Modular Course B: Creative Design in shoe Industry

Unit B2 – Computational tools and prototyping

Lecture LB2.3 – AI and Generative Design in F&L products

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T2.2 – Development of modular courses and training material.

D2.2 – Modular Course in Creative Design

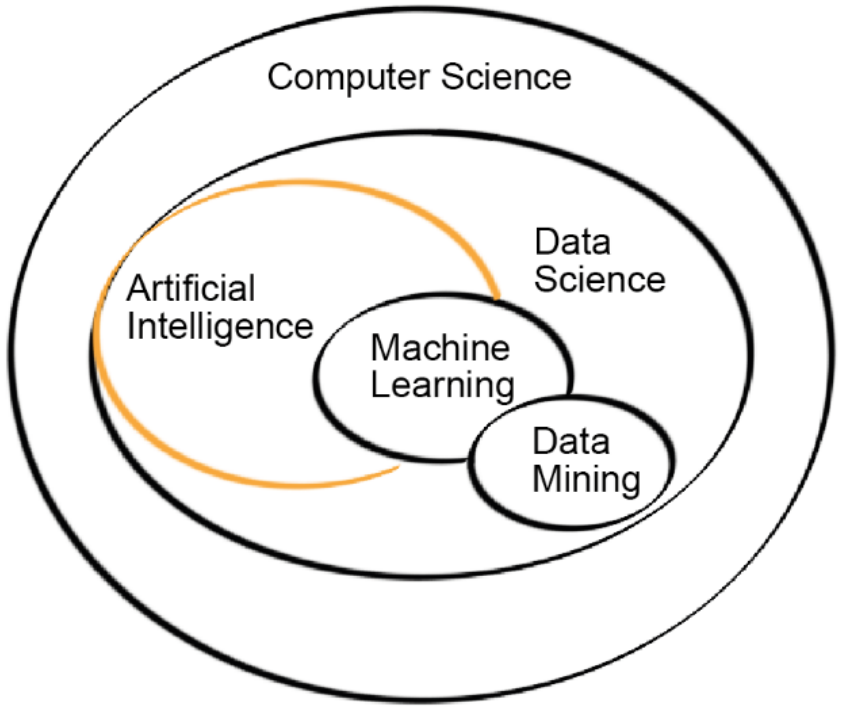
Contents

Introduction

- Over the years and the evolution of technology, the way we perceive and apply the design of footwear and leather goods has changed.
- Generative design and Artificial Intelligence are two areas that shape the present and future of fashion and design, and open new horizons.
- Coming from different scientific fields, but they complement each other in a new context where creativity, technology and innovation meet.
- Generative design is a specific application of Artificial Intelligence that focuses on the use of Artificial Intelligence algorithms to create and optimize designs.
- Artificial Intelligence is a broader field that includes

Artificial Intelligence (AI)

- Artificial intelligence refers to computer systems that can perform complex tasks normally done by human-reasoning, decision making, creating, etc.
- Analyse large amounts of data, aiming to identify patterns and internal relationships that enable the generation of predictions.
- Today AI is a precious technology in many sectors because it allows machines to perform tasks typical of human operators, and often, thanks to the superior computing power of devices, even faster and with a lower error



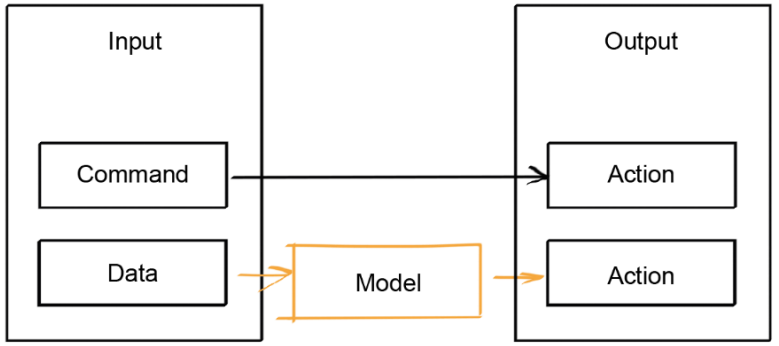
Artificial intelligence position in data-related fields. Source: Figoli, F. A., et al., 2022

Artificial Intelligence (AI)

- Break into two macro-categories:
  - weak AI: systems trained to solve specific tasks, for example, virtual assistants, such as Amazon's Alexa.
  - strong AI: systems that seek to emulate human reasoning and better solve complex and unknown problems autonomously.

AI- Machine Learning (ML)

- The topic of artificial intelligence is vast, and it includes a set of sub-branches.
- In terms of diffusion and potentialities, the most relevant is machine learning (ML).
  - Which enables devices to autonomously learn and improve their capabilities.
  - which implies the use of statistical models based on data and empirical information to identify patterns and improve performances over time.
- It is so interesting because the learning process is not explicitly programmed.
- Instead of an input command, a device is provided with input data, which are then processed through a model into an output.
- We can train a device to make autonomous decisions, adapt and modify assumptions based on provided data and on encountered errors.



Input command vs Input data.
Source: Figoli, F. A., et al., 2022

AI Applications

- Artificial Intelligence is an ever-growing and improving technology that can benefit many areas of work.
- There is no sector that has not incorporated it.
- The most common applications of Artificial Intelligence are:
  - Business
  - Finance
  - Banking
  - Healthcare
  - Law
  - **Manufacturing**
  - **Design and Engineering**
  - Security
  - Transportation

AI Applications

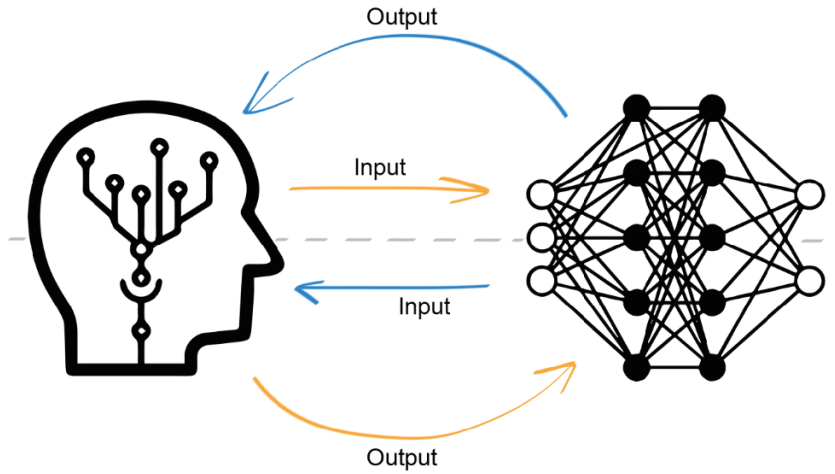
- **Manufacturing :** The introduction of robots and intelligent systems, which can analyze a situation and decide autonomously, has improved the speed and flexibility of the production chain. Machines can now perform multiple tasks simultaneously (e.g. assembly and quality control) and select the appropriate action depending on the needs.
- **Design and Engineering:** Artificial Intelligence software can actively assist designers and engineers in developing specific components to improve performance, reduce the amount of material required, predict and correct errors, etc.

AI and Design

- Design and artificial intelligence (AI) may seem like two distant fields, since the former focuses on the creativity and sensitivity of the designer, while the latter focuses on the rigorous calculation of the machine.
- AI is capable of offering many possibilities during the steps of the design process.
- In product design, AI can have two main areas of application:
  - product itself
  - design process.
- AI can be either:
  - design material: final product is equipped with AI functions
  - design tool: AI is applied to enhance and optimize the results of the design process.

AI in the Design Process

- Aims to overcome human limitations and improve their capabilities, optimizing resource allocation and enhancing creativity.
- In human-machine collaboration with Artificial Intelligence systems: technology is now becoming an almost equal partner to humans.
- In this new relationship, there are two teammates who create a continuous and productive exchange between them.
- Both the designer and the machine can receive input data and send output data to the corresponding one
  - creating a data exchange cycle that ends



The back-and-forth cycle established in a human-AI collaboration. Source: Figoli, F. A., et al., 2022

AI in the Design Process

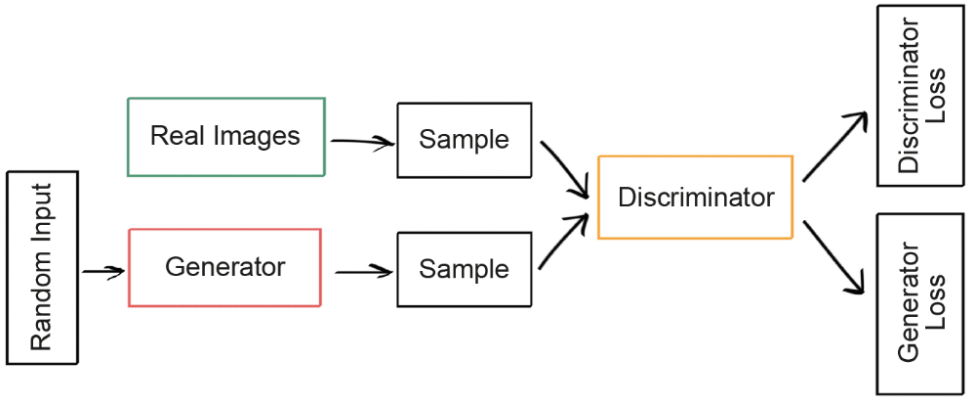
- AI influences the designer's creativity, the designer strongly influences the AI output, achieving a collaborative exchange.
- The human helps the machine improve, so that the device can then improve the quality of its contribution to the human.
- Study developed a framework for new design tools integrating AI, outlining three possible roles in the development of a design idea.
  1. AI as representation creation.
     - AI systems can act "to provide inspiration, expand the scope of design, or trigger design actions by suggesting texts or images".
  2. AI as an empathy trigger.
     - AI could support the designer's descriptive thinking, is often applied to construct scenarios, and is valuable for broadening the scope of possible design ideas.
  3. AI as engagement.
     - AI can help the designer avoid fossilization by motivating them to perform typical design actions, such as reformulating the problem, examining different cognitive domains, applying lateral thinking, etc.

AI in the Concept Phase

- In concept phase are defined:
  - design ideas, aesthetic choices, main functions, user interaction methods and technical solutions.
- It is the heart of the design process and usually requires many resources engaged in many activities.
- AI should not be understood as a tool that standardizes and flattens individualities, but as an impressively flexible tool capable of preserving and enhancing them, allowing each designer to act in the way they prefer.
- The five categories of AI applications are
  - image generator, sketching assistant, model generator and modifier, facilitator and concept evaluator.

AI in the Concept Phase

- **Image Generator**
- Collecting visual information to stimulate the designer's creativity can be challenging.
  - AI systems can overcome this obstacle with excellent results, generating visual inputs that are entirely new and targeted to the specific design topic.
- For this kind of application, the mainly employed AI models are based on the so-called generative adversarial networks (GANs), which can generate high-quality images with high accuracy from the provided input data.



Overview of a basic Generative Adversarial Network (GAN) structure. Source: Figoli, F. A., et al., 2022

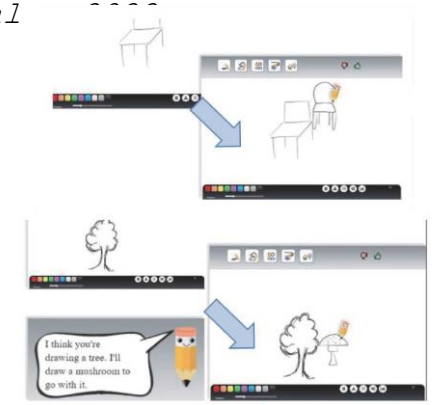
AI in the Concept Phase

- **Sketching Assistant**
- Sketching is an activity that exists throughout the design process, but it becomes essential during the development of the idea. Drawing is the designer's tool by definition.
- It is not only a means of visualization and communication, but also a reasoning tool in which creativity and reflection are stimulated.
- The role of AI is to act as a creative stimulus
  - leading the designer to reshape the situation, rearrange the values at stake, reevaluate its assumptions and avoid the fossilization of a particular idea.

AI in the Concept Phase

- The applications of Artificial Intelligence for sketching are few and limited.
- Some of them are:
  - Sketch-rnn (Ha & Eck, 2018): It allows the user to draw specific objects in strict collaboration with a recurrent neural network (RNN) system.
  - Collabraw (Fan et al., 2019): an online environment for collaborative sketching of simple visual concepts.
  - Drawing Apprentice (Davis et al., 2016): AI can recognize the semantic information contained in the input drawing provided by the user and based on it, draw from scratch either identical or complementary objects.

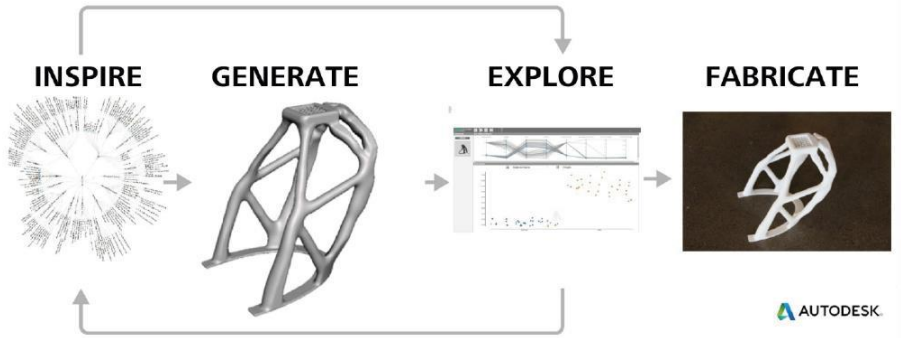
Collabdraw (Fan et al., 2019). Source: Figoli, F. A., et al



Drawing Apprentice (Davis et al., 2016). Source: Figoli, F. A., et al., 2022

AI in the Concept Phase

- **3D CAD modelling**
- Construction of a 3D model is a common practice in the later stages of a project
  - idea needs to be made precise, feasible and ready for production.
- AI is widely used with many applications and functions
  - production chain and improving quality control operations.
- Design is experiencing a trend of fluidization of design tools, which is mainly driven by AI systems.
- Design industry c and tools, such as AI tools, and revise es.



Autodesk Dreamcatcher (Williamson, 2017). Source: Figoli, F. A., et al., 2022

AI in the Concept Phase

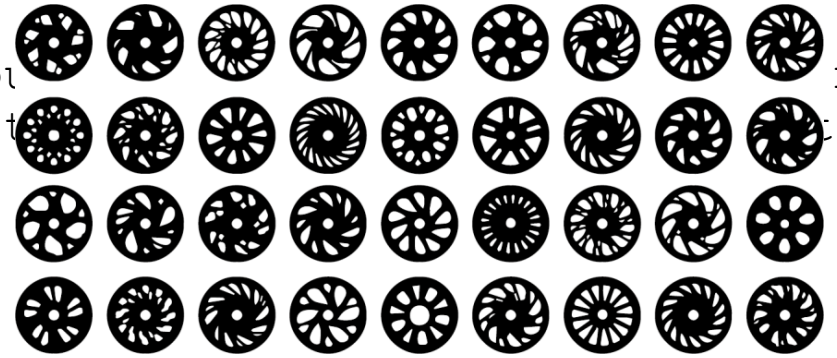
- AI converges into CAD is founded upon both subjective and quantitative simulation methodologies.
  - Quantitative reproduction yields precise results through scientific computing programs in conjunction with FEA and conventional CAD software.
  - Subjective displaying can’t create exact impacts.
- AI acts as a substitute for a product design evaluation team and simplifies the modeling process.
- If AI and decision-making techniques derived from product design are generally applied to AI programming, the product development cycle can be significantly shortened.

AI in the Concept Phase

- The combination of Artificial Intelligence and 3D CAD includes the following basic functions:
  - The parts of a machine must be maintained in a progressive form.
  - The model shapes are similar and placed in a multi-level-based form.
  - It can include new added substances or components in the database.

AI in the Concept Phase

- AI-Project Dreamcatcher (Autodesk): create thousands of different 3D models starting from the data provided by the human user.
  - type of object, dimensions, weight limits, stress, materials, cost, reference models.
- AI- Framework conceptually like Dreamcatcher (Oh et al. 2019): considers both mechanical performance and aesthetics simultaneously.
  - From a simple inpu model can autonomously generate several t ions of varying complexity.



Generated design options (Oh et al., 2019). Source: Figoli, F. A., et al.,

AI in footwear design and manufacturing

- Artificial Intelligence is revolutionizing footwear design through various applications.
- Aspects of AI footwear design and manufacturing:
  1. Footwear Designs with A.I
  2. Production Optimization with A.I
  3. Customization in footwear, powered by AI
  4. Material efficiency
  5. Circular Economy and A.I

AI in footwear design and manufacturing

1. Footwear Designs with AI
   - Generative Design
     - Algorithmic Creativity: AI creative thinking with design capabilities based on input parameters, resulting in the creation of unique and innovative shoe designs.
     - Design Optimization: Optimization of designs not only for aesthetics but also for functional aspects. ensuring that comfort, performance and other factors such as weight and durability are maximized.
     - Rapid Prototyping: Designs AI generated can be created quickly using 3D printing or other advanced manufacturing techniques, allowing for faster design iteration and validation.
   - Material Selection
     - Material Analysis: Analysis of properties of various materials, such as strength, flexibility, weight and environmental impact. Helps in selecting the most suitable materials for a specific shoe design.
     - Cost Efficiency: Assessing the economic efficiency of materials, taking into account production costs and market factors. Helps in balancing quality and cost in footwear production.
     - Sustainability: AI is instrumental in choosing eco-friendly materials that align with sustainability goals, reducing the environmental footprint of footwear production.
   - Consumer Insights:
     - Market Research: Examining massive amounts of data to identify emerging consumer preferences and market trends.
     - Demand Forecasting: Accurate predictions about which types of shoes are likely to be in demand.
     - Customization: consumer feedback and preferences can be used for products align closely with what the market desires.

AI in footwear design and manufacturing

2. Production Optimization with AI
   - Supply Chain Management:
     - Demand Forecasting: AI uses historical data, markets, and other factors to accurately predict demand.
     - Inventory Management: AI systems can automate and optimize inventory management, ensuring that raw materials and components are available when they are needed.
     - Supplier Selection: AI can evaluate supplier performance and identify reliable and cost-effective suppliers, contributing to a more efficient supply chain.
   - Quality Control:
     - Real-Time Inspection: AI-powered computer vision systems can inspect each shoe in real time during production, identifying defects or imperfections that may not be detected by human inspectors.
     - Consistency: AI ensures that the quality of each shoe is consistent.
     - Data Analysis: Quality control data can be analyzed to identify improvements in the production process, enhancing overall quality.
   - Manufacturing Automation:
     - Robotic Automation: performing tasks such as cutting, sewing and assembling parts with high precision and speed.
     - Process Optimization: optimizing production processes in real time to improve efficiency, reduce energy consumption and minimize errors.
     - Labour Cost Reduction: automation reduces labor costs, allowing people to focus on more creative and complex tasks, such as design and problem solving.

AI in footwear design and manufacturing

3. Customization in footwear, powered by AI
   - Personalized Fit:
     - 3D Scanning: AI-based 3D scanning technology is used to take precise measurements of a customer's feet.
     - Machine Learning Algorithms: process the 3D scanning data and determine the optimal design and dimensions for each shoe, ensuring the perfect fit.
     - Tailored Insoles and Lasts: created with the help of 3D printing, to match the shape of the individual's foot, providing superior comfort and support.
   - Style Preferences:
     - AI-Driven Design Platforms: Customers can access AI design platforms that allow them to co-create their footwear.
     - Virtual Try-On: Allows customers to visualize the appearance and fit of custom shoes, helping them make informed decisions.
     - Instant Pricing: Real-time pricing calculation based on selected customizations, ensuring transparency and affordability.

AI in footwear design and manufacturing

4. Material efficiency
   - AI Optimization of Material Usage:
     - Analysis and optimization of material use in footwear design and production.
     - Evaluating factors such as physical properties of materials, cost factors and environmental impacts.
   - Reducing Wast:
     - Ensuring that material resources are used wisely, reducing excess and waste in the production process.
     - Manufacturers can contribute to a cleaner and more sustainable production process.
   - Meeting Sustainability Targets
     - Helps achieve sustainability goals by making more environmentally friendly material choices and minimizing waste.
     - Using recycled materials, choosing materials with a lower carbon footprint and ensuring ethical and environmentally friendly practices throughout the supply chain.
     - A critical aspect of sustainable footwear production, consumers and regulators are demanding more responsible and environmentally friendly practices in the footwear industry.

AI in footwear design and manufacturing

5. Circular Economy and A.I
   - Material Tracking:
     - Tracking and tracing of materials used in footwear production throughout their life cycle. Origin, composition, use of materials.
     - Better visibility into the flow of resources, ensuring accountability and transparency in the supply chain.
   - Material Sorting:
     - Separation of different materials, making recycling and upgrading more efficient.
     - Ensuring that materials are appropriately directed for processing and remanufacturing.
   - Recycling Initiatives:
     - Identifying opportunities for recycling and reusing materials.
     - Vital in reducing the need for new raw materials and cutting down on waste.
   - Upcycling Strategies:
     - Proposing creative ways to upgrade materials, turning them into higher value products.
     - Promoting innovative ways to extend the lifespan of materials and products, reducing waste and supporting a circular economy.

Generative Design

- Using algorithms to generate multiple solutions based on defined goals and constraints.
- Designers can automatically explore a wide range of intelligent, optimized options.
- It does not replace human creativity but rather expands the possibilities and inspiration.
- AI is the engine behind generative design.
  - can generate hundreds of design variations in a fraction of the time, taking into account factors such as material usage, structural integrity, cost, and performance, to create innovative and optimized designs.
  - Allows designers to identify what works, detect patterns, select the option with the best performance, and drive product innovation more efficiently.

Benefits of Generative Design

Increased creativity
A vast number of design possibilities and the creation of innovative solutions.

Improved efficiency
Can optimize designs based on given constraints and goals.

Time savings
Automation of the design process to generate and evaluate design options

Enhanced collaboration
Bridges the gap between different disciplines and expertise.

Generative design software

- Genetic design software offers users more than the traditional functionality of CAD software.
- The following are popular software programs that offer genetic design capabilities:
  - **Fusion 360 from Autodesk:** Fusion 360 offers users a powerful set of modeling tools, including sketching, direct modeling, surface modeling, parametric modeling, mesh modeling, rendering, and more.
  - **Creo Generative Design from PTC:** Leveraging the cloud, this software allows users to create optimized design concepts while simultaneously exploring and testing multiple design iterations quickly.
  - **nTop Platform from nTopology:** The nTop Platform software promises users complete control over every aspect of the optimization process and its results.
  - **NX from Siemens:** Beyond generative design, the main feature that NX offers is digital twin technology.
  - **MSC Apex Generative Design from MSC Software:** the software combines

Generative Design and 3D Printing

- Genetic design algorithms often create high-performance organic shapes with a supporting mesh.
  - expensive or impossible to manufacture with conventional manufacturing technologies.
- 3D printing is essential for these types of applications.
- 3D printing works well with genetic design
  - flexible and fast means of producing a high-resolution 3D model of one or more design iterations for a cost-effective final product.
- 3D printing is becoming practical for small and mid-volume parts for a growing number of applications.

Generative Design and 3D Printing in Footwear

- New Balance has made significant breakthroughs through genetic design and 3D printing.
- 2015: Partnered with digital design studio Nervous System to engage a genetic design process to develop a midsole that would better adapt to performance data from a runner.
- 2017: partnered with Formlabs
  - develop Rebound Resin a proprietary, production-ready photopolymer resin with five times the tear strength, three times the tensile strength, and two times the elongation of other production-grade 3D-printed elastomeric materials on the market.
  - Notable advancements in shoe manufacturing and helped deliver better products for end-users.
  - The two companies continue to work together with the ultimate goal to mass-produce custom running shoes tailored to each customer through generative design and novel 3D printing materials.

New Balance collaborated with Formlabs for high-performance shoes with generatively designed midsoles. Source: https://formlabs.com

Questions

- What Is Generative Design?
- The most common applications of Artificial Intelligence are healthcare, design and engineering, and air transportation. **True or False**
- AI in product design can have two main areas of application, product and design process. **True or False**
- Design industry could not implement AI tools and stay traditional ones. **True or False**
- The creation of unique and innovative shoe designs is possible through input parameters of artificial intelligence. **True or False**
- Artificial Intelligence (AI) in genetic design enables increased creativity, time saving, and enhanced collaboration. **True or False**
- A popular 3D CAD software program that offer genetic design capabilities is Adobe Photoshop. **True or False**
- 3D printing does not work well with genetic design because it impossible to manufacture high-performance organic shapes by this tool. **True or False**

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