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ISSN (Print: 2537-0154, online: 2537-0162)

Proceedings of the Academic Research Community on Social and Behavioral Sciences

Research Paper

Received: 13 September 2025, Accepted: 03 December 2025, Published online: 31 January 2026

**DOI: 10.21625/archive-sr.v10i1.1239**

# Beyond the Human: Exploring AI Creativity through the Works of Daniel Bolojan Studio and Coop Himmelb(l)au.

**KAMOUN Sami**[1]

[1] *Assistant Professor at the Higher School of Science and Technology of Design (TUNISIA).*

## Abstract

Context: This study examines the co-creativity between human and non-human agents that influences certain contemporary architectural and artistic trends. It focuses on two significant works generated through artificial intelligence programs: *Machine Perceptions: Gaudi + Neural Networks*, designed by Daniel Bolojan Studio in 2018, and *Deep Himmelb(l)au*, developed by the Coop Himmelb(l)au agency in 2019.

Method: The research is based on an in-depth scientific review of these two projects as well as on the use of artificial intelligence - particularly deep learning techniques - in design and architecture. It also integrates a visual analysis relying on photographic and videographic material drawn from key conferences.

Results: *Machine Perceptions: Gaudi + Neural Networks* seeks to develop a prototype AI algorithm capable of recognizing and reinterpreting geometric and aesthetic compositional principles inspired by Antonio Gaudí's Sagrada Família. By contrast, *Deep Himmelb(l)au* explores the acceleration of Coop Himmelb(l)au's architectural design process through the use of a generative program capable of autonomous and continuous reinterpretations inspired by the agency's projects.

Conclusions: Both projects, grounded in the training of digitized image banks, go beyond the capacities of conventional text-based artificial intelligence programs such as *DALL-E* or *Midjourney*. The work of Bolojan and Vermisso, based on CycleGANs, produces a two-dimensional "hallucination" of architectural space, whereas Coop Himmelb(l)au exploits a diversity of collaborative neural networks to engage with the third dimension. Although still emerging, these initiatives demonstrate the potential of artificial intelligence to open new creative frontiers that transcend the artist's creation.



***Keywords***

*Artificial intelligence, Deep Learning, Generative adversarial networks, Architectural space, Aesthetics*

## 1. Introduction

Our contribution to creation beyond the human focuses on artificial intelligence in architecture, conceived as a non-human form of collaboration with human creativity. The adverb *beyond*, as defined in dictionaries, evokes notions of surpassing and transcending, thereby intensifying, in our context, the concept of "human creation." The notion of "beyond the human" can be understood as synonymous with the post-human - that is, what follows the human: an imperfect human being potentially enhanced through biotechnology, thereby challenging the very boundaries and dialectical interplay between human and machine. It may also signify a new form of humanity, renegotiating its condition and traditions - a kind of "decentering of the human" (Delaporte, 2021) - without necessarily implying its exclusion or relativization.

Moreover, the notion of "beyond the human" can also be understood as the transhuman, that is, a being in transition seeking to transcend its human condition, less radical than the post-human yet still in pursuit of evolution. It also represents "a kind of bridge between the human and the post-human" (Goffi, 2017). While humanism engages us in an anthropocentric philosophy, post-humanism and transhumanism lead us into an anthropotechnological and fictional thought, a kind of "neo-," "supra-," "super-," "hyper-," "over-," "extra-," or "quasi-" humans-imaginary beings that alter the image of the natural human and experiment with the boundaries delineating the human and the non-human. Beyond the human thus manifests itself through a variety of technophile avatars, such as mutants, cyborgs (cybernetic organisms), androids, clones, organorgs (tool-equipped organisms), robots, or even zombies, as demonstrated in Thierry Hoquet's typological essay (Hoquet, 2021).

In the domain of art, *beyond the human* intersects with science-fictional themes, evoking a utopia of change and questioning the limits of the human and its biological body. For example, the performances of the Australian artist Stelarc illustrate this. In 1976, he suspended himself from hooks piercing his skin in a performance lasting between 12 and 32 minutes. In 1993, he projected onto a screen sounds and images captured by a robot placed inside his body. In 2006, he surgically implanted an ear on his own arm through cell growth. Another significant example is the disfiguration and refiguration of the face through implants, experimented with by the French artist Orlan, aimed at deconstructing norms of female beauty. One can also mention *Genesis* by Eduardo Kac (1999), in which the artist creates a synthetic gene granting humans a form of transgenic supremacy, as well as *May the Horse Live in Me*, where Marion Laval-Jeantet publicly injects herself with horse immunoglobulin, reinterpreting the concept of liminality. Yet another example of creation beyond the human can be found in Guy Ben-Ary's work *CellF* (2015), in which a neural network derived from a skin biopsy produces a form of cybernetic and post-human music via analog synthesizers.

Works generated by artificial intelligence programs, as particular artistic expressions transcending human creation, have now established a significant place in both the fields of art and architecture. Artificial intelligence was first introduced in cinema during the 1930s, and later formalized as a scientific discipline in the mid-1950s. Originally, it was defined as "the science and engineering of making intelligent machines, capable of performing actions that would normally require human reasoning" (McCarthy, 1956). Since then, numerous similar definitions, emphasizing the distinction between human and machine intelligence, have been proposed. Although these definitions are not always consensual, they generally acknowledge that creativity—a notion at the core of our research—remains fundamentally human. According to Farzaneh and Pitrone (2024), "AI is creative if and only if humans provide it with the necessary data, algorithms, and objectives, and if they know how to interpret the results produced by the AI and take the actions those results suggest." In this regard, the creativity specific to artificial intelligence may be described, according to Boden (2021), as "combinational," "exploratory," and "transformational." However, as Latour (1999) notes, it is "neither a property of humans, nor of non-humans, nor even of God." Unaware of the aesthetic value of its productions and of the emotions associated with them, artificial intelligence creation thus differs from the human creative process, which passes through visual perception before being translated into the gesture of the hand.

The paternity of artificial intelligence is attributed to the British mathematician and logician Alan Turing for his famous Turing Test, described in an article entitled *Computing Machinery and Intelligence* in 1950. In this experiment, a human blindly communicated with another human and a machine, whose responses had to be appropriate, intelligent, and sensitive enough to convince the interlocutor that they were of natural origin. A few years later, in 1956, the term "artificial intelligence" was proposed for the first time during a seminar on "thinking machines" organized by mathematicians at Dartmouth College in New Hampshire. That same year, the Logic Theorist computer program developed by Allen Newell and Herbert Simon was able to prove 38 of the 52 mathematical theorems published in Whitehead and Russell's *Principia Mathematica*.

In 1958, Herbert Simon, one of the pioneers of artificial intelligence, predicted that within ten years, machines would become world chess champions. Although this prediction only materialized forty years later, in 1997, when IBM's supercomputer *Deep Blue* defeated world champion Garry Kasparov, it is noteworthy that the first automaton capable of playing and winning chess games dates back to 1914. Kasparov's defeat marked a turning point in the collective perception of human intelligence in relation to machines and of the limits of the latter (Kasparov, 2017: 248). By 2012, deep neural networks—algorithms capable of accurately predicting the behavior of a process based on its determining factors—won the *ImageNet* challenge, an international image recognition competition. A few years later, in 2016, the *AlphaGo* algorithm triumphed over Korean master Lee Sedol in the game of Go. Since then, other Go champions as well as numerous players of similar video games have been defeated by artificial intelligence endowed with unmatched endurance.

Although still in its beginnings, the art world has also been profoundly affected by the upheavals induced by artificial intelligence. The results achieved thus far are promising, even fascinating, far surpassing our human imagination. For example, *Paul the Robot*, a portrait-drawing machine created in 2011 by French artist Patrick Tresset as part of his PhD, automatically produces whimsical drawings with artistic value, bearing a certain resemblance to Jean Tinguely's sculptures. We may also cite *Adversarially Evolved Hallucinations* by Trevor Paglen, in which a series of images related to themes such as magic, demonism, or divination present, through artificial intelligence, curious, surreal representations. Similarly, the *Artificial Intelligence Creative Adversarial Network* created at SCOPE Miami Beach in 2018 is a technology based on machine learning, which, by drawing on hundreds of thousands of sampled images from art history, creates ultra-contemporary paintings inspired by past styles while proposing legitimate aesthetic research.

Other significant projects involving machine learning as a specific form of artificial intelligence include *Portrait of Edmond de Belamy,* created by the Paris-based collective Obvious in 2018. Trained on tens of thousands of paintings from various periods of art history using a Generative Adversarial Network (GAN), this work presents a stylistic amalgam often compared to the paintings of Francis Bacon. The same GAN technology was used in *Neural Zoo* by Sofia Crespo, also created in 2018, combining elements of the microscopic biological world. Another notable example is *Memories of Passersby I* by Mario Klingemann, an installation involving two generative screens based on 17th- to 19th-century portrait photography and producing uncanny images. Likewise, *UUmwelt* by Pierre Huyghe, exhibited at London's Serpentine Gallery in 2018, in which curious images were generated from data scanning the brain activity of a subject. Such works based on artificial intelligence, particularly on neural networks, have now given rise to a current referred to in Anglophone circles as *"GANism."*

Architecture, like art, has joined the growing list of fields explored by artificial intelligence. Examples of co-creation between AI and architecture are multiplying, attesting to a novel dialogue between technological innovation and human creativity. Among these examples is the *Daedalus Pavilion* by Ai Build, a 3D-printed architectural installation constructed by robots programmed with artificial intelligence. This project was presented at NVIDIA's GPU Technology Conference in Amsterdam in 2016, illustrating the ability of machines to produce complex structures with remarkable precision. Other initiatives, such as *Spacemaker AI* and *XKool Technology*, also launched in 2016, position themselves as "invisible assistants" (Leach, 2021: 120), intended to support rather than replace architects. These tools enhance the design of spaces by optimizing various parameters such as spatial use, light exposure, and circulation. Moreover, the *Agent-Based Parametric Semiology* developed by Daniel Bolojan and Patrik Schumacher in 2017 extends this approach by combining GANs and multi-agent simulations inspired by life processes to explore potential interactions between the spatial organization of hypothetical architectures and the social behaviors they may generate. Also in 2017, the immersive installation *Archive Dreaming* by Refik Anadol Studio allowed visitors to navigate millions of digitized archival documents via three-dimensional graphic interfaces, offering a new way of revisiting the narratives, memories, and cultures of Istanbul. In 2019, the project *Machine Perceptions: Gaudí + Neural Networks* ingeniously combined images of *La Sagrada Família* with natural forest landscapes, creating unimaginable visual hallucinations. From another angle, *Deep Himmelb(l)*au aims to accelerate the architectural design process by leveraging images of past projects by *Coop Himmelb(l)au*.

In 2019, Refik Anadol Studio, a pioneer of digital art, pursued its exploration of artificial intelligence's potential with the project *Machine Hallucination: NYC*. This project is based on the analysis of vast datasets of photographs from social networks, transformed by machine-learning algorithms to offer a unique, immersive visualization of New York

City. That same year, another major project emerged: the Master's thesis of Tanislas Chaillou, entitled *ArchiGAN*, defended at the Harvard Graduate School of Design. This work proposes an algorithmic model capable of generating different spatial arrangements for entire apartment floor plans. Also in 2019, at the Bi-City Biennale of Urbanism and Architecture, the neural network *AI-chitect* was presented. This program enables schematic sketches to be transformed into standardized architectural drawings. Finally, at the intersection of design and social critique, *Can the Subaltern Speak?* by Behnaz Farahi interrogates the external threats faced by Iranian women. This conceptual project, also produced in 2019, features a mask adorned with 18 pairs of eyes, equipped with artificial intelligence capable of producing its own language in Morse code. This work establishes an unprecedented dialogue between technological prowess and social redemption.

## 2. Materials and Methods

In this research, we focus on two significant works: *Machine Perceptions: Gaudi + Neural Networks*, designed by Daniel Bolojan and Emanouille Vermisso in 2018, and *Deep Himmelb(l)*au, developed by the architectural firm Coop Himmelb(l)au in collaboration with Daniel Bolojan, Efilena Baseta, and Karolin Schimidbaur in 2019. Our methodological approach is based on a cross-referenced and critical analysis of these two projects, exploring their aesthetic and technological dimensions, with particular attention to the implications of artificial intelligence—and more specifically deep learning—in architectural and artistic creation. This methodology follows a qualitative and descriptive framework, structured around several axes. First, a graphic analysis through a detailed examination of the generated images and 3D simulations derived from the works. Second, a descriptive study, based on the exploration and interpretation of spatial and aesthetic readings drawn from official sources. Finally, a videographic analysis, developed through the extrapolation of video recordings from freely accessible international conferences, documents the design processes, simulation stages, and the creative intentions of the designers.

Our methodology, therefore, aims to produce a critical synthesis articulating the aesthetic, architectural, and technological perspectives of the works under study, while raising a series of questions: How does non-human creativity manifest itself in these projects? What role does artificial intelligence, particularly deep learning, play in the architectural and artistic design process? What kinds of spatiality, aesthetics, and works emerge from these computational programs? What could be the future of architecture as a discipline? What lessons can be drawn from these experiments, and what perspectives do they open up? What challenges, impacts, and risks accompany this co-creation between humans and AI?

## 3. Results

### 3.1. *Machine Perceptions: Gaudi + Neural Networks* by Daniel Bolojan

Daniel Bolojan, the principal designer of our case study, is the founder of *Nonstandardstudio*, an agency specializing in the application of artificial intelligence to architecture, established in 2013 and based in the United States. The agency explores, in particular, deep learning techniques and their uses in architectural design. This approach to artificial intelligence, whose origins date back to the 1940s, achieved significant progress during the 1980s before experiencing a spectacular breakthrough from 2010 onwards (Ganascia, 2025). Trained as an architect, Bolojan graduated in 2008 from the Ion Mincu University of Architecture and Urbanism in Bucharest, Romania. He also obtained a design degree in 2014 from the University of Applied Arts in Vienna, where he is currently pursuing a PhD in architecture. He subsequently worked at internationally renowned firms such as Coop Himmelb(l)au and Zaha Hadid Architects, contributing to various avant-garde projects. In parallel, he has taught workshops and seminars at the Institute of Structure and Design of the University of Innsbruck (Austria), as well as at the School of Architecture at Florida Atlantic University (United States). His research focuses on the potential of artificial intelligence to enhance human creativity in the built environment, particularly in the fields of architecture and design.

Among his notable works are *Machine Perceptions: Gaudí + Neural Networks* and *Deep Learning Sagrada Familia*, carried out between 2018 and 2019. In these projects, Bolojan developed neural prototypes based on generative adversarial networks (GANs), capable of analyzing the aesthetic and semantic principles of Antonio Gaudí's works and generating new reinterpretations. In 2019, he also contributed to *Deep Himmelb(l)au*, a project undertaken within the Coop Himmelb(l)au office, which sought to accelerate the design process through a generative program inspired by the firm's previous projects.

Emmanouil Vermisso, the second contributor to our case study, is an Associate Professor of Architecture at Florida Atlantic University, while simultaneously pursuing a PhD at the University of Patras in Greece. Vermisso studied architecture at the University of Westminster in the United Kingdom and Syracuse University in the United States. He also worked at internationally renowned firms such as Foster+Partners. His current research focuses on artificial intelligence in design, with the aim of better understanding the creative and cognitive processes of the architect. Some of his works have been awarded and published in specialized journals such as the *International Journal of Architectural Computing*, receiving recognition from notable organizations, including the Association for Computer Aided Design in Architecture (ACADIA), Education and Research in Computer Aided Architectural Design in Europe (eCAADe) in 2007 and 2008, Computer-Aided Architectural Design Futures (CAAD Futures) in 2011, and the Sociedad Iberoamericana de Gráfica Digital (SiGRADi) in 2019.

*Machine Perceptions: Gaudí + Neural Networks* (Figure 1) is a study that explores the possibilities of generative design using artificial intelligence to learn, at different scales of reading, the aesthetic characteristics of Antonio Gaudí's work. This project relies on neural networks to analyze and interpret photographs of the interior of *La Sagrada Família*, as well as video sequences captured during a walk in a nearby forest (Figure 2). *La Sagrada Família*, Gaudí's most significant and complex work, embodies the genius of this visionary architect of Catalan Modernismo, who combined the skills of sculptor, painter, blacksmith, and mathematician. In this study, Daniel Bolojan and Emmanouil Vermisso sought to explore the collective perception of visitors in relation to this iconic building. Their objective was to generate a "hallucinated" space, founded on alternative realities derived from subjective and unconscious interpretations of these perceptions (Bolojan & Vermisso, 2020: 100). *La Sagrada Família* was chosen as a case study because of its exceptional spatial complexity. This complexity is expressed in the ambiguity of tectonic distinctions between its various components, blurring the boundaries between architectural elements (ibid.).


Figure 1: Image depicting the beginning of the animation of *Machine Perceptions: Gaudi + Neural Networks.* Bottom,

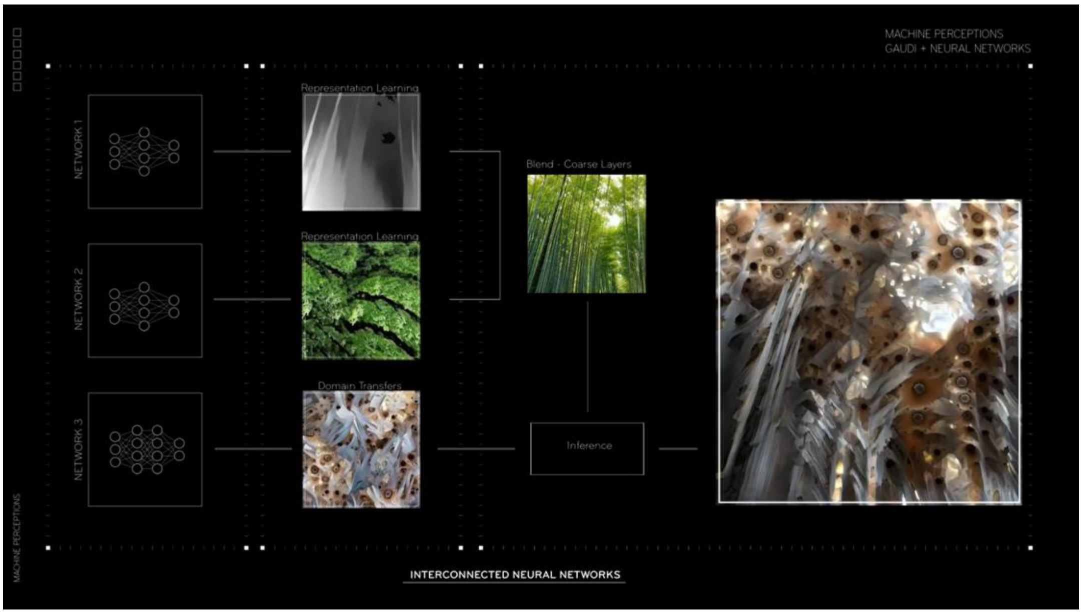


Figure 2: Image illustrating the interconnection of neural networks, combining interior views of the central nave of *La Sagrada Família* with forest images taken near the monument.

Initially conceived as an “expiatory temple” dedicated to the Holy Family, *La Sagrada Familia* has since become an emblematic basilica and an indispensable monument of the Barcelona landscape. Since 2005, its crypt has been inscribed on the UNESCO World Heritage List. Although still unfinished, the monument inherits its Gothic floor plan from the project originally designed in 1882 by the architect Francisco de Paula del Villar. Antonio Gaudí took over the construction two years later and remained in charge until his tragic death in 1926. To date, only the Nativity facade, one tower, and part of the apse wall have been completed. Despite the destruction of the architect’s workshop by fire and acts of vandalism during the Spanish Civil War in the 1930s, construction has continued to this day, testifying to the remarkable commitment to completing this architectural masterpiece. Built with millimetric precision, the building is scheduled for completion in 2026, coinciding with the centenary of Gaudí’s death.

Although its construction began more than a century ago, the unfinished work of *La Sagrada Família* underscores the necessity of advanced digital technologies to interpret and understand Antonio Gaudí’s conceptual vision (Makert & Alves, 2016). Gaudí left behind neither a clear architectural theory nor defined axioms, but rather a set of spatial reflections. When asked whether *La Sagrada Família* followed in the tradition of the great cathedrals, he replied: “No, it is the first of an entirely new series” (Zerbst, 1999). Indeed, Gaudí approached space in a resolutely organic manner. He conceived the structure by drawing direct inspiration from vegetal forms and developed an abstract, fluid architectural language, blending parabolas, hyperbolas, helicoids, conoids, and ruled surfaces - complex forms requiring colossal mathematical calculations. To achieve this, he handcrafted numerous prototypes, both in miniature and full scale. In *La Sagrada Família*, particularly in the main nave, towering tree-like columns rising harmoniously toward the sky emerge as the dominant formal figure. Gaudí summarized this intention by stating: “It will be like a forest of trees” (Curti, 2020). In this stylized forest, “we are confronted with the joy of life, flora, fauna,” observes Judith Urbano (Urbano, 2023). Gaudí also enriched the design with abundant ornamentation populated by figurines of birds, wild animals, and sacred characters. The result is a masterpiece where nature and the sacred fuse into a visionary architecture - at once neo-Gothic and retrofuturistic.

Often described as a “Bible in stone” (ibid.), *La Sagrada Família* draws inspiration from Gothic, Moorish, and Catalan vernacular influences. Nicknamed by Gaudí as the “cathedral of the poor,” it was conceived as a place of worship for the workers of Barcelona. The building adopts a basilical plan, symbolizing the cross of Christ. Gaudí designed it as a basilica with five longitudinal naves and a transept composed of three naves, forming a Latin cross. It is encircled by a rectangular cloister and twelve peripheral towers representing the apostles. In addition, six central towers are planned, one dedicated to Christ and another to the Virgin Mary. The choir is completed with an apse and bordered by an ambulatory. The altar is surrounded from the outset by seven radiating chapels, each dedicated to the sorrows and joys of Saint Joseph. In his architectural conception, Gaudí proposed a symbolic reading of the mystical body of Christ (Zerbst, 1999). Each façade illustrates a major stage in the life of Jesus: the Nativity façade, facing east and constructed between 1883 and 1926, celebrates his birth; the Passion façade, to the west, erected between 1954 and 1977, evokes his suffering and passion; and finally, the Glory façade, still under construction, symbolizes the resurrection and eternal life.

*Machine Perceptions: Gaudí + Neural Networks* is an architectural creation beyond the human, insofar as much of the creativity emerges from an alternative approach to human authorship. The work is based on an artificial intelligence program applied to an architectural corpus, particularly that of *La Sagrada Familia,* and enriched by advanced digital technologies. The creativity of the AI is revealed through a process of “machinic hallucination,” whereby hybrid images are generated from a vast database of digitized visuals. The outcome takes the form of an immersive animation, offering a novel aesthetic that merges Antoni Gaudí’s organic naturalism with the algorithmic inventiveness of an AI capable of transcending the boundaries of human creation. Within this framework, *Machine Perceptions: Gaudi + Neural Networks* was developed during a workshop entitled *Gaudi's Hallucinations*, organized as part of the eCAADe-SIGraDi 2019 conference in Porto. This two-day workshop explored the role of architecture in the era of the Fourth Industrial Revolution through more than two hundred presentations and workshops, the results of which were published in the proceedings. During the event, nearly three thousand images of Gaudí’s works were processed using a generative adversarial network of the *CycleGAN* type, an artificial intelligence technique that enabled the production of novel spatial and aesthetic visualizations of *La Sagrada Familia*. Unlike popular programs such as *DALL-E*, *MidJourney*, or Stable Diffusion, which generate images from textual prompts, this AI technique relies on training a visual corpus directly introduced into the machine, thus opening the way to radically new spatial and aesthetic reinterpretations.

*Machine Perceptions: Gaudí + Neural Networks* was published online as a video of approximately two and a half minutes (video 1). Online on June 11, 2021, on the Vimeo platform, it was presented at the 17th Venice Architecture Biennale as a demonstration of the *Gaudi's Hallucinations* workshop. The video opens with a quotation from Jacques Derrida, taken from his book *The Truth in Painting*, which interrogates the notion of perception (Derrida, 2010). From the fifteenth second onward, hallucinatory high-resolution images appear, depicting dreamlike manifestations of the nave of the building. These representations are derived from a corpus of nearly 500,000 photographs, processed and trained within the latent space of the AI program - a kind of “computational mind” (Oktan, 2024).

At the twenty-third second of the video, a second grid of images appears, representing the main nave of the monument - what Bolojan and Vermisso refer to as a “feature map” (Figure 3). This grid undergoes a topographic transformation generated pixel by pixel. At the twenty-ninth second, metamorphosis effects unfold within the latent space, exploring the infinite possibilities of the algorithm (Figure 4). By the forty-third second, the process of deep learning is illustrated. This process superimposes and blends, layer by layer, a low-angle photograph of the building’s interior with an image of trees photographed at a similar angle in a nearby forest (Figure 5).

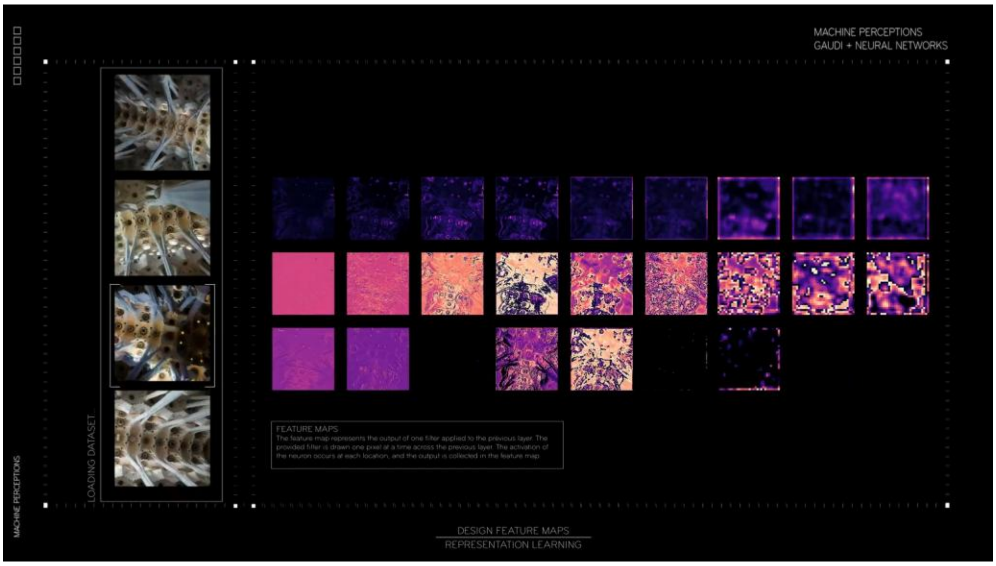


Figure 3: Feature map of *Machine Perceptions: Gaudí + Neural Networks.*

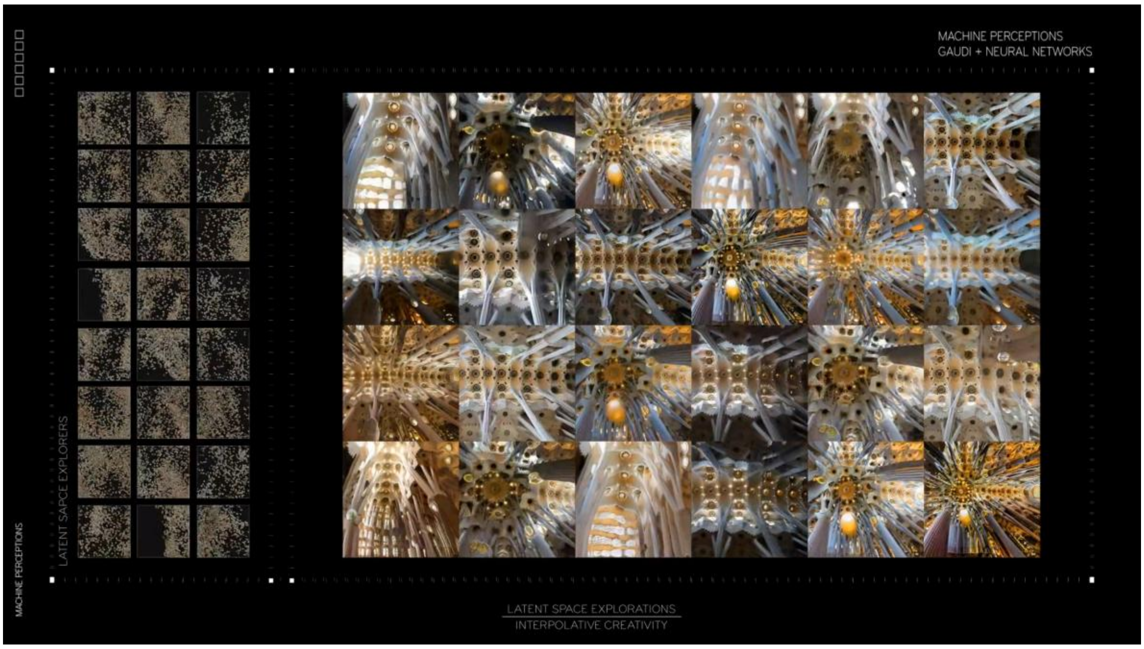


Figure 4: Illustration of the image training process through deep learning.

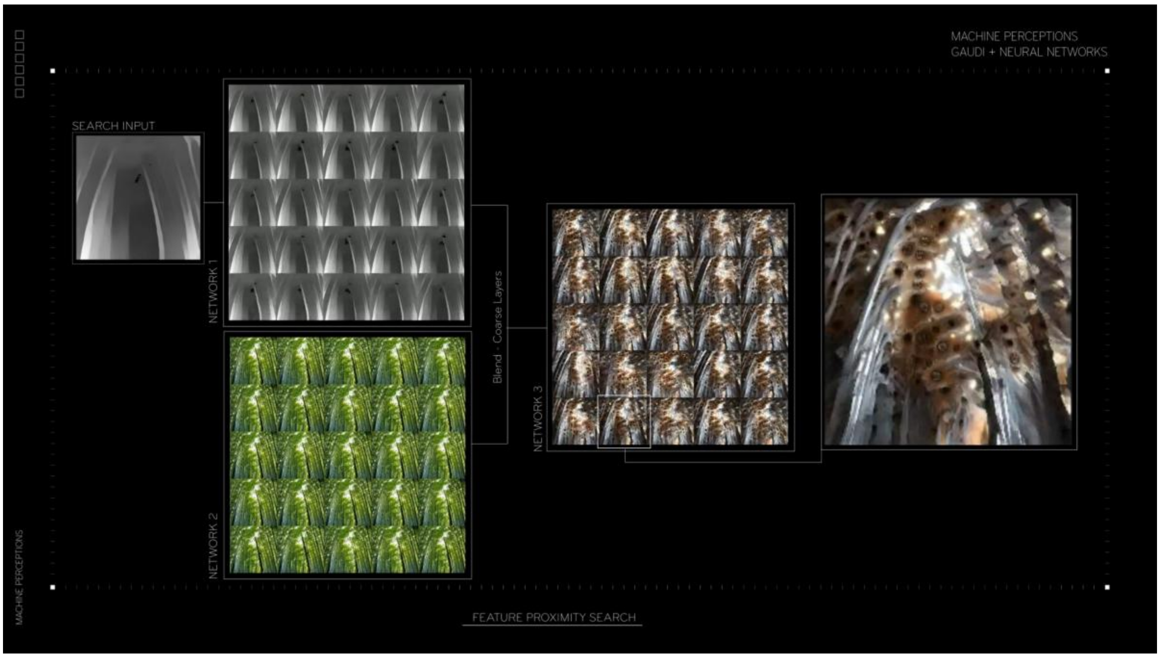


Figure 5: Demonstration of deep learning using the Coherent Generative Adversarial Networks (CycleGAN) technique to blend interior images of La Sagrada Família with those of trees from a nearby forest.

By the end of the first minute, the outcome of this spectacular data training is revealed: AI-generated images presenting an alternative and fascinating vision of the interior space of *La Sagrada Família* (Figure 6). What is perceived oscillates between different sensitive impressions: at times a staged mummified skull evoking death and resurrection; at times a fragment of mountainous rock finely chiseled by a natural hand; at times again a marine sponge, revealing and concealing itself with the rhythm of a tide. These atypical visions animate twenty seconds later, establishing a dreamlike and hallucinatory atmosphere—between optical illusion, echoing Gaudí's aesthetic, and immersion in the depths of an organic world of remarkable plastic power. Finally, at the beginning of the second minute, a concluding note drafted by the designers appears, outlining both the advantages and the challenges related to the confrontation between human perception and that of an emergent GAN algorithm.

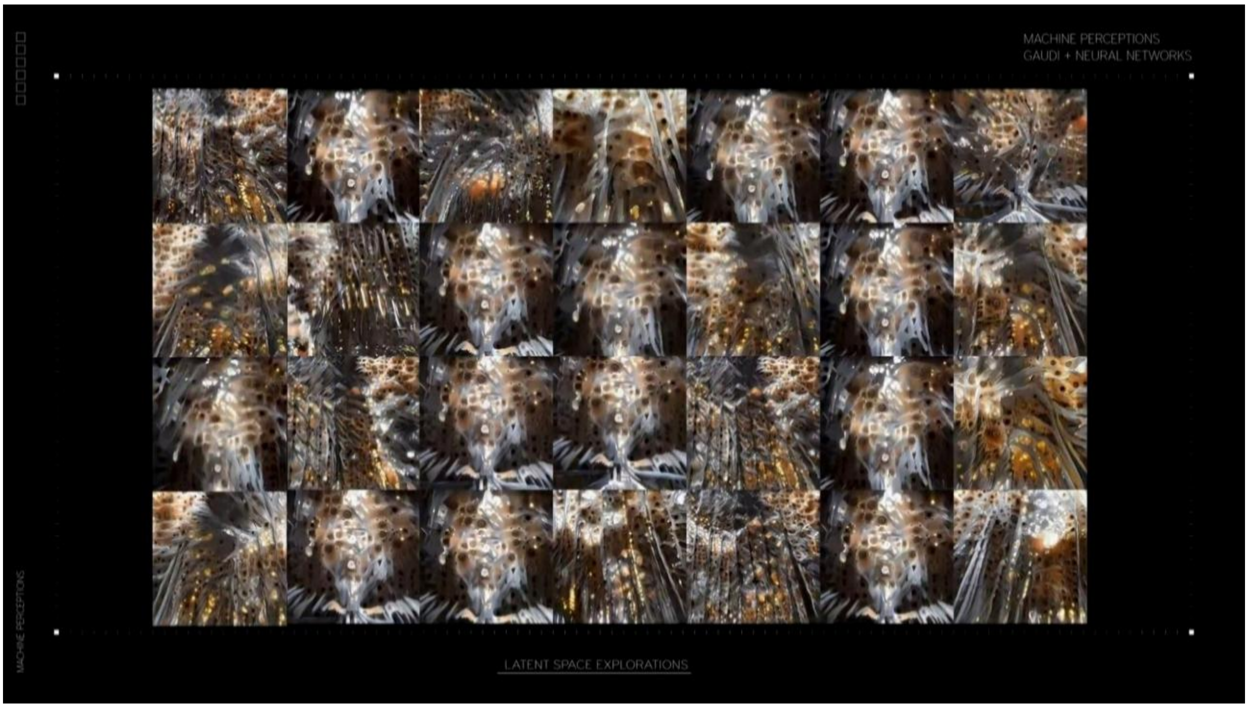


Figure 6: Images generated as part of the *work Machine Perceptions: Gaudí + Neural Networks*.

Generative Adversarial Networks (GANs) constitute the deep learning technique widely used in the project by Bolojan and Vermisso. Developed in 2014 by Ian Goodfellow and his collaborators, GANs are based on the competitive interaction between two artificial neural networks: a generator and a discriminator (Ganascia, 2025). The two networks confront each other in a contest where the first generates a sample from a database trained within the latent space of the AI program, while the second attempts to identify it as real or artificial. In other words, the generator seeks to deceive the discriminator, while the latter evaluates the credibility of the generated data. This process results in “hyper-fabricated” data of often astonishing creative quality. The ultimate goal of this interaction is to reach a “Nash equilibrium,” that is, a situation where the strategies of both networks are optimized such that neither can improve its performance. This equilibrium, however, is difficult to achieve due to the complexity of interactions between the two networks (Goodfellow et al., 2016).

Generative Adversarial Networks have given rise to several variants, among which the *CycleGAN*, employed by Bolojan and Vermisso in their project. *CycleGANs*, short for Cycle-Consistent Generative Adversarial Networks, were developed to transform preexisting images or to generate new ones that are photorealistic, hybrid, or entirely abstract (Figure 7). In the work *Machine Perceptions: Gaudí + Neural Networks*, Bolojan and Vermisso train their model using real images of the Barcelona forest and photographs taken inside *La Sagrada Família*, thus enabling the discriminator to reliably assess whether or not an image corresponds to the interior of the monument’s central nave. To achieve this, they used metrics such as the Structural Similarity Index Measure (SSIM), as well as very deep convolutional networks (VGG network). The generator then created new images based on these inputs, which were subsequently submitted to the discriminator for categorization. Through this iterative corrective process, the generator progressively refined its image transformation until most of the generated images were validated by the discriminator.

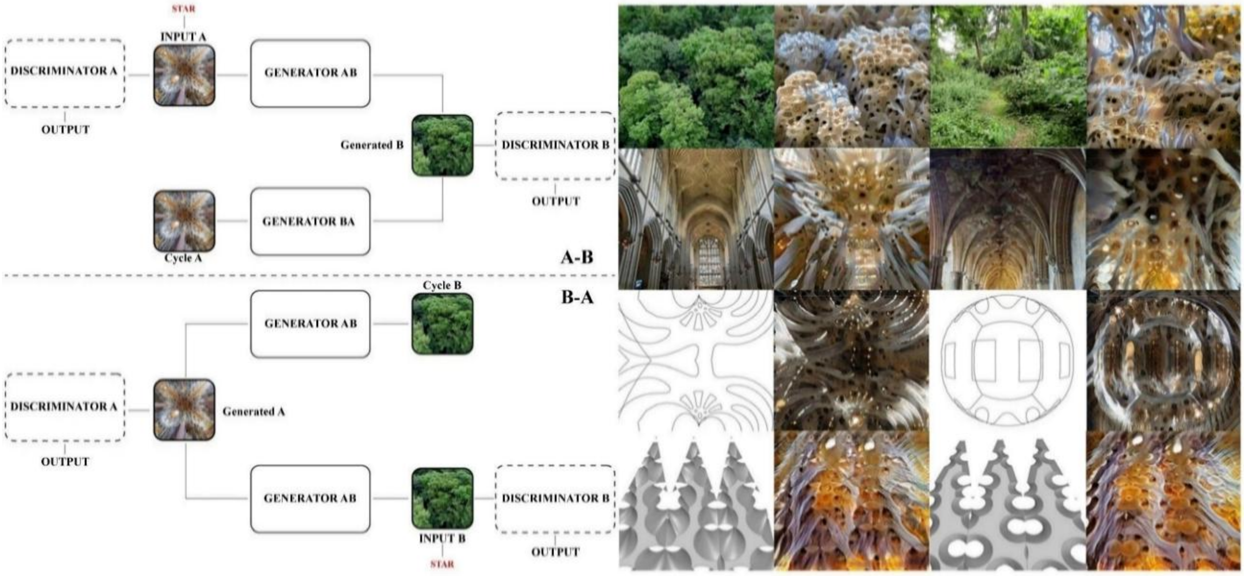


**Figure 7:** Operating principle of a *CycleGAN* in the work *Machine Perceptions: Gaudi + Neural Networks*. The network must demonstrate its ability to learn the translation between domain A (that of the central nave of Gaudí's monument) and domain B (that of tree images), as well as the reverse, from B to A.

From an architectural perspective, the results obtained through this artificial intelligence approach are impressive, particularly when it is used to enrich the formal language more organically, pushing beyond what is traditionally present in the work of *La Sagrada Família*. Although it relies on two-dimensional images, this approach to creation via artificial intelligence could greatly assist architects in pushing the boundaries of design, while offering insights into the importance of specific architectonic elements of the sampled building. However, exploration in the third dimension represents both a technological challenge and a promising advancement in creative practice (Bolojan & Vermisso, 2020: 104). Furthermore, this experiment reinterprets the human perception of what Gaudi's work represents in the unconscious of observers, while also mapping these spatial impressions to "generate mutated versions of spaces based on alternative [real/virtual] realities" (ibid.).

The work *Machine Perceptions: Gaudí + Neural Networks* illustrates a rich graphical ingenuity, revealing a previously unknown synergy between a historical masterpiece and an AI-generated creation produced by cutting-edge algorithms. Nevertheless, the *CycleGANs* employed raise several challenges. First, the relevance of image hallucination depends on the available computational power, particularly the computer's graphics processing capacity. Moreover, these algorithms produce only two-dimensional images and approach three-dimensionality solely through perspective representations, thereby limiting their sublime transcription of *La Sagrada Família*. Finally, the identification and categorization of the generated images are influenced by the comparison technique used and the number of pixels, which condition their quality, currently considered "limited" and "failing to account for many nuances of human perception" (Zhang et al., 2018: 1).

## 3.2. *Deep Himmelb(l)au* by Coop Himmelb(l)au

Born in the wake of Viennese Actionism, Coop Himmelb(l)au is an architecture firm founded in 1968 by Austrian architects Wolf Prix and Michaël Hölzer, together with Helmut Swiezinsky, a Polish-born architect. Wolf Prix, the firm's principal director, is a prominent figure of Deconstructivism and an active member of several architectural institutions. Michaël Hölzer and Helmut Swiezinsky remained members of the firm until 1971 and 2001, respectively. The name *Coop Himmelb(l)au*, chosen by the founders, is a German wordplay meaning "to build the sky." It also alludes to *Himmelbau*, referring to the "blue of the sky," which explains the parenthesis around the "l" in *Blau*.

Coop Himmelb(l)au achieved paradoxical success through its intervention on a Viennese rooftop for the design of a law office, which earned it an invitation to the landmark *Deconstructivist Architecture* exhibition held at the Museum of Modern Art in New York in 1988. This exhibition brought together a handful of architects labeled as "deconstructivists," who sought to produce buildings capable of establishing a critical distance between architecture and the meanings intrinsically tied to it. Another spectacular project was *Open House*, designed for an elderly Austrian psychoanalyst who wished to spend his final years in Malibu, California. Notably, the first sketch of this house was produced with eyes closed, hand-drawn "like a seismograph" (Rambert, 2015), recalling certain automatic drawings practiced by Dadaists and Surrealists in the 1920s and 1930s (Zukowsky, 2006). The unsettling imbalance of the house's spaces generates sensations of slippage, instability, and dramatization that "implode the relation to reality in the name of heterotopia" (Hugues, 2010). Working in this way in a state of "semi-consciousness" (Mönninger, 2010: 20), Coop Himmelb(l)au seemed to aim at "opposing the vital function of aesthetics to the leaden dogma of profitability" (Roder, 2002). Bold projects such as the East Pavilion of the Groningen Museum in the Netherlands (1994), the Seibersdorf Research Center in Austria (1995), the Media Pavilion of the Sixth Venice Architecture Biennale (1996), and more recently BMW Welt or the European Central Bank in Germany, as well as the Musée des Confluences in France, all bear witness to an unprecedented distortion of our habitual sensory perceptions.

The works of Coop Himmelb(l)au have consistently adopted a visionary approach that integrates computational advances and cutting-edge technologies, including artificial intelligence. According to Wolf Prix, architecture must embrace the possibilities offered by artificial intelligence, considering it not merely as a "tool" but as a "collaborator" that enriches creativity (Feng, 2024: 18). This ambitious perspective has raised ethical concerns among critics such as Timnit Gebru, who views AIs as "stochastic parrots": "parrots because they repeat the [information] from which they have learned; stochastic because they rely solely on probabilities" (Ganascia, 2025). Prix, by contrast, perceives AI as an unexplored potential, comparing it to the feathers of a dinosaur developed by nature without foreseeing that they would one day enable flight. For him, artificial intelligence is a tool that will allow "architects to fly" (Prix, 2024). It is within this spirit of openness and adventure that *Deep Himmelb(l)au* emerged - an unprecedented research project at the crossroads of architecture, professional practice, and artificial intelligence (Figure 8). This experimental work, as its name suggests, employs deep learning techniques to teach computers to interpret, design, and enrich the creativity of the practice through images of its past projects (Prix, Schmidbaur, et al., 2022: 14).

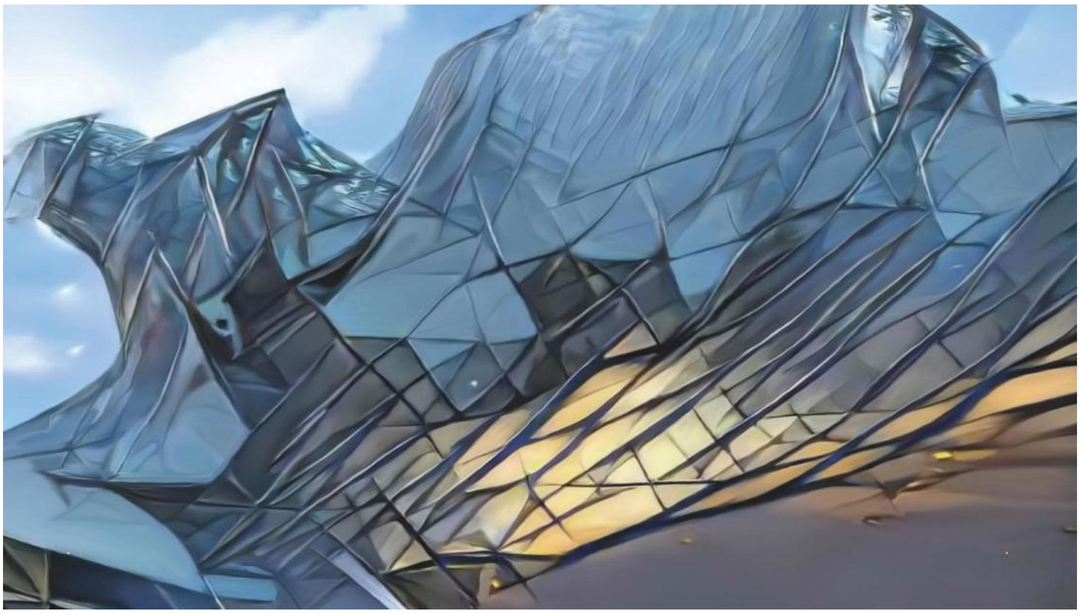

**Figure 8:** *Deep Himmelb(l)au,* a work based on the generation of various projects drawn from the archives of the Coop Himmelb(l)au agency.

Generative Adversarial Networks (GANs), introduced in the previous chapter, constitute a subfield of artificial intelligence aimed at extracting and automatically generating knowledge from massive datasets projected into latent space. Inspired by the functioning of the human brain, they reproduce with high fidelity its mechanisms of learning, prediction, and decision-making. In the context of the *Deep Himmelb(l)au* project, the primary models employed were *CycleGANs*. Similar to the *Machine Perceptions: Gaudi + Neural Networks* project, these networks were used to generate stylized architectures, reinterpreting the distinctive aesthetics of Coop Himmelb(l)au. This process enabled the creation of novel visualizations that merge the agency's identity with the creative potential of algorithms.

The generative networks used in *Deep Himmelb(l)au* operate in the same manner as those in *Machine Perceptions: Gaudi + Neural Networks*, but this time they were trained on a corpus of images from the practice's earlier projects, spanning nearly fifty years of production and preserved in both analog and digital archives (ibid.). These archives include simple hand-drawn sketches, miniature models, photographs, 2D drawings, 3D models, and construction details. Immersed in an iterative network of generator and discriminator, the *CycleGANs* not only recognize and distinguish iconographic content within batches of images, but also generate new architectural spaces. Each neural network trains itself to understand the analyzed semantics and underlying compositional rules in order to produce novel images without requiring human supervision (Leach, 2021: 104). The result is not a mere replica of the practice's past projects but rather an amalgam - a genuine "augmentation of the design process" (Bolojan, 2022) - constructed from hundreds of thousands of data inputs introduced into the system during its training. This gives rise to a spectacular cinematic immersion in an imaginary landscape of hallucinatory building forms, reminiscent of Coop Himmelb(l)au's characteristic aesthetic (Leach, 2021: 104).

*Deep Himmelb(l)au* is a collaborative endeavor bringing together Wolf Prix and Karolin Schmidbauer on the conceptual side, Daniel Bolojan and Efilena Baseta on the computational side. This project explores the potential of deep learning to produce a semantics intrinsic to the formal language of Coop Himmelb(l)au. It is worth emphasizing that *Deep Himmelb(l)au* represents the most advanced research to date in artificial intelligence applied to architecture, particularly in its capacity to explore three-dimensionality through supervised learning models beyond *CycleGANs*. Furthermore, the work has been recognized by *DigitalFUTURES*, a platform dedicated to architecture that annually organizes a series of scholarly activities focused on the latest technologies in computational design and fabrication, including artificial intelligence.

The *Deep Himmelb(l)au* program is based on a network of nodes structured around several GAN models—primarily *CycleGANs*—themselves grounded in the dialectic between generator and discriminator. These interconnected GANs iteratively and incrementally interpret the agency's earlier projects. They are organized around three thematic axes: Gestalt, organization, and technique (Bolojan, 2022). The first, Gestalt, addresses the formal dimension of architecture and relies on image generation. The second organization focuses on the functional dimension, training models with plans and sections. Finally, the third technique deals with technological aspects, particularly those related to environmental challenges.

The *Deep Himmelb(l)au* program includes several modes of architectural generation. First, it presents itself as a cloud of miniature images (Figure 9), gathering the agency's various projects and thereby constituting a visual mapping of its latent space. Certain areas within this space correspond to specific aesthetics that are easily identifiable by the user, thus facilitating interaction with the program. Selecting a particular region of the cloud allows the generation of an animation, whether as a two-dimensional representation—fixed through plans and sections—or as a three-dimensional projection producing hallucinatory perspectives and volumetric simulations. Furthermore, the program offers the possibility of modeling physical prototypes, digitizing them, and subsequently assessing their environmental performance (Figure 10). Finally, a third module enables the user to generate new variants of architectural images from textual prompts (Figure 11). The user then enters a description, in the manner of *Midjourney* or *DALL-E*, to obtain building proposals corresponding to the given statement, ranked according to text–image likelihood ratios.

It should be recalled that *Midjourney* and *DALL-E* are generative AI programs capable of transforming textual inputs—sometimes absurd—into coherent images (Ramesh et al., 2021). Developed by the American company OpenAI in 2021, *DALL-E* uses a deep learning model to produce detailed, high-quality images that demonstrate a refined semantic understanding of the user's textual input and remarkable compositional abilities. *Midjourney*, which appeared a year later, distinguishes itself through greater efficiency in generating painterly images. Trained on a vast corpus of artistic works, it has acquired an understanding of artistic canons and of painting in particular (Mahmoud, 2022). Thus, while *DALL-E* seems more oriented toward the formal composition of the images it generates from textual prompts, *Midjourney* privileges its visual and aesthetic qualities (D'Armenio et al., 2024).

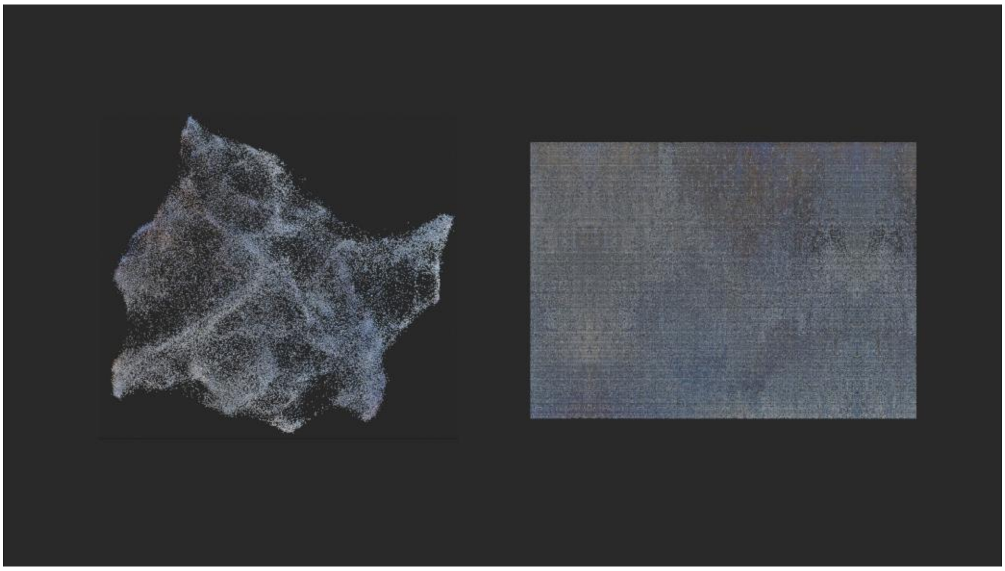

Figure 9: Visualization of the latent space of the work *Deep Himmelb(l)au*, represented as a cloud of miniaturized images.

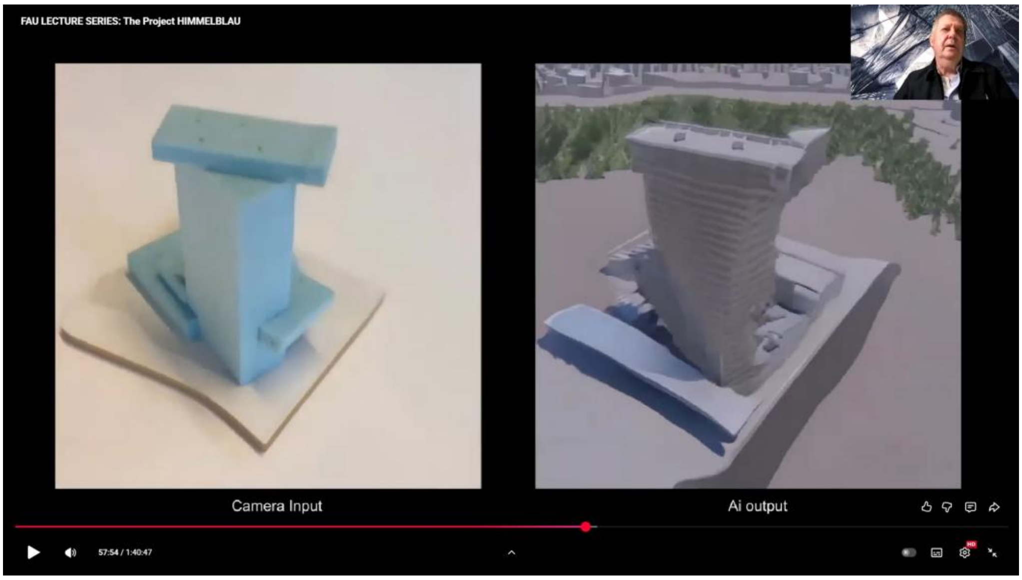


Figure 10: Digitization of a study model from a camera capture, aimed at assessing its environmental performance.


Figure 11: Images generated from textual prompts.

*Deep Himmelb(l)au* is manifested through a series of videos published online. The first and most notable, lasting one minute and forty-seven seconds, was released on June 4, 2020, on Vimeo and on the agency's website (video 2). It presents a subtle-hued 3D simulation, immersing the viewer in a promenade around a constantly transforming building, thereby generating new spatial interpretations (Figure 12). The sequence's aesthetic draws on a metaphorical interweaving of the agency's landmark projects, such as the UFA Cinema Center (Dresden, 1998), the JVC New Urban Entertainment Center (Mexico, 2001), and BMW Welt (Munich, 2007). In this simulation, the ceiling - sometimes constructed and fixed, sometimes absent and dissolved - disappears under a succession of overlapping visual layers that intersect and distort, thus altering the architecture of the building.

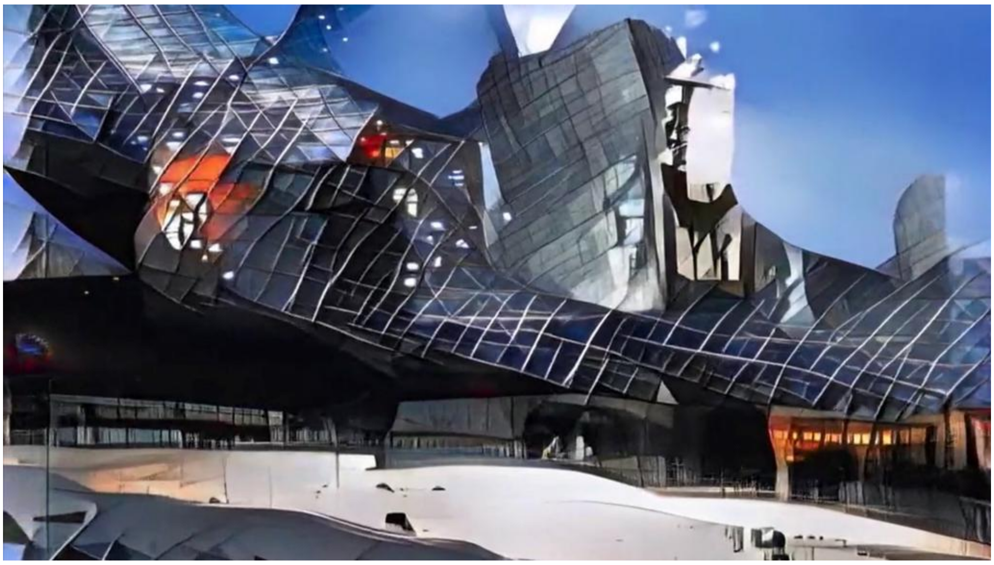

Figure 12: Image extracted from a video.

The second video, about one minute in duration, was posted on October 18, 2019, on the agency's website and YouTube channel (video 3). It presents an accelerated tour around buildings with blurred and perpetually metamorphosing contours (Figure 13). This animation appears to correspond to a proposal for a port development competition in Crimea, Russia, mentioned by Wolf Prix during a videoconference in 2021 (Leach & Prix, 2021). Its deformed, at times even crushed, aesthetic evokes Francis Bacon's paintings, particularly the *Portrait of Michel Leiris* (Figure 14). The animation also integrates formal reminiscences of projects realized by the agency, such as the Dalian Conference Center (China, 2011), the European Central Bank (Frankfurt am Main, 2014), and the Musée des Confluences (Lyon, 2014).

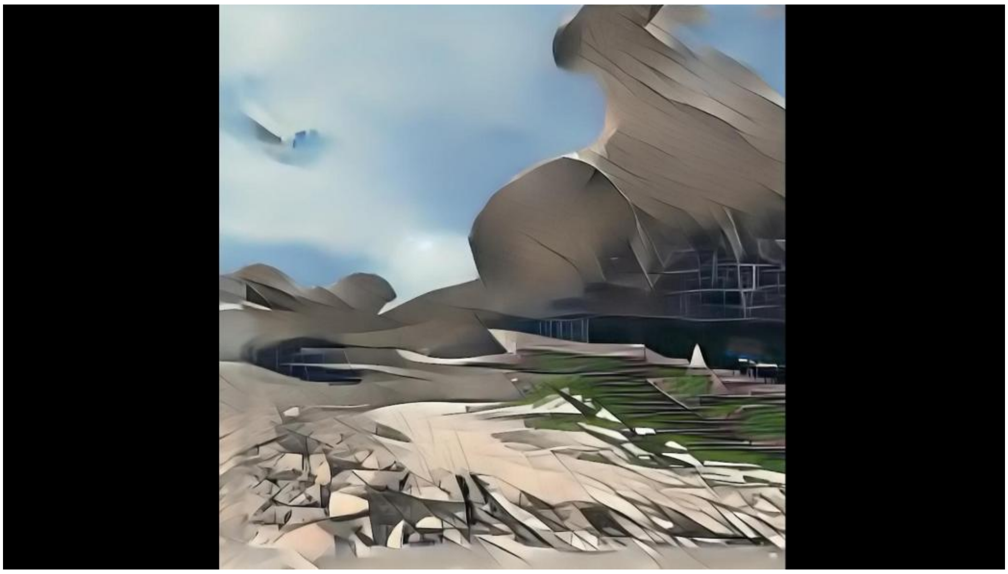

Figure 13: Image extracted from a video.

**Figure 14:** *Portrait of Michel Leiris*, oil on canvas painted by the British artist Francis Bacon in 1976.

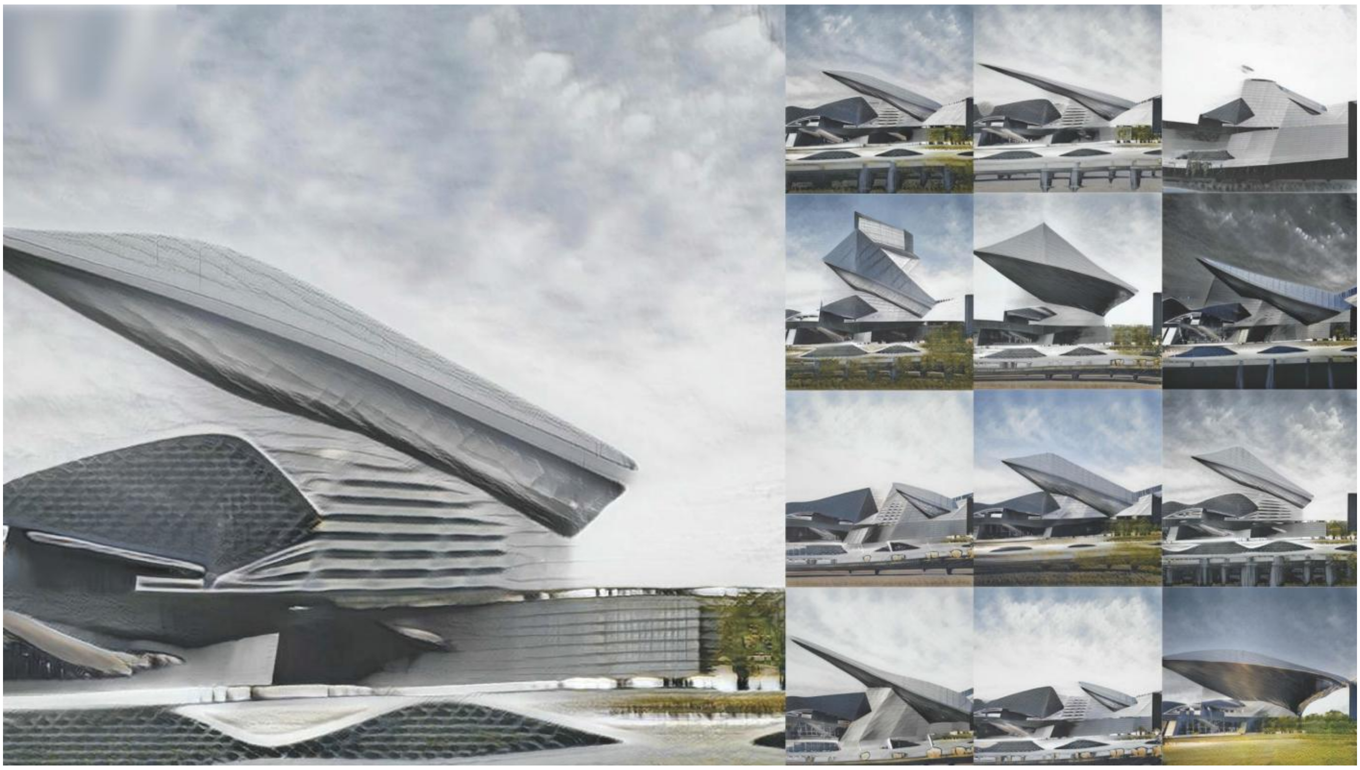

**Figure 15:** Image illustrating the various building transformations obtained through deep learning techniques.

The third video, lasting about ten seconds, appears around the fifty-ninth minute of a lecture entitled The Project Himmelblau, delivered at the FAU School of Architecture on February 23, 2021 (video 4). It also circulates on social media, particularly Facebook (video 5). Dating from 2021, this sequence presents the conceptualization of a congress center associated with a hotel complex, dominated by a sloping roof with exaggeratedly knotty and protruding forms (Figure 15). This metaphorical roof, oscillating between bulging volumes and unfolded surfaces, hollows out and expands to evoke an armored shell. Enhanced by sophisticated material effects, it leaves the viewer with a singular impression tinged with strangeness, even surrealism.

The programming of *Deep Himmelb(l)au* mobilizes a variety of Generative Adversarial Network (GAN) models, enabling it to perform complex conceptual tasks. CycleGANs, which play a predominant role, are distinguished by their ability to establish correspondences between two different visual domains without requiring aligned image pairs (Bellale and al., 2022). They notably allow the extraction, within the program's latent space, of the aesthetic features of previously trained images, which can then be synthesized to generate coherent stylistic transformations. StyleGANs, for their part, offer refined multi-scale control over the manipulation of image styles and achieve such a degree of realism that synthetic images often become indistinguishable from their real counterparts (Lago et al., 2022). Pix2Pix models condition image generation based on input data (Joyce, Terry, and Den, 2021, p. 1). In this context, they ensure the transformation of images while preserving the iconographic characteristics of the source data. By combining these different models, the algorithmic approach of *Deep Himmelb(l)au* provides artificial intelligence with a significant advantage for complex tasks such as the conversion of two-dimensional spaces into three-dimensional ones, self-learning, and the synthesis of multiple digitized representations (Yousif & Vermisso, 2022).

*Deep Himmelb(l)au* is capable of addressing new spatial perspectives inherent in the morphogenesis of Coop Himmelb(l)au and making them communicable, rather than evolving in the traditional way from experiences, knowledge, and creativity passed down from generation to generation. Despite the heterogeneity of its formal language, *Deep Himmelb(l)au* has succeeded in faithfully creating unique works of art consistent with the agency's predominant style, thereby pushing the boundaries of architecture and technology. These creations affect the invention of architectural aesthetics and challenge our very definition of the discipline, without, however, fully surrendering control of the design process to artificial intelligence (Feng, 2024: 23). AI-driven creation, while unable to access human consciousness or emotion, nonetheless exceeds our cognitive capacity—an aspect that raises ethical concerns for some and skepticism for others.

Since its earliest works, Coop Himmelb(l)au's creative approach has been engaged in an "open process" (Prix, Schmidbaur et al., 2022: 15), initially initiated through seismic and intuitive sketches, rich in meaning and open to interpretation. With the advent of digital tools, this method of manual and analog drawing first gave way to parametric models that made complex geometry manageable and controllable, then to photogrammetry for measuring and reproducing models, next to robotic arms and additive manufacturing that broadened the field of possibilities, and eventually to computer-aided manufacturing, simulations, and digital animations that temporalized space and its representation. Remaining faithful to this openness to the "other," the engagement with machine learning and artificial intelligence in *Deep Himmelb(l)au* combines all these techniques in a retroactive and hybrid process oscillating between the poietic and the technological. Indeed, computational tools, since their emergence in the 1990s, have been welcomed at the agency—not as substitutes for conceptual means but as amplifications and spatial optimizations. It is, in fact, a form of astonishing co-creation that surpasses human talent to yield an architecture *beyond the human*—oriented toward the future, yet deeply rooted in the past.

## 4. Conclusion

Table 1: Comparative Table: *Machine Perceptions: Gaudí + Neural Networks* / *Deep Himmelb(l)au*

| **Category** | ***Machine Perceptions: Gaudí + Neural Networks*** | ***Deep Himmelb(l)au*** |
|---|---|---|
| Designers | Daniel Bolojan, in collaboration with Emmanouil Vermisso. | Wolf Prix, in collaboration with Daniel Bolojan and Efilena Baseta. |
| Date | 2018. | 2019. |
| Description of the Work | Reinterpretation of the aesthetic characteristics of Antoni Gaudí's work, particularly those of La Sagrada Família. | Generation of stylized architectures reinterpreting the distinctive aesthetic of the Coop Himmelb(l)au agency. |
| Medium | Video rendering was published online in the form of a short sequence of approximately two and a half minutes. | Video renderings were published online as a series of video sequences, each lasting a few minutes. |
| Type of AI | Generative artificial intelligence based on deep learning. | Generative artificial intelligence based on deep learning. |
| Type of GANs | A single neural network: CycleGAN. | A combination of neural networks: CycleGAN, StyleGAN, and Pix2Pix. |
| Functioning of GANs | CycleGANs are capable of establishing correspondences between two distinct visual domains. | CycleGANs establish correspondences between distinct visual domains; StyleGANs allow finer control over image manipulation and achieve a higher degree of realism; Pix2Pix conditions image generation based on specific input data. |
| Image Bank | Set of real images of the Barcelona forest and photographs of La Sagrada Família, particularly its central nave. | Set of images drawn from the agency's previous projects: sketches, miniature models, 2D drawings, 3D models, construction details, etc. |
| Training Data Regime | The data are subject to an interaction between a generator (responsible for modifying images of La Sagrada Família) and a discriminator (responsible for evaluating the generated images). | The data are subject to an interaction between a generator (responsible for modifying images of Coop Himmelb(l)au's projects) and a discriminator (responsible for evaluating the generated images). |
| Integration of the Designer in the Process | The designer provides the AI program with input images and selects the type of neural network to be trained on these images. | The designer provides the AI program with input images and selects the type of neural network to be trained on these images. |
| Objective of the Training | To produce a spatial and aesthetic "hallucination" of Antoni Gaudí's work through La Sagrada Família. | To produce a spatial and aesthetic "hallucination" of Coop Himmelb(l)au's architectural language. |
| Image-Based Generation | Two-dimensional generation of architectural spaces derived from interior perspectives. | Generation of two-dimensional (plans, sections, perspectives) and three-dimensional (3D modeling) spatial animations. |
| Text-Based Generation | - | Generation of images from textual prompts. |
| Technological Challenges | Limitations related to CPU and GPU computing power; rendering is limited to interior perspectives. | Limitations related to CPU and GPU computing power; 3D renderings remain restricted in complexity. |
| Creative Challenge | To interpret Gaudí's formal and organic language through the generative biases of a neural network. | To transpose Coop Himmelb(l)au's stylistic signature into a latent space capable of generating new creative variants. |

We have explored two forms of beyond the human creation generated by artificial intelligence using deep learning techniques based on Generative Adversarial Networks (GANs). In the first case, animated images are produced by combining the Art Nouveau aesthetic of Antoni Gaudí with a cinematic interpretation of a wild forest captured on video. In the second, the deconstructivist style, which has significantly shaped the history of contemporary architecture, is reinvented in the spirit of the Coop Himmelb(l)au agency using an archive spanning nearly fifty years (See the Comparison Table 1).

*Machine Perceptions: Gaudí + Neural Networks* manifests as a hallucination of animated images recreating the interior space of La Sagrada Familia. In contrast, *Deep Himmelb(l)au* offers a hallucinatory deconstructivist immersion, integrating the distinctive style of the Coop Himmelb(l)au agency. The creativity of these works lies in the ability of artificial intelligence to learn, comprehend, and produce unique artworks that transcend human creation, while faithfully respecting the styles of Antoni Gaudí and Coop Himmelb(l)au.

Unlike text-based AI systems such as *DALL-E* or *MidJourney*, these works rely on a database of digitized images, mimicking the behavior of the human brain by anticipating graphic outcomes, making aesthetic decisions, and demonstrating unsupervised visual sensitivity. The work of Bolojan & Vermisso, limited to *CycleGANs*, results in a two-dimensional hallucination of architectural space, whereas Prix's approach employs a variety of collaborative neural networks to explore the third dimension.

The creative challenge in these case studies depends on numerous factors, including the quality and quantity of images trained within the latent space, recognition and comparison algorithms, the computational power of machines, and the deep learning techniques employed. Although artificial intelligence can generate new architectural forms, it remains devoid of awareness of its own creative capacity. For the time being, its role is limited to presenting a promising level of imagination, acting as an "assistant" or prosthetic extension in the service of the architect.

Although still emerging within architecture and design, artificial intelligence opens new creative frontiers, both in physical spaces and cyberspace, thus becoming a privileged field of exploration for designers. However, this technological advancement should be framed by at least a minimal set of rules and regulations. Without such guidelines, it would be futile to envision a coherent future for inhabited space, particularly when considering memory systems inspired by the functioning of the human brain.

How might architecture evolve beyond human creation, and how should it be appropriated? How can the role of AI in the creative process be regulated? Should moral and ethical rules be integrated into the knowledge learned by the machine? Should their use be controlled through permits? What form of architecture would we wish to see emerge from artificial intelligence in this context? These questions remain open, calling for a thorough reflection on the role of artificial intelligence in the future of architecture and human creativity.

**Acknowledgments**

Not applicable.

**Funding declaration**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors/individuals.

**Ethics approval**

Not applicable

**Conflict of interest**

The author(s) declare that there is no competing interest.

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