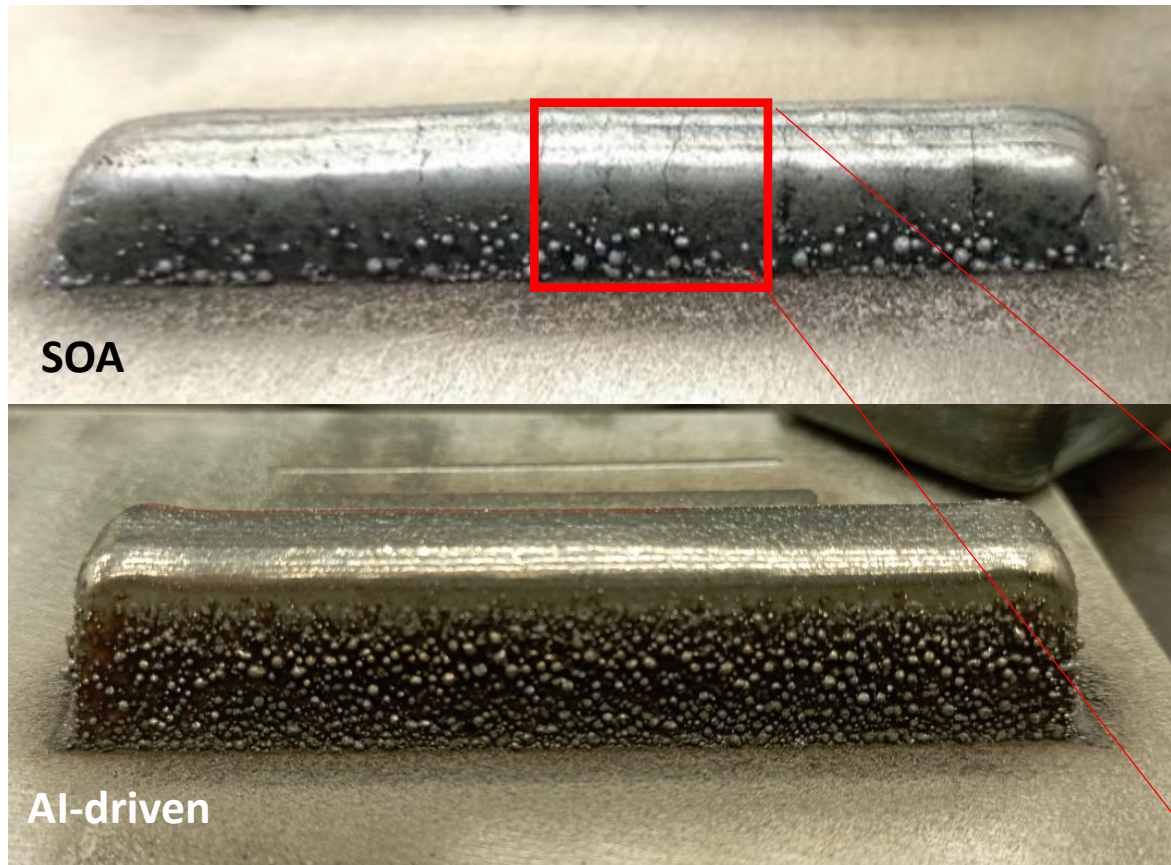
Gregores-Coto et al. TO BE PRESENTED AT EUROMAT 2023 ACCEPTED

On going

A few conclusions

- Generative AI has been demostrated as a potential tool to boot creativity in design taks

- The role of Generative AI can be divided in several branches along the design pase of a product

- Is this technology a substitute of human agents?

- What are the new challenges?

- What are the limmits?

Thank You!!

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santiago.muinos@aimen.es