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How AI challenges architectural design

Understanding AI from a historical perspective

We would like to start our reflexion on AI by considering the long history of techniques in order to underline that AI has its roots in a continuous evolution coming from antiquity. Thus, we first mark the fact that the mathematization of the world is not a recent process but rather a long, slow and continuous phenomenon. We first consider the works of Villars de Honnecourt, an artist from the 13th century, who lived in the northern France, and who wrote a portfolio containing about 250 drawings on architectural designs. The sheet 40, from the folio 20, shows a man measuring the height of a building with the help of a measuring tool, shaped in a rectangular triangle. Tools and measurement go with human activities. During the same period, Raymond Lulle (1233 env. -1316), a Catalan philosopher and theologian, paved the way of the universal logic and try to show how combinatorial operations can simulate reasoning (Weibel, 2018). The abstraction becomes the support of the understanding and the thinking. Five centuries later, Jacques de Vaucanson (1709-1782), inventor and mechanical engineer, constructed several famous automata called the Flute Player, the Digesting Duck, and the Tambourine Player. These machines are experiments in automation and demonstrate the possibilities of autonomy. Automation and autonomy are still today controversial concepts that feed the debates on the risks of technologies. Jacques de Vaucanson participated in the industrial revolution by contributing to the development of machine tools and, for a long time, technological progress was linked to social challenges and claims. At the end of the 19th century, Charles Babbage (1791-1871) and Ada Lovelace (1815-1852), both with a passion for mathematics, developed the Analatical Engine and the Difference Engine, which are the beginnings of the electronic and computational machines we know today. A strong relationship established between the hardware, i.e. the physical components that perform the computation, and the software that constitutes the program and defines the sequences of operations.

The cybernetic moment

Following this long evolution of techniques, cybernetics was born in the 1940s and constitutes an acceleration in the digitization process of our activities. Logic, algebra, recursion, iteration, network geometry, topology and geometrical-fractal on the one hand, and regulation, feedback, behavior, control, cognition, machines and artificial animals on the other, are all topics that animate scientific communities and that will constitute the vast field of information and communication sciences and techniques. It is in this fertile and transdisciplinary context that the term cybernetics was born. It

was proposed by Norbert Wiener (1894-1964) on the occasion of the publication of his book Cybernetics : or Control and Communication in the Animal and the Machine (Wiener, 1948). Cybernetics is concerned with the understanding of phenomena, both natural and artificial, and involves the study of communication and control processes in living beings and machines.

By the 1950s, Cybernetic was based on two distinct approaches (Cardon et al., 2018). The first is called Symbolic and is based on the development of expert systems, which seeks to reproduce specialized reasoning. Expert systems are programs designed to simulate decision making by a machine and based on explicit rules and symbolic representation of the world. The second approach, called Connexionist, implied probability and statistics and sought to achieve intelligence through learning. At the moment, Warren McCulloch (1898-1976), Walter Pitts (1923-1969) and later Franck Rosenblatt (1928-1971) worked on the Perceptron, which is considered to be the first artificial neuron. The machine learnt new skills by trial and error with the help of an artificial neural network, it is a classification algorithm that makes its prediction based on a mathematical regression function. If machine learning (ML) algorithms constitute the family of the artificial intelligence, some other processes are evolved.

Thus for instance, L-systems, shape grammar, cellular automata, evolutionary and genetic algorithms, all these mechanisms represent generative processes that have been the subject of researches in the field of architectural design for many years. The recent development of big data and the increase of the computing capacities has allowed the democratization of these techniques. Today, ML libraries and online AI systems are readily available to designers and are transforming the design processes and postures.

Recent developments

Several recent publications examine the creative potential (Campo & Leach, 2022; Leach, 2021) of AI, its risks and limitations. Sociopolitical and ethical issues are discussed (Crawford, 2021), as well as aesthetic implications for the cultural domain (Manovich, 2018; Manovich & Arielli, 2022).

Limiting our considerations to the initial design phase, we consider two distinct tooling strategies.

Online AI systems

For a few years and increasingly in recent months, several online AI systems have been available. They make AI easily accessible. Two kind of services are proposed. The first ones offer accessible interfaces and allow to easily generate representations and contents from an already learned model. Examples include text-to-image, text-to-video or image animation platforms[1] and the popular chatbot ChatGPT. The second is ML libraries accessible via APIs and hosted on powerful server farms. For example, Tensorflow is offered by Google and can be run online with google colab, or ML.net is offered by Microsoft. While these services involve coding, some

[1] Midjourney, Dall-e, Dream studio, RunwayML

nocode platforms[2] allow us to train models and use them in our own application. This workflow has been directly experimented in the architectural domain (Steinfeld et al., 2019). Finally some open-source Graphical User Interfaces allow us to locally interact and customize an AI model[3] with our own images collection.

ML directly accessible from the digital design environment (DDE)

Some ML libraries are available directly from the software used by the designer, they become plug-ins or stand-alone processes whose results are imported into the DDE. This promising avenue has been explored by Salamanca (Salamanca et al., 2023). The workflow begins with a parametric model, from which a data set is generated and evaluated; a variational autoencoders (VAE) is trained; then geometries are generated from the latent space and the solutions space is explored and visualized from the DDE. Other strategies focus, for example, on 3D models generation, through voxel discretization, using a machine learning Procedural Content Generation (PCGML) algorithm (Koh, 2022), or attempt to transform images generated by a GAN algorithm into 3D models, using inverse perspective techniques (Chando Kim & Huang, 2022).

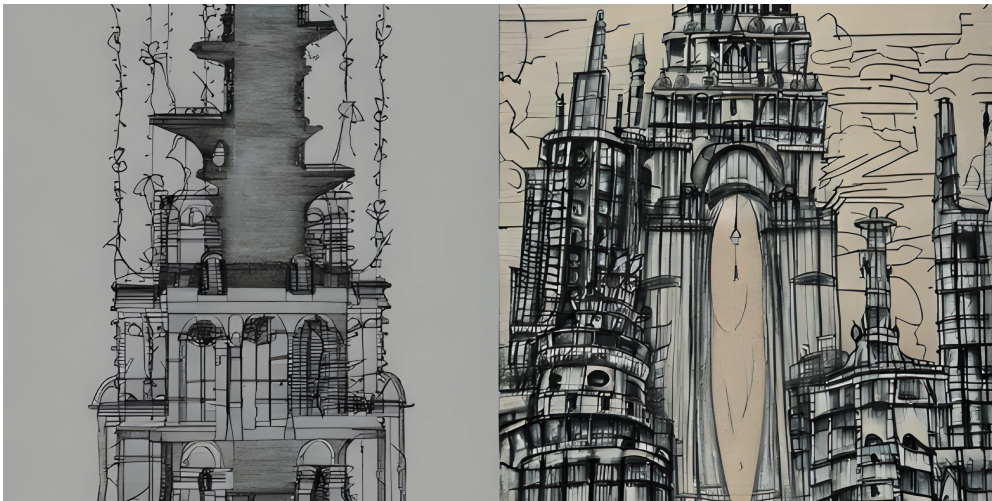## Introducing AI in the curiculum

Figure 1. Alexandre Martineau, Bachelor 3 : a drawing like tim burton with a tower like rem koolhaas

If the information about text2image techniques are known to a public of experts, it is only during the year 2020 that the applications accessible to the general public have made their appearance. Dall-e, Midjourney at first, then Stable Diffusion and many other variations allowed everyone to test and start to make an opinion. It is perhaps really with "Theatre d Opera Spatial" composed by Jason Allen with Midjourney that the power and the quality of the images that can be generated by artificial intelligence could be measured. This work, presented at the Colorado State Fair Fine Art Competition in August 2022, won first prize creating a wake of consternation but

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[2] Lobe.ai, Teachable Machine
[3] Stable diffusion and Automatic1111 for instance

also admiration. Allen never hid the fact that he had worked with Midjourney, artists cried out for the loss of their art, or more exactly of the market that could feed them, by soulless machines so cultural.
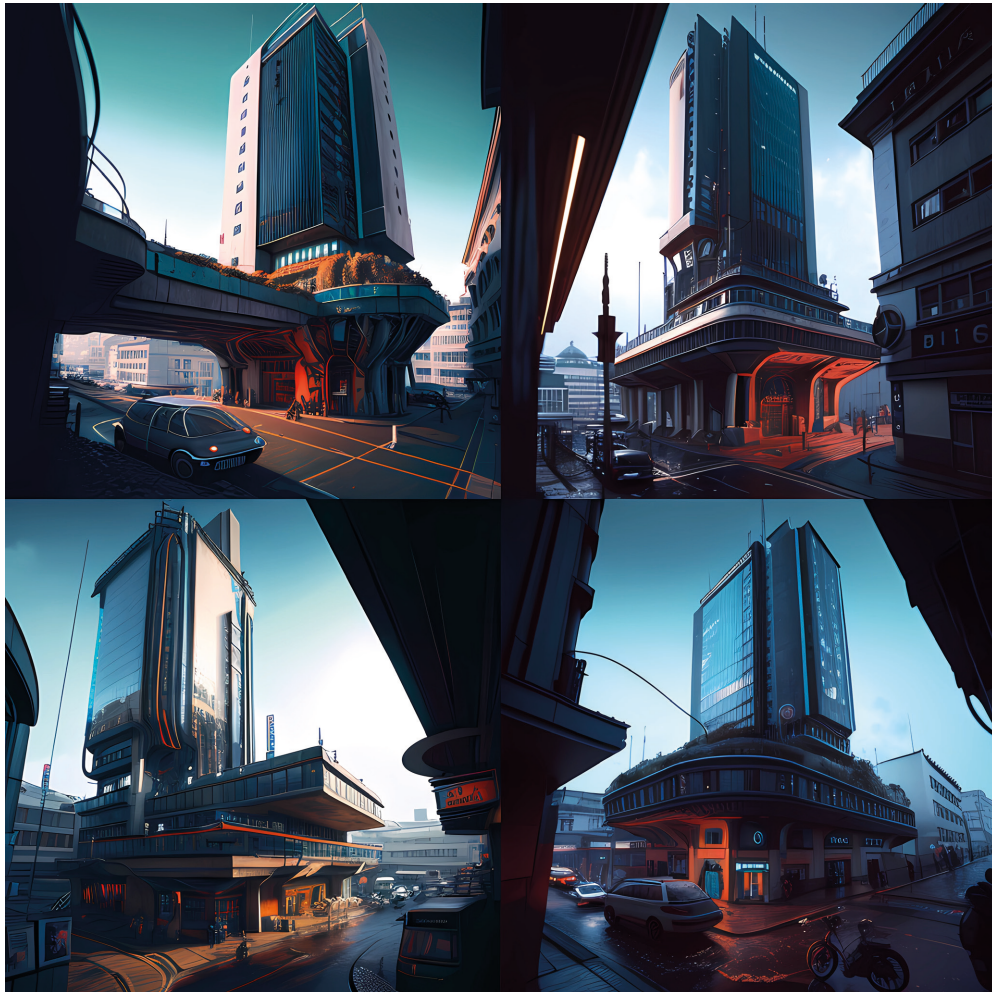

Figure 2. Ewen Cloirec, Master1, transfiguration os Nantes' iconic tower, prompt: Tour de Bretagne like cyberpunk city

The revolt of the artists and well a concern about their market, because, it is now understood that the quality of the artist does not depend on his talent to realize, but on his way of imagining the process of engendering. Big names such as Anish Kapoor or Richard Serra or many more, do not make their works themselves, they are made by competent technical teams. In the field of architecture, the question is more subtle. The image in the project is only an intermediate stage, it is not the result of the realization but what allows to make it emerge, to maintain the coherence of the proposal and finally to communicate the project. Since the advent of digital technology available on a large scale at the turn of the century, the architect's line is no longer a distinctive, identifying sign, as it once was with personalities such as Mies

Van der Rohe, Le Corbusier, Aldo Rossi or Sant Ellia for example. At the pedagogical level, the image is the proof of the research. It is the proof of the search for visual references and the proof of a graphic exploration of hypotheses. The first activity has been undermined by the evolution of the Internet. With an infinite number of images available, the construction of references, or the link between what one finds and the question one is developing, is already disrupted. It is not uncommon for teachers to receive a plethora of references that are not properly characterized. The graphic exploration then becomes problematic in and of itself. The lack of graphic solutions to represent such or such elements (a human, a tree, a piece of furniture) sometimes prevents doing so.

The possibility of creating convincing images very quickly with Dall-E or Midjourney would provide the opportunity to have both reference for inspiration and aesthetic solutions for developing projects. Rather than being faced with student productions that would risk hiding their origin on the side of Artificial Intelligence, we believe it would be more pedagogical to officially introduce this process as an additional conceptual tool available to future architects. For this purpose, specific courses are proposed with a progression protocol such as the one presented below.

The program is designed as a step-by-step process that starts with a basic prompt enabling the combination of two different worlds. For instance, one could create a dog niche in the style of Zaha Hadid. As the process continues, more complex definitions are introduced, drawing on references that can be stylistic, programmatic, or thematic. The final stage requires participants to specify their project, aligning the sketches they have already produced with the results generated by the AI.

Figure 3. Arpi Mangasaryan, Nantes flooded, eploratory work

The instructions are as follow.

You will use an AI engine to develop a project following the following criteria: Create a project in the style of a reference architecture, but with a twist. For example, a dog niche in the style of Zaha Hadid or the Tower of Babel in the style of Le Corbusier.

- *Create a contemporary urban scene that includes ecological challenges.*
- *Create a futuristic or retro-futuristic scene that may include flying cars or roads like in Metropolis, take the scene and make it comic book-style.*
- *Create a rural scene in the style of a known painter.*
- *Create a terrifying image referencing a known pictorial work or style (such as Zdzisław Beksiński or Hans Ruedi Giger).*
- *An architecture that combines two architectural styles or movements.*
- *An architecture that combines different types of materials referencing specific styles.*

An exploration of your project by showing what you have imagined and how you can reexamine them using AI.

Two platforms are recommended in this exercise :

- https://huggingface.co/spaces/stabilityai/stable-diffusion or/and https://www.photoroom.com/backgrounds

They are free, easy to access unlike Dall-E or Midjourney.

Figure 4. Noémie Brunet, master 1, mixing styles, prompt: Farnsworth house with modernisme and postmodernism

Results among several groups of students

Many surprising examples have been created by students along the recurring tests we've made along the semester. Understanding how to create a prompt was quick, but it took more time to develop prompts that effectively capture the ideas and expectations presented in the text. Students were able to complete the initial six questions and iterate through an average of 4 to 10 images in just a few hours. However, difficulties arose when attempting to recreate their projects through descriptive language. It was challenging for students to find the appropriate words, analogies, and references to accurately convey their project. It is clear that the challenge is not due to the limitations of text-to-image technology, but rather the students' ability to articulate their ideas effectively.

Figure 5. Marion Dolo, Master 2, a Doll House Gaudi Style

Figure 6 - Goullo Djenab Bah, Master 1, prompt: Futuristic city made out of bamboo and mud

Discussion

We are currently pondering over how the emergence of text-to-image platforms, and soon text-to-3D platforms, will impact the pedagogy in architecture. We have the option to disregard them as a mere byproduct, or we can proactively anticipate the changes they may bring.
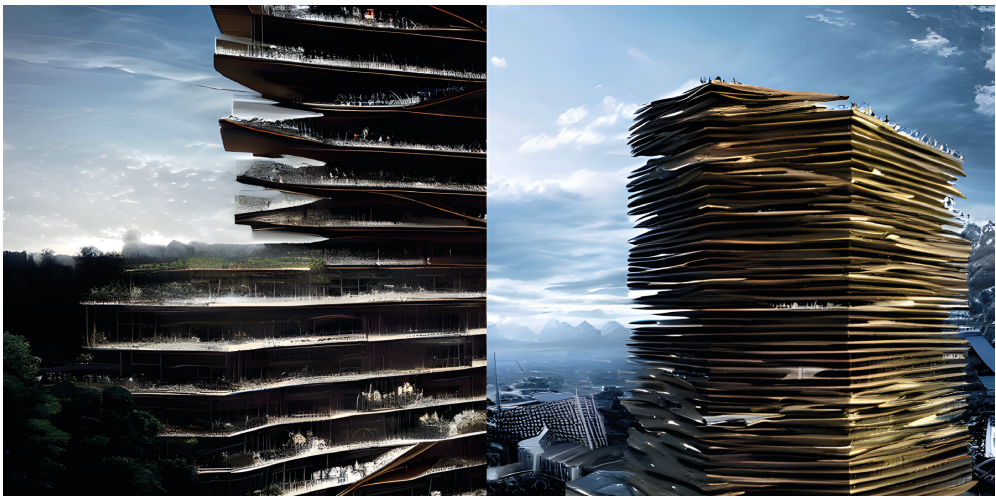

Figure 7. Margot Gesnoit master 2, Kengo Kuma meet Peter Zumthor to build the new and futuristic Babel Tower in an apocalyptic atmosphere

Following this, it has been interesting to see how ChatGPT, the other game changer, provides answers on the impact of Text2Image platforms for architects. The chat-machine has been a bit guided to generate a pro and con answer and therefore listed *improved engagement, time-saving, flexibility and accessibility.* It is noteworthy that the criticisms primarily revolve around the unreliability of the information. GhatGPT points out *Accuracy*, l*ack of creativity, over-reliance* and the *cost, some text2image AI tools may come with a cost, which can be a barrier to adoption for some educators.* When asking what expertise shall not be replaced by text2image AI tools, the chatbot enumerates *technical knowledge, communication skills and adaptability.* When comes the question of using AI in the curriculum, ChatGPT gives an ecumenical answer: *"It is important to note that the use of text2image AI tools should be integrated into the curriculum in a way that enhances students' learning and does not replace traditional forms of learning and visualization. Text2image AI tools should be used to supplement and enhance traditional forms of learning, rather than replace them entirely".*

In early 2023, we saw an increasing number of platforms emerging, such as Dall-e2, Stable Diffusion, and Mid Journey, which have become some of the most popular ones. Additionally, there are other platforms such as Leonardo, NightCafé, Maze Guru, Deep Dream Generator, DeepAI, ArtBreeder, and Patterned, which are also gaining attention among users. Many students are concerned and repeatedly ask whether AI will replace them. This is a question that arises with every technological advancement and is not limited to those in the field of architecture. However, it is not people who are at risk, but rather certain tasks that they perform, especially those that do not add any significant value. This means that expertise will need to shift towards the two ends of production - focusing on input data and evaluating the output data. Experts will need to determine what is necessary to address a particular problem and qualify the responses obtained.

1_ Usine de voiture   2_ Usine de voiture   3_ Usine de voiture

1_ Station essence   2_ Station essence   3_ Station essence

Figure 8 - Loïs Gorin, Master1, explorations with Gaudi's style

Conclusion

Figure 9. Trying to design a Le Corbusier's style project : prompt : designing a villa in Le Corbusier style architecture using the 5 points of modernity and mimicking villa Savoy

One of the main challenges that students face is effectively describing their architecture projects in precise and evocative language, in order to ensure that the AI-generated proposals accurately reflect their creative vision. Should they begin by outlining the style, proportions, environment, or instead focus on the finer structural or aesthetic details, or take a more metaphorical approach? To address this issue, an experiment was conducted that tasked students with designing an alternative history project in the style of Le Corbusier, specifically a villa that adheres to the five principles of modern architecture. Numerous attempts were made, but the results were quite disappointing as they fell short of incorporating the elements of modernity. Ultimately, ChatGPT was tasked with creating the prompt, which it did by incorporating the key characteristics of the modernist movement: The working prompt gives:

Create a realistic image of a villa in the style of Le Corbusier, a famous Swiss-French architect known for his modernist designs. The villa should be two stories tall and have a flat roof with a terrace. The facade should be made of reinforced concrete and incorporate large windows with steel frames. Incorporate elements from Le Corbusier's style, such as: Pilotis: Use columns or pilotis to lift the house off the ground, creating an open space beneath the house. Free plan: Create an open interior with a free-flowing floor plan, which allows for flexibility in how the space is used. Ribbon windows: Use continuous horizontal bands of windows, providing ample light and an unobstructed view of the outside. Roof terrace: Incorporate a flat roof with a terrace that provides an outdoor space for relaxation or entertaining. White color: Use white paint on the facade to reflect sunlight and create a clean, modern aesthetic. Functionalism: Emphasize functionality in the design, with a focus on providing a comfortable living space with minimal ornamentation. Overall, the villa should showcase Le Corbusier's signature style of modernism, with a focus on functionality, open space, and natural light.

Over the past few decades, the digitization of architectural plans and the subsequent adoption of BIM, have brought significant changes to the daily workings of architectural agencies. With the introduction of AI, a new phase of transformation has emerged, but this development is not comparable to previous ones. Unlike previous digital tools, AI does not merely modify or enhance existing production methods but has the potential to revolutionize the very modes of creation themselves. Therefore, we are prompted to engage in a more complex and nuanced reflection on the potential consequences of AI's implementation.

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