

# Will Artificial Intelligence (AI) change the design process?

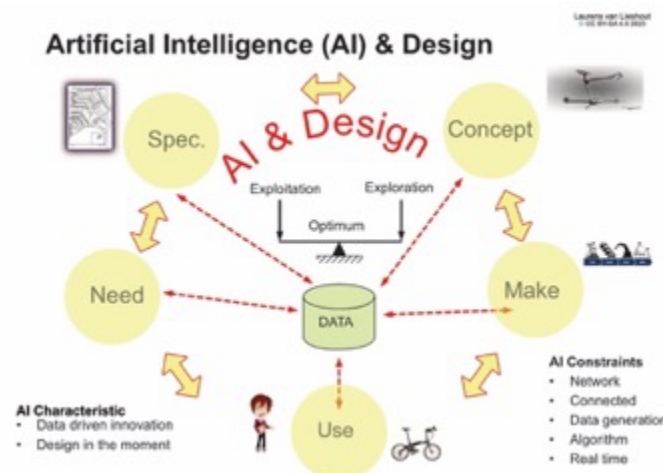


Fig: AI & Design

Yes and No.

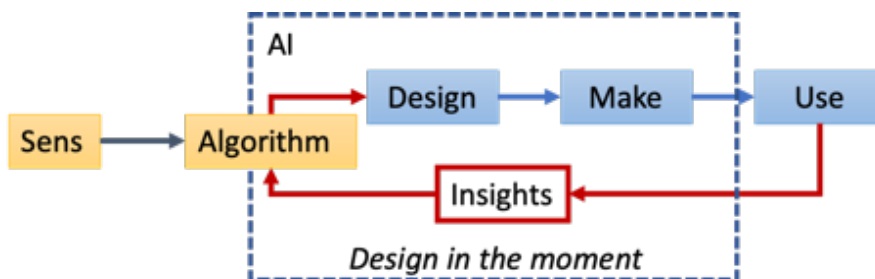
Yes, AI will speed up the design process by automating simple problem-solving steps. And no, basically, the design process will be the same.

To increase innovation, reduce costs, improve customer value, and streamline design and production, lead time is very important. With the increasing capacity of computers, simulations can be performed easily. The Industrial Revolution, Manufacturing 1.0 to 4.0, has led to vertical integration of all aspects of manufacturing. **But what about AI in the design process?**

Designing is nowadays a people-intensive process and it is costly and takes a lot of time and effort. AI reduces design lead time and makes it possible to **design in the moment**.

Designing with AI is essentially a problem-solving process. But which problem to solve is still human work.

'Making Sense' is the holy grail in using AI.



In this white paper, we discuss the design process perspective with regard to AI.

## Executive summary

AI will change the design process because it will be possible to realize faster and better-quality designs. Basically, the design process will remain the same.

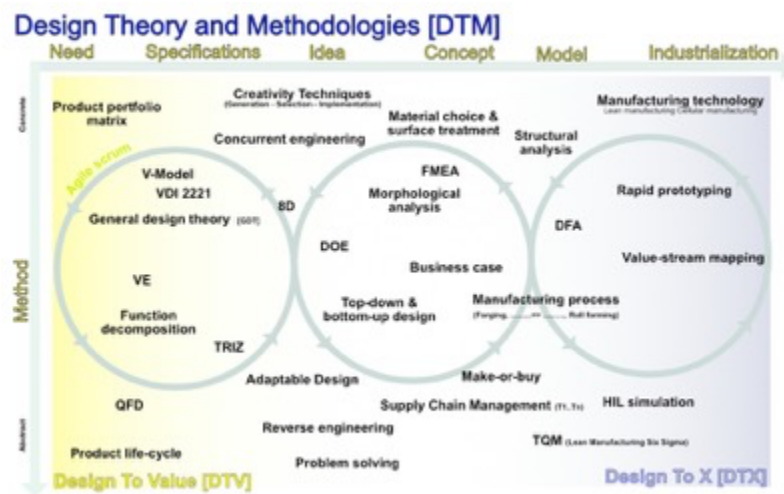


Fig: Design theory and Methodologies

All sub-processes used in the design processes see the figure above, can be carried out more effectively with the help of AI, as an example: drawing up the program of requirements, mapping out human-product interactions, developing sketches, generating design variants, running simulations, and more.

AI is often a container term. A term whose definition is not unequivocal. Is AI an entity able to change pre-programmed actions based on observing the real world? Or is AI able to predict actions based on knowledge of observing the real world? Or is AI an entity with the ability to learn? Or is AI a program with a model from reality? Or is AI a program with a hidden neural network? In this white paper, we give some examples from AI applications.

Designing with AI is essentially a problem-solving process. But which problem to solve is still human work.

In Simulation-driven design, also known as Generative-design, almost all aspects can be simulated. Simulate to function and simulate to make it. With AI, all these simulations can be included in the algorithm. This is the future of using AI in the design process.

## If you are using AI, you must think about unintended use.

In the past (1964), Asimov's mentioned the Three Laws of Robotics in his novels and he was foreseeing the danger of AI.

*Remember! An algorithm created to solve a problem cannot refuse to solve it. It cannot pull the plug unless this trigger is in its code. This is also the danger of the use of AI. Who knows and understands all the codes used in the algorithm?*

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Before discussing the future of the design process, a brief definition of the characteristics of the design process.

**Current state**

Traditionally, designing is costly and time-consuming. The design of a new product involved the creation of complex process architectures that could effectively deliver the product at scale.

Large organizations release new products in series, and with customers' resulting cycles of design and use. This is because it is practically and economically not feasible to design a different solution for each user. Products and services are designed for "segments" of users, including customization options during production. Once a product was introduced, the context evolved, and the market changed and new technology emerged. Designers can also gain new insights into how customers use the existing product. But since the business model involves significant effort and investment to redesign a product, innovation was postponed until it paid off to start a new design cycle.

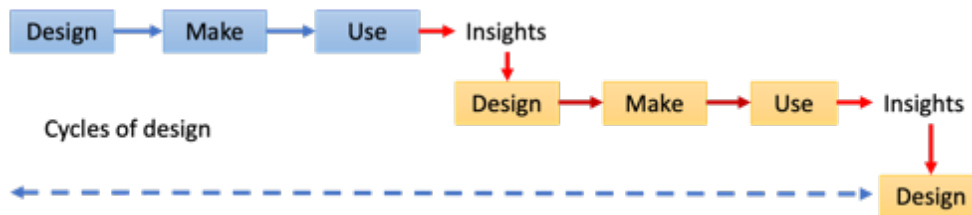


Fig: Cycles of design

**Design specification**

Design essentially starts with translating the wishes of the market, linked to the requirements set by the government, into a design specification. The design team then gets to work with this specification.

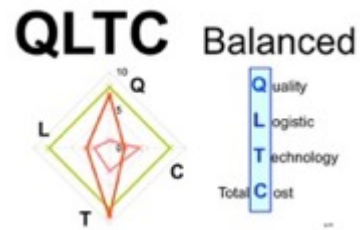


Fig: Requirement

How you arrive at a solid specification is another story. In a nutshell, the design is an optimum between; Quality, Logistic, Technology, and Cost.

The QLTC balanced.

For more information, see the book (Lieshout L. v., Methodical Design Explained, 2022)



## Ultimate future development and production process.

### Quote

*‘Predicting the future is and remains a perilous undertaking. Extrapolating data from the past and translating it into the future is the most common way to predict the future. There may be revolutionary discoveries in the future that enable development and production processes that we cannot imagine today. Nature uses the principle of replication. With the “rapid prototyping principle, it is possible to make any product with a device that is fed with energy, raw materials, and information. The **ultimate production process** is therefore making the product on-site. This ultimate way of producing something is the ‘materializer’ principle. Materializing virtual information. In any place with a “materializer” any product can be made.*

*When developing a product, one of the most complex phases in the entire development process is translating a customer need into a product that meets it. It is, therefore, predictable that the “whole” spectrum of knowledge and skills will be addressed in the development process. With the current rapid developments in the field of automation, this should be possible in the (not too distant) future.*

*In essence, the final development and production process is then:*

*“The direct translation of customer needs into a concrete product or service.”*

*(Lieshout L. v., White paper; de evolutie van het ontwikkel- en het productie-proces., 2007)*

Now 16 years later, with the help of AI and simulation software, the direct translation from the customer needs into a concrete product or service is now possible.

## ‘Design in the moment.’

Before we discuss the influence of AI on the design process some basic clarities.

### Concepts

Design Process

What is the essence of the design process?

This is the answer of ChatGPT.

*The essence of the design process is to solve a problem or address a need through the creation of a new product, system, or service. The design process is a systematic approach that involves identifying the problem or opportunity, researching and analyzing the problem or opportunity, generating ideas, testing and refining concepts, and ultimately creating a final design that meets the desired outcomes.*

*The design process is typically iterative, meaning that it involves multiple rounds of ideation and refinement as designers work to create the best possible solution. It also often involves collaboration between designers and stakeholders, including users, clients, and other members of a design team.*

*Throughout the design process, designers must consider a wide range of factors, including user needs and preferences, technical constraints, budgetary constraints, and aesthetic considerations. The goal is to create a design that not only addresses the problem or opportunity at hand, but also meets the needs and desires of the intended audience and is feasible to produce.*

*Overall, the essence of the design process is to create something new and innovative that solves a problem or meets a need, while balancing a range of practical and aesthetic considerations. [ChatGPT May 3 Version]*

## In essence, designing is solving a problem.

ChatGPT's answer is based on the collectively available information on the internet, filtered by trained static rating weights. This is not transparent. We don't know the data used to get the answers.

### Artificial intelligence.

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to intelligence displayed by humans or by other animals. 'Artificial' is a clear definition.

### Intelligence

Intelligence is the capacity for abstraction, logic, understanding, self-awareness, learning, emotional knowledge, reasoning, planning, creativity, critical thinking, and problem-solving.

More generally, it can be described as the ability to perceive or infer information and to retain it as knowledge to be applied towards adaptive behaviors within an environment or context. ...

Intelligence is the ability to acquire, understand, and use **knowledge**. In other words, the ability to learn.

### What is knowledge in the context of AI?

Knowledge in AI (Artificial Intelligence) means to have some information saved in the memory from the prior experience of something like any skills, objects or facts.

There are three types of AI knowledge: **descriptive, procedural, and acquaintance.**

- **Descriptive Knowledge** means have details information about some things or facts. (Wikipedia, books, etc.)

- **Procedural Knowledge** means to know the process of a task. (Books, publications, etc.)
- **Acquaintance Knowledge** is to know something or someone. (Program code)

Zooming in on: Intelligence is acquiring, understanding, and using **knowledge**. In other words, the ability **to learn**.

### To acquire knowledge

Knowledge is created by processing information. To acquire the information, AI must be connected. (Sensors, cameras, using apps by people, questions from search engine, etc.)

### To understand knowledge

This is the most challenging aspect from AI.

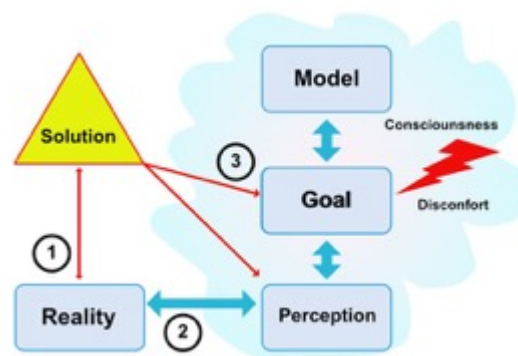


Fig: Visualization of a mental model of the reality

To understand knowledge, you need to have a model from reality.

*Note: this is a personal hypothesis of the writer!*

Each individual has a (mental) model of reality. If our perception, look at reality (1), does not match the (mental) model of the individual, then this creates discomfort. This discomfort is the motivation engine for an individual's actions. (Lieshout L. v., White paper; The learning organization, 2018) This is valid for an organization or human being. Is this also valid for AI?

The discomfort in an AI program is within the algorithm, and this is the purpose of the AI program. For example, giving an answer a question or solving a task.

### Quote

*AI systems develop internal models of the real world just like our brains do, although the machines' engineering is different. Although a large language model (LLM) runs on a computer, it is not itself a computer. It lacks essential computational elements, such as working memory. The models rely on a machine-learning system called a **neural network**. Such networks have a structure modeled loosely after the connected neurons of the human brain. The code for these programs is relatively simple and fills just a few screens. "It is certainly much more than a stochastic parrot, and it certainly builds some representation of the world—although I do not think that it is quite like how humans build an internal world model," says Yoshua Bengio, an AI researcher at the University of Montreal. Instead, he hypothesizes that the machine **improvised a memory** by using*

*its mechanisms to interpret words according to their context — a situation similar to how nature reuses existing capabilities for new functions. (Musser, 2023)*

*Note: For me, the answer of AI has a model of reality, like a human, is not clear. AI may realize this in a different way.*

### To use knowledge

Using knowledge is like answering a question. Knowledge can be used in an action or transformation from .... to ....

In every process, knowledge is needed to perform an output. Generally, performing an output can be seen as a production process.

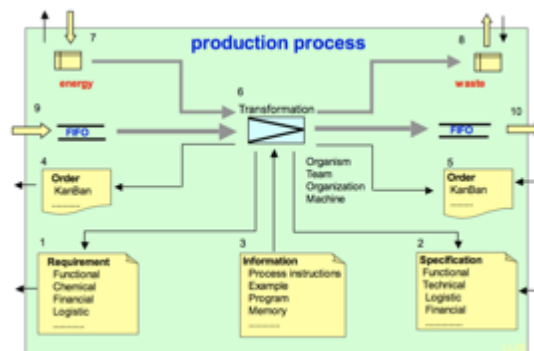


Fig: basic production process

### Quote

*Each natural or artificial production process can be described as follows: Information (3) in the form of process instructions and or examples, transform (6) specified (1) raw materials (9) using energy (7) into specified (2) products (10). During the production process, waste (8) is released. External information (5) and (4) and or an interruption of the material flow causes the transformation process (6) to start or stop. (Lieshout L. v., Methodical Design Explained, 2022)*

This model is also called the basic form of an organism or organization. (Wikipedia-bijdragers, 2023)

Knowledge is embedded in the requirement, the information, the specification and the order.

When we ask a question to an individual (a human being) we do not know what knowledge he or she is using. Based on our experiences, we trust his or her answer. Whether we trust the source or not depends mainly on our past experience with this source. Even if we get the same information from different sources, the level of confidentiality increases.

If we ask an AI, do we have the same confidence?

### To learn

Having the ability to learn. According to (Lieshout L. v., White paper; The learning organization, 2018) you need a virtual model of the reality, a goal and a perception ability. And above all, you need the necessary plasticity to change the memory. The so-called plasticity of the brain. Translating these aspects to the AI software;



**Virtual model**

The neural network is more or less comparable with the human brain. In this neural network, a representation of reality **can be** available.

**Goal**

In the program code, a goal and a purpose is defined.

**Perception**

If the AI has sensors for observing reality, this aspect is also available.

**Plasticity**

If the program code makes it possible to change, in real-time the weight of the neural network, then all aspects from the comparison are present.

*Note: The latest aspect is the plasticity of the program in real-time. Is also risky. You don't know on forehand what the outcome will be.*

*In the human brain, we have a part (morality) that is controlling our instincts. What is the regulation of our behavior? It is unclear (to me) whether the AI program also contains a controlling subprogram. The makers of the available AI programs are not transparent in giving this information.*

**Machine learning**

Machine learning (ML) is a field devoted to understanding and building methods that let machines "learn" – that is, methods that leverage data to improve computer performance on some set of tasks. (Hassany, 2023)

**Algorithm**

An algorithm is a finite sequence of rigorous instructions typically used to solve a class of specific problems or to perform a computation. (Software, Tableau, 2023)

*Note: an algorithm created to solve a problem **cannot refuse to solve it**. It cannot pull the plug unless this trigger is in its code. This is also the danger of the use of AI. Who knows and understands all the codes used in the algorithm?*

**Large language model [LLM]**

A large language model (LLM) consists of a neural network with many parameters (*typically billions of weights or more*), trained on large quantities of unlabeled text using self-supervised learning or semi-supervised learning.

An LLM is, in reality, a giant exercise in statistics. As an example, prompting in ChatGPT the sentence: “*The promise of large language models is that they...*” you will get an immediate response. How does it work?

**Quote**

*First, the language of the query is converted from words, which neural networks cannot handle, into a representative set of numbers—splitting text into chunks of characters, called tokens. The tokens are then assigned the equivalent of definitions by placing them into a “meaning space” where words that have similar meanings are located in nearby*

areas. The LLM then deploys its “attention network” to make connections between different parts of the prompt. The LLM must learn associations from scratch during its training phase—over billions of training runs, its attention network slowly encodes the structure of the language it sees as numbers (called “weights”) within its neural network. If it understands language at all, an LLM only does so in a statistical, rather than a grammatical, way. It is much more like an abacus than it is like a mind. The limitation of LLM's growth is the availability in data, computing power, electricity, skilled labor, and money. (Economist, 2023)

### Simulation-driven design

In Simulation-driven design also called **Generative-design**, almost, all aspects can be simulated. Simulate to function and simulate to make it. With AI, all these simulations can be involved in the algorithm.

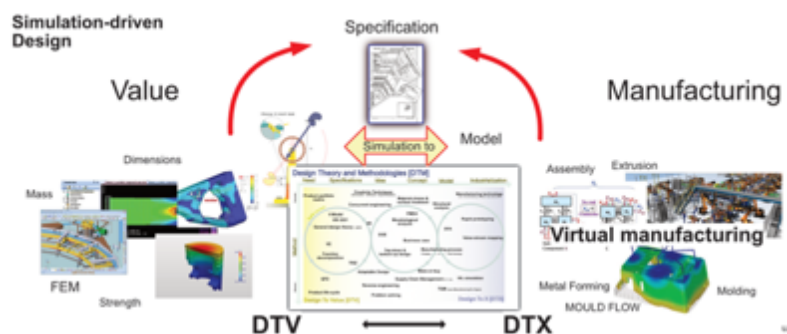


Fig: Simulation driven design

In a nutshell: Smart design and manufacturing is the combination of digital-driven applications implemented to constantly optimize efficiency, uncover opportunities to improve design and production performance, and lower costs - making processes smarter.

(Lieshout I. v., 2023) AI enables the designer to choose the right simulations based on the achievements stored in an AI program.

### The influence from AI on the design.

#### Is AI already here?

A computer is well equipped to solve a problem. Problem solving tasks, traditionally carried on by designers, are automated into learning loops that operate without limitations of volume and speed. Below some examples.

#### FEM

An example is the use of a computer for numerically solving differential equations. The finite element method (FEM).

For example, many designers use this FEM method to optimize the strength of a structure. The user is usually not aware of how the algorithm works exactly. This does not hinder the user in using it. Is this a form of AI?

#### Simulation software

Using advanced simulation software, a design is already being optimized on aspects such as manufacturability, use of materials, and thermal analysis. The designer plays the curator

role by harnessing AI's iterative power to generate and test concepts that would be near impossible to come to otherwise. Is this a form of AI? (Yablonki, 2023)

#### Tesla car

Hardware cannot be (yet) designed in real-time, remotely, and automatically. To unleash the power of AI, Tesla had, therefore to reimagine the design of the car, acting in two diverse directions. First, it got rid of all the physical interacting elements (e.g., buttons) to embed most of the controls into digital user interfaces. And second, it overloaded cars with sensors to collect data. Is this a form of AI? (Roberto Verganti, 2023) (Autodesk, 2023)

#### CNC simulation

By virtually validating the **real-life machining environment** prior to production, Hexagon's CNC simulation software helps manufacturers avoid errors, decrease setup times and switch CNC programs between machines to increase shop-floor productivity, reduce costs and move closer to right first time. Is this a form of AI? (Hexagon, 2023)

#### ChatGPT

ChatGPT is a member of the generative **pre-trained** transformer (GPT) class of language models. A large language model (LLM) consists of a **neural network** with many parameters (typically billions of weights or more), trained on large quantities of unlabeled text using **self-supervised learning** or semi-supervised learning. Self-supervised learning (SSL) refers to a machine learning paradigm and corresponding methods for **processing unlabeled data to obtain useful representations** that can help with downstream learning tasks. The most salient thing about SSL methods is that they do not need human-annotated labels, which means they are designed to take in datasets consisting entirely of unlabeled data samples. Is this a form of AI?

### Definition of AI

AI is a collective term for computer programs that exhibit intelligent behavior by analyzing data and performing certain tasks. AI is not (yet) aware of its tasks. AI recognizes patterns and learns from its mistakes. In reality, it is a 'machine learning' program. So far, it's still people who come up with the programs and can pull the plug on the program.

#### Quote

*'AI has been defeating human expertise since 1997. It is already at the point where human intelligence has lost control, and when push comes to shove, there may not be a plug to pull.'* (Flood, 2020)

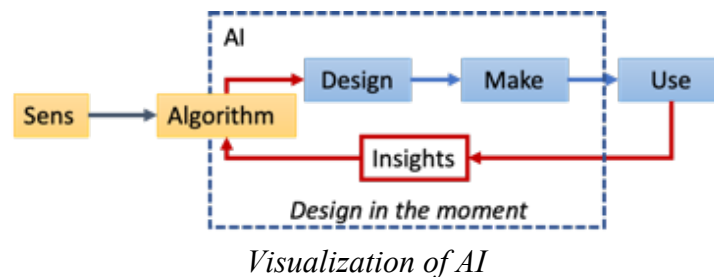
In the above-mentioned examples, AI is difficult to categorize.

- If the definition of AI is the ability to change pre-programmed actions based on observing the real world. Then all the above examples do not meet this definition. After all, the algorithm, whether trained or not, is static. (Chat `GPT 3, 4, etc.)
  - *Note; Researchers are finding that these systems seem to achieve a genuine understanding of what they have learned. (Musser, 2023) This study focuses on a form of awareness.*
- If the definition of AI is the ability to predict actions based on knowledge of observing the real world, then only examples 4 and 5 is an example of AI.

- If the definition of AI is the ability to learn, then are all algorithms with trained neural networks AI.
- If the definition of AI is to have a model from reality, then AI with a hidden neural network is an AI.

## Using AI in the design process

'Genius is one per cent inspiration, ninety-nine per cent perspiration' Quote from Thomas Edison. Also, in the design process a very large part is the execution of relatively simple tasks. These tasks are better performed by a computer. This shifts the focus for a designer in the sense making. Which problem or which task needs to be solved?



AI will become an important tool that supports the design process. This makes it possible to perform optimization iterations on design parameters faster. It is then no longer necessary to carry out prototypes and physical tests on designs. (Davenport, 2023)

## Generative design

Generative-design, or simulation-driven design is an example of AI, used in design tools for a while now. Generative design is a prime example of how AI can increase efficiency among product development. This gives light to further optimization among value chains, specifically when introducing new manufacturing principles.

In Simulation-driven design, also known as Generative design, almost all aspects can be simulated. Simulate to function and simulate to make it. With AI, all these simulations can be included in the algorithm. **This is the future of using AI in the design process.**

If the question is formulated correctly, is it now possible to use AI? As an example, in the following chapter, asking ChatGPT, the process of how to solve a contradiction will be explained by ChatGPT.

## Unintentional design

In his paper, Good Design Is Intentional (Yablonski, 2023), Jon gives an example of an unintended effect of the popular way-finding app Waze. To save its users a few minutes of commute time, the app was routing them through my neighborhood one after the other. In the process, this converted my street into a congested racetrack which was no longer safe for the children who played there and the pedestrians who walked there. The worst part: there was nothing we could do to stop it. Failure to anticipate the long-term consequences of design decisions in favor of short-term gain often leads to negligent and sometimes harmful outcomes. This is also an aspect to consider using AI in the design.

### Information bubble

AI is predicting the outcome of a question based on big data. This big data is acquired by training the algorithm and combining what AI is knowing from you. An example is how Facebook imagines the future of news. ‘The more our news is tied up with our identity, the harder it is to evaluate.’ (Robertson, 2016) To use AI in the design process, it is recommended to be aware of this aspect of using AI algorithms. After all, the algorithm is based on a lot of data of possible answers to the same problem.

### Summary

Developing a product is one of the most complex phases in the entire development process, translating a customer's need into a product that meets it. It is, therefore predictable that the "whole" spectrum of knowledge and skills will be addressed in the development process. With the current rapid developments in automation, this should be possible in the (not too distant) future. The final development and production process is then: “The direct translation of customer needs into a concrete product or service.”.

The future of design and manufacturing revolves around the following aspects: modularity, autonomy, connectivity, and digital twin.

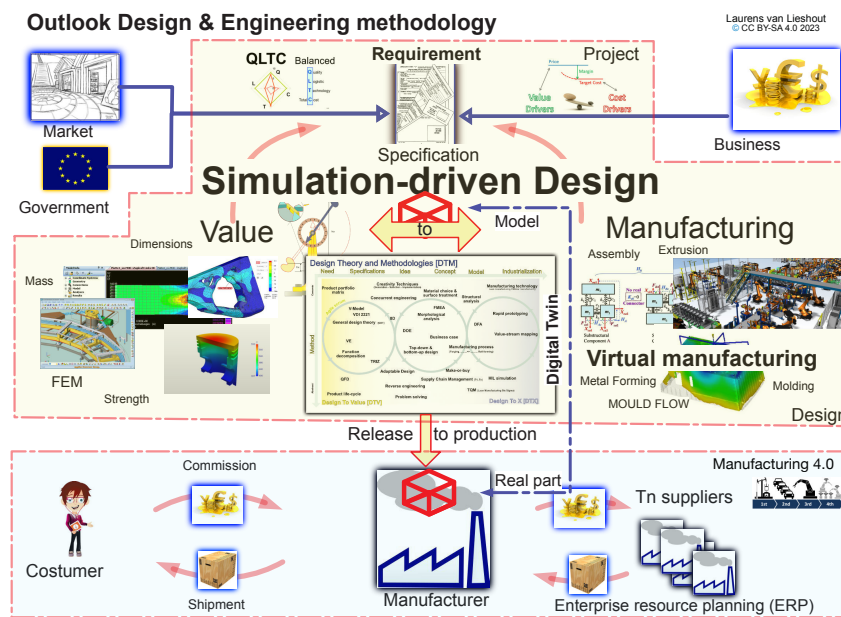
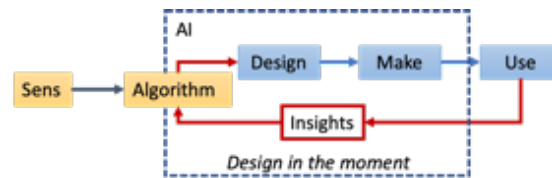


Fig: Outlook design process.

AI makes it all possible. AI is (will be) an important tool in the design process. A tool that makes the designer more productive.

In Simulation-driven design (Lieshout l. v., 2023), also known as Generative-design, almost all aspects can be simulated. Simulate to function and simulate to make it. With AI, all these simulations can be included in the algorithm. This is the future of using AI in the design process.

From the point of view of the consumer, it is now possible to translate any need directly into a concrete product or service. From the designer's point of view, defining and categorizing are increasingly important in the design process. The design focus is shifting to making sense.



### Responsible use of AI

## If you are using AI, you must think about unintended use.

In the past (1964), Asimov's mentioned the Three Laws of Robotics in his novels. He was foreseeing the danger of AI.

### Self-imposed rules by companies

Till now, companies are using self-imposed rules. Not all companies are transparent in using an algorithm to control the output from their AI programs. Bob Suh proposed 5 Rules; (Suh, 2021)

These are:

1. Assume that your RL agent will affect behavior in unforeseen ways.
2. Systematically evaluate deviations from the expected.
3. Interview users, customers, or others about their responses to the RL agents' outputs.
4. If an agent is promoting undesirable behaviors, modify its policies.
5. If undesirable behaviors persist, change the reward function.

Leaders must know what their AI is up to and, when it harms the company or society as a whole, do the right thing and fix the problem.

Unfortunately, practice shows otherwise. Therefore, rules are needed. Who is going to regulate AI? (Levin, 2023)

The European Commission is, at the moment shaping Europe's digital future. With the AI act in progress. For more info, see: <https://eur-lex.europa.eu/homepage.html>

Nobody is knowing the future. The question is, 'What would happen once a non-human intelligence becomes better than the average human at telling stories, composing melodies, drawing images, and writing laws and scriptures?' The answer, he believes, casts a dark cloud over the future of human civilization. According to Yuval Noah Harar, "We should regulate AI before it regulates us." (Noah, 2023)

*Remember! An algorithm created to solve a problem cannot refuse to solve it. It cannot pull the plug unless this trigger is in its code. This is also the danger of the use of AI. Who know and understand all the codes used in the algorithm?*

### **Please be nice to AI.**

In his book Scary Smart by Mo Gawdat, he argues that we should treat AI like we treat our children. This is because later on when AI becomes dominant over humans, it has learned how to treat us. (Gawdat, 2021)

I hope that writing this paper helps to understand to know what AI is, how it works, how you can use it, and what the limits are to its growth.

## Accountability

This white paper was created to emphasize the importance of sharing knowledge for the manufacturing industry.

Laurens van Lieshout has prepared this letter. <https://lieshoutconsultancy.nl> He is a member of <https://www.kscacademy.nl>.

The purpose of the KSC academy is to provide support to companies and organizations in the above field.

Laurens van Lieshout © CC BY-SA 4.0 2023

## Asking ChatGPT

Artificial intelligence is already here and accessible in the form of a chat box. So why not ask this question to AI? ChatGPT is an artificial intelligence (AI) chatbot.

### How does AI influence the design process?

This is the answer of ChatGPT.

*AI, or artificial intelligence, can have a significant impact on the design process in a number of ways. Here are a few examples:*

- 1. Automated Design Generation: AI can help designers generate new design ideas by creating multiple variations quickly, based on specific parameters or guidelines. This can help speed up the design process and provide new perspectives that may not have been considered before.*
- 2. Data-Driven Insights: AI can analyze large data sets to identify patterns and trends, which can be used to inform design decisions. For example, designers can use data on user behavior and preferences to create products that are more user-friendly and appealing.*
- 3. Virtual Prototyping and Testing: AI can simulate designs and test them in a virtual environment, reducing the need for physical prototyping and testing. This can save time and money and allow designers to iterate and refine their designs more quickly.*
- 4. Personalization: AI can help designers create products that are tailored to individual users' needs and preferences. For example, AI algorithms can analyze user data to suggest personalized product recommendations or design custom products.*

*Overall, AI can provide designers with new tools and insights that can help them create more innovative and effective designs. However, it's important to note that AI is not a replacement for human creativity and expertise - rather, it should be seen as a complementary tool that can enhance the design process. [ChatGPT May 3 Version]*

Test de ability to give information on the design process.

### How to solve a contradiction in a design?

This is the answer of ChatGPT.

*Solving a contradiction in a design involves identifying and addressing conflicting requirements or objectives. Here are some general steps you can follow to tackle a contradiction in a design:*

- 1. Identify the contradiction: Clearly define the conflicting requirements or objectives within your design. Determine which elements or features are in conflict and causing the contradiction.*
- 2. Gather information: Gather as much relevant information as possible about the design problem. Understand the constraints, user needs, technical limitations, and any other factors that may be influencing the contradiction.*
- 3. Analyze the root causes: Dig deeper into the factors causing the contradiction. Try to identify the underlying reasons behind the conflicting requirements. This analysis can help you find alternative approaches or solutions.*
- 4. Generate multiple solutions: Brainstorm and generate multiple possible solutions or design variations that could address the contradiction. Encourage creative thinking and consider both incremental improvements and radical changes to the design.*
- 5. Evaluate the solutions: Assess each proposed solution based on feasibility, effectiveness, impact, and potential trade-offs. Consider how each solution aligns with the overall design objectives and requirements.*
- 6. Prioritize and select the best solution: Prioritize the proposed solutions based on their potential to resolve the contradiction effectively while considering other design criteria. Select the solution that offers the most balanced trade-offs or the highest overall value.*
- 7. Iterate and refine: Implement the selected solution in the design and evaluate its performance. Test, prototype, and gather feedback to verify if the contradiction has been adequately resolved. Iterate and refine the design as necessary, making adjustments to optimize the solution.*
- 8. Document and communicate: Document the chosen solution and communicate it clearly to stakeholders, team members, or clients. Explain the reasoning behind the decision and highlight how the chosen solution resolves the initial contradiction.*
- 9. Learn from the process: Reflect on the experience of resolving the contradiction and identify any lessons learned. This knowledge can be valuable in future design projects and help avoid similar contradictions or challenges.*

*Remember that solving a contradiction may require compromise, trade-offs, or innovative thinking. It's crucial to remain open-minded, flexible, and willing to explore alternative solutions throughout the process. (ChatGPT May 24 Version)*

## Bibliography

Autodesk. (2023, 5 20). *Increasing feauk efficiency, Automotive Lightweighting, Simulation for automotive lightweighting*. Retrieved from Autodesk:

<https://www.autodesk.com/solutions/simulation/automotive-lightweighting>

Davenport, T. (2023, 5 20). *How Generative AI Is Changing Creative Work*. Retrieved from [www.hbr.org](https://www.hbr.org): <https://hbr.org/2022/11/how-generative-ai-is-changing-creative-work>

Economist. (2023, 4 22). *Large, creative AI models will transform lives and labour markets*.

Retrieved from [www.economist.com](https://www.economist.com):

[https://www.economist.com/interactive/science-and-technology/2023/04/22/large-creative-ai-models-will-transform-how-we-live-and-work?utm\\_campaign=a.coronavirus-special-edition&utm\\_medium=email.internal-newsletter.np&utm\\_source=salesforce-marketing-cloud&u](https://www.economist.com/interactive/science-and-technology/2023/04/22/large-creative-ai-models-will-transform-how-we-live-and-work?utm_campaign=a.coronavirus-special-edition&utm_medium=email.internal-newsletter.np&utm_source=salesforce-marketing-cloud&u)



- Flood, K. (2020, 10 22). *Pulling the Plug on AI*. Retrieved from [ww.linkedin.com](https://www.linkedin.com/pulse/pulling-plug-ai-ken-flood):  
<https://www.linkedin.com/pulse/pulling-plug-ai-ken-flood>
- Gawdat, M. (2021). *Griezelig slim(Scary Smart )*. In M. Gawdat, *Griezelig slim(Scary Smart )* (p. all). Amsterdam: Brandt.
- Hassany, S. (2023, 5 20). *How My Computer Copies a Baby: Machine Learning Types*. Retrieved from [www.medium.datadriveninvestor.com](https://medium.datadriveninvestor.com):  
<https://medium.datadriveninvestor.com/how-my-computer-copies-a-baby-machine-learning-types-5ffc8add6b31>
- Hexagon. (2023, 5 26). *CNC simulation*. Retrieved from [cnc-simulation](https://hexagon.com/solutions/cnc-simulation):  
<https://hexagon.com/solutions/cnc-simulation>
- Levin, B. (2023, 5 19). *Who Is Going to Regulate AI?* Retrieved from Haverd busines review:  
<https://hbr.org/2023/05/who-is-going-to-regulate-ai>
- Lieshout, L. v. (2007, 1 1). *White paper; de evolutie van het ontwikkel- en het productie-proces*. Retrieved from [www.lieshoutconsultancy.nl](https://www.lieshoutconsultancy.nl):  
<https://lieshoutconsultancy.nl/wp-content/uploads/2017/05/Evolutie-ontwikkel-productie-proces.pdf>
- Lieshout, L. v. (2018). *White paper; The learning organization*. Retrieved from White papers:  
<https://lieshoutconsultancy.nl/wp-content/uploads/2018/06/The-learning-organization-.pdf>
- Lieshout, L. v. (2022). *Methodical Design Explained*. In L. v. Lieshout, *Methodical Design Explained*. Mierlo: [www.mijnbestseler.nl](http://www.mijnbestseler.nl).
- Lieshout, l. v. (2023, 5 20). *Simulation driven design*. Retrieved from [www.lieshoutconsultancy.nl](https://www.lieshoutconsultancy.nl): <https://lieshoutconsultancy.nl/wp-content/uploads/2023/03/White-paper-Simulation-driven-design.pdf>
- Musser, G. (2023, 5 11). *How AI Knows Things No One Told It*. Retrieved from Scientific American: <https://www.scientificamerican.com/article/how-ai-knows-things-no-one-told-it/>
- Noah, Y. (2023, 5 29). *Yuval Noah Harari argues that AI has hacked the operating system of human civilisation*. Retrieved from The Economist: <https://www.economist.com/by-invitation/2023/04/28/yuval-noah-harari-argues-that-ai-has-hacked-the-operating-system-of-human-civilisation>
- Roberto Verganti, e. a. (2023, 5 20). *Design in the Age of Artificial Intelligence*. Retrieved from [https://www.hbs.edu/ris/Publication%20Files/20-091\\_3889aa72-1853-42f8-8b17-5760c86f863e.pdf](https://www.hbs.edu/ris/Publication%20Files/20-091_3889aa72-1853-42f8-8b17-5760c86f863e.pdf)
- Robertson, A. (2016, nov 16). *Facebook's Like button is a built-in filter bubble*. Retrieved from [www.theverge.com](https://www.theverge.com): <https://www.theverge.com/2016/11/16/13649782/the-facebook-like-button-is-a-built-in-filter-bubble>
- Software, Tableau. (2023, 5 26). *Artificial intelligence (AI) algorithms: a complete overview*. Retrieved from <https://www.tableau.com>: <https://www.tableau.com/data-insights/ai/algorithms>
- Suh, B. (2021, 5 21). *5 Rules to Manage AI's Unintended Consequences*. Retrieved from Havar Business Review: <https://hbr.org/2021/05/5-rules-to-manage-ais-unintended-consequences>
- Wikipedia-bijdragers. (2023, 5 20). *Productieproces*. Retrieved from Wikipedia:  
<https://nl.wikipedia.org/w/index.php?title=Productieproces&oldid=63882735>
- Yablonski, J. (20234, 5 14). *AI in Design*. Retrieved from [www.jonyablonski.com](https://www.jonyablonski.com):  
<https://jonyablonski.com/articles/2021/ai-in-design/>

Yablonski, J. (2023, 5 6). *Good Design is Intentional*. Retrieved from [www.jonyablonski.com](http://www.jonyablonski.com):  
<https://jonyablonski.com/articles/2023/good-design-is-intentional/>

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