

A QUESTION OF STYLE

Style, Artificial Intelligence and Architecture

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At the beginning of the 20th century the German Architect and writer Hermann Muthesius (Fig.1) proposed to rid the architecture discipline entirely from the term *Style* and to replace it rather with the notion of *Type*¹. An attempt to divorce architecture from its pompous 19th century Historicism, a Style that identified itself with the imitation and at times amalgamation of various historical styles. The grandeur of the Ringstraße in Vienna can be considered one of the prime specimens of this development – including a parliament in the Greek style², the city hall in a Flemish Neo-gothic Style³ and Museums in Neo-Renaissance Style⁴. The formation of the *Deutsche Werkbund*⁵ (Fig.3) in 1907 moved the debate further in regards to discussing the difference between Style and Type. In contrast to Style that is connotated with particular, identifiable features, positioning buildings in a specific timeframe and culture, type talks about the result of basic geometries, specific production technologies and materialities. The time was calling for an association that does not specialize in any specific architecture (rural, urban, domestic, official, religious or otherwise) but rather created a frame for the entirety of living.



Figure 1: Anna and Hermann Muthesius drinking tea around 1900. Wiki Commons

The Motto of the Werkbund says it all ‘vom Sofakissen zum Städtebau’ (from the sofa upholstery to urban design), and reflects on the notion of the ‘Gesamtkunstwerk’, the all-encompassing piece of art. The ideas circulating at this time (also with other associations such as the Wiener Werkstätte or the Art & Crafts movement in the UK) most certainly drew from Gottfried Semper’s desire to reinvent the discipline in the face of the impact of industrialized fabrication vs. craftsmanship as well as its methods of materialization. Semper, possibly the first materialist thinker in the discipline, was obsessed with the feedback loop between material and human ingenuity. It would be interesting to hear what he would have to say facing the possibilities of a contemporary, posthuman, design universe.

Muthesius concept of the *Type* proposed that form presides over function, and that instead of inventing ever new styles and shapes, architects and designers should rely on standardized shapes (‘typisierung’), such as platonic solids, as starting point for every kind of design wither this be industrial design, architecture or urban design. Although Muthesius is considered one of the ideological fathers of the Bauhaus, he was profoundly suspicious of the Bauhaus, as he considered the Bauhaus nothing but yet another Style⁶, undermining his attempts to rid the discipline from the burden of Style.

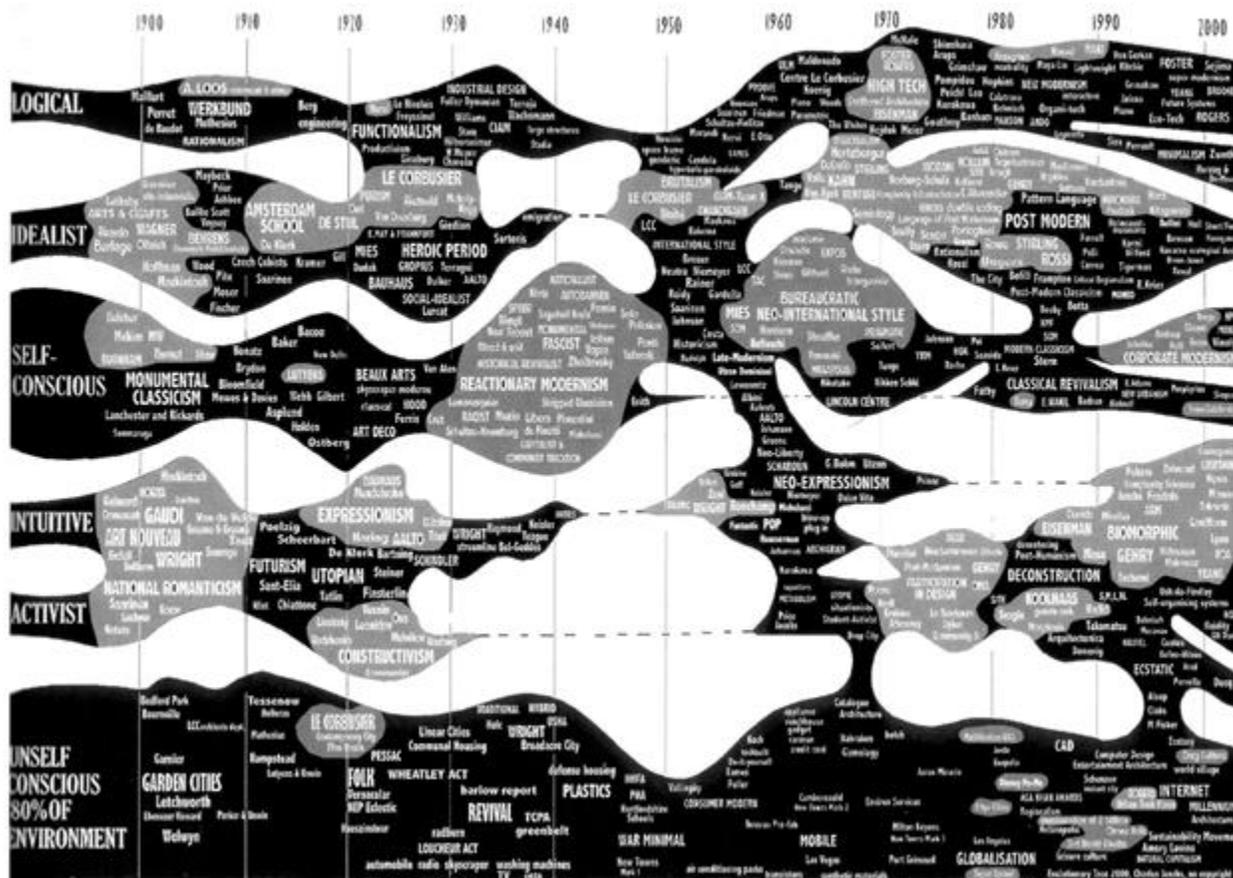


Figure 2: Charles Jencks, *Evolutionary Diagram*, 2000, “...Now that the century is over it is time to ask what it meant for architecture. This is a harder question than it first appears. Did Modern architecture, as its apologists claim, triumph over other contenders? What was the

relationship of commercial practice to quality - did the best architects lead or only influence the profession? Did good architecture trickle-down or was it dumbed-down? Or did a hundred mini-movements tell the real story of the century; or was it like that of the past, one of spec builders, the DIY industry and self-build?...

... It is true that certain architects of the previous century - how strange those words ring for Modernists - were creative forces that lasted for longer. Mies was a power to be reckoned with in the '20s and '60s. Le Corbusier, Frank Lloyd Wright and Aalto, who with Mies made up the big four, were seminal at more times and Kahn, Stirling, Eisenman and Gehry, the little four, each had two small periods of influence. But even these protean characters, in order to stay relevant and on top, had to reinvent themselves about every 10 years... Usually when historians look at the recent past they do so with the eyes and taste that rigidly exclude the variety, contradictions, mess and creative wealth of a period, and we applaud them for so doing. All history writing is selective and based on theories of what really matters, and there is no way around this limitation. But there are ways to compensate for perspectival distortion and over the last 30 years I have devised a method, the evolutionary tree, which if it is not completely inclusive is at least balanced in its selective effects

....As can be seen in the classifiers to the extreme left of the diagram, it is based on the assumption that there are coherent traditions that tend to self-organize around underlying structures. These deep structures, often opposed to each other psychologically and culturally, act like what are called, in the esoteric science of nonlinear dynamics, 'attractor basins': they attract architects to one line of development rather than another. Why? Not only because of taste, training, education and friendships, but because of type-casting and the way the market forces architects to have an identifiable style and skill. In a word, specialization....⁷

Ever since the Style vs. Type debate⁸, the term Style has been observed with suspicion in the discipline. The entire 20th century was mainly trying to avoid the term at all costs. However, if we take Muthesius' criticism of the Bauhaus seriously, we can state that also the 20th century was profoundly driven by questions of style. From the Bauhaus to the Deconstructivists – Style reigned supreme also in the 20th century (Fig.2).

A closer look into the suspicious noun *style*



Figure 3: Fritz Hellmut Ehmcke: Deutsche Werkbund Ausstellung Köln. Courtesy MOMA

First and foremost, there is a series of methods as of how to explain the noun *style* in a consensual manner. These definitions are applied to a series of different disciplines and criteria. For example, in the fabrication industry *style* is understood as a particular designation, or the title of a machine or machine part. In literature it pertains to a distinctive manner of expression – just think about realist literature, romantic literature or the flowery style of 18th century poetry. *Style* can also be applied to human behaviour with all its mannerisms, ticks, physiological and psychological behavioural features. All of which are encapsulated in a distinct *style* of behaviour – conduct is a main expression of personal style: courteous, discreet, abrasive. Of course the term is also associated with questions of manner and technique, in that things are done or created in a unique style (just remember, for example, the attribution of painting of unknown origin with denominations such as “in the style of Caravaggio” (Fig.4)), and finally the term is applied to things that are fashionable – *to care about aspects of AI in architecture is in style at the moment.*



Figure 4: *The Card Players*, follower in the style of Caravaggio, Harvard Museum

The complexity of the term *Style* consists in the unusual weight and flexibility of the concept itself. In essence the concept defines the main basic rulesets of artistic achievement and excellence. The term *Style* itself is a latecomer to the considerations of the examination of artistic endeavour and is being discussed in a fierce fashion to this very day. The etymology of the term in various languages such as the French and English *Style*, the Italian *Stile* and the German term *Stil*, can be traced back to one Latin root: *Stilus*. The Latin *stilus*, is a tool in the form of a stake or pike that transmuted in the common understanding to “a pointed tool for writing or engraving wax tablets.”⁹ During the period of the Roman Empire this tool was fabricated using either metal, bone, or ivory, with a pointed end to scratch letters into the soft wax of the tablet, and a flattened end that allowed to flatten the wax again, basically erasing the text. The metonymic transformation of the term from the purely descriptive -in order to describe a tool- to a metaphor describing the qualities of an orator (and thus the formal qualities of art – its *style*) occurred already in antiquity, for example through the works of Marcus Tullius Cicero¹⁰

A pointy stick showed the way to *Style*. An instrument of warfare, siege and violence -the stake, the pike- turned into an expression capable of identifying the changing characteristics and the passage of time in

architectural production. In a way it's befitting that a bellicose tool of leaguer, which in itself is a form of architecture, turns into the term to describe (scribe-stylus-style!) the morphology of architectural production. The Roman *Stilus* however is also the ancestor to the writing stylus – the historic tool of the trade of the architecture discipline, wither this be for the penning of timeless architectural rulesets such as Vitruvius books, or the literal scratching of plans on floors (Fig.5). The German words *Grundriss* (plan) and *Aufriss* (elevation) still contain parts of the word *Riss* denoting the origin of scratching plans onto the plaster of medieval building huts and workshops using, you guessed it, pointed sticks.

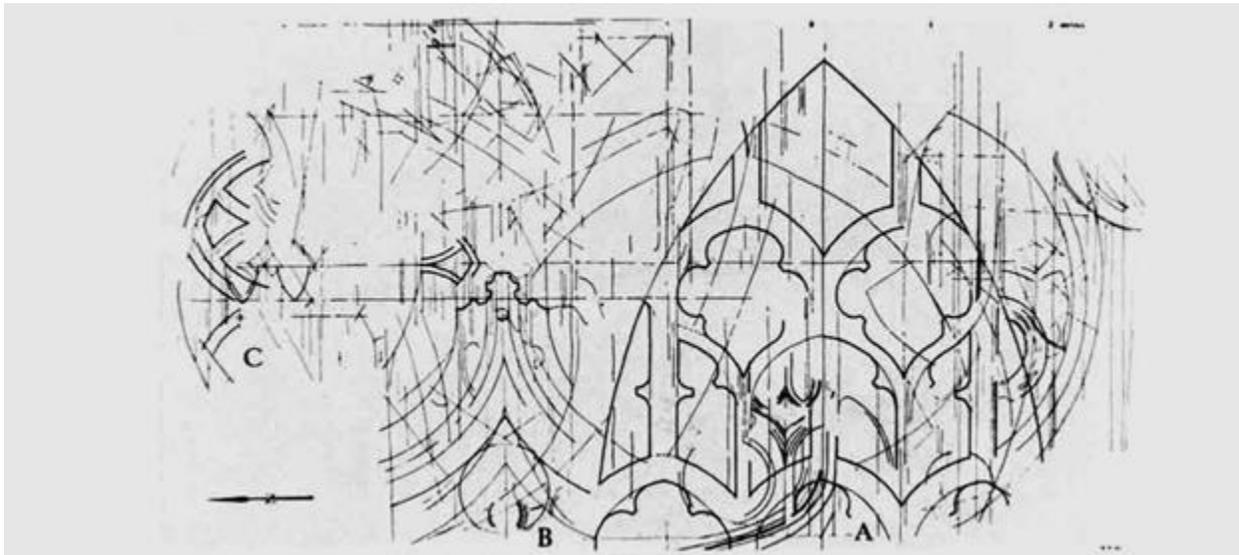


Figure 5: Scratched Gothic drawings on the framing ground of the York Cathedral - the "Reissboden". In *Oberösterreichische Heimatblätter*, 37. Jahrgang, Heft 2, 1983, P. 128

Ultimately the *Stilus*, the ancient Roman writing tool that paved the way to the term *Style*, creates a bridge to our contemporary writing of code, in which the written word -the lines of code- serves as a model for the accurate description of spatial, architectural conditions.

The term *Style* in this frame of conversation can be divided into two specific cases. Case one is the idea of *Style in Architecture*. Case two is the use of the term in *Computer Science*. In combination, these two instances form the frame of this essay on the emergence of novel considerations of style in the architecture discipline through the application of *Neural Networks*. More specifically: through the adoption of *Style transfer* as a technique.

Neural Style Transfer (NST) as a tool of Architectural Interrogation

In order to discuss the nature of style in architecture, I would like to rely on the works of Gottfried Semper as the grand seigneur of the conversation on style. In his opus magnum *Style in the Technical and Tectonic Arts, or, Practical Aesthetics*, Semper laid out a comprehensive interrogation of style as a driver of architectural innovation, divided into the material driven chapters textiles, ceramics, carpentry and masonry.

Semper's interrogation of the provisions of style transformed the discourse on aesthetics, architecture and art history (Fig.5).

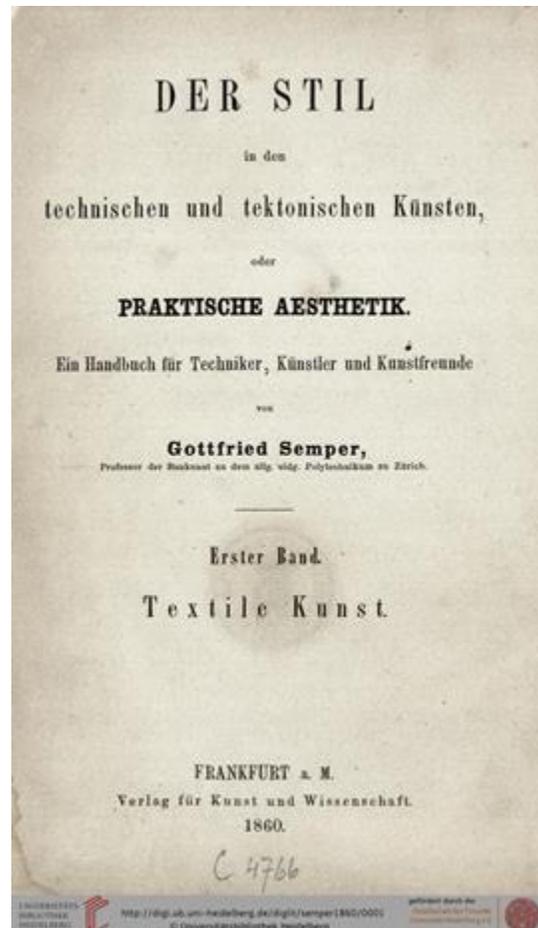


Figure 6: Gottfried Semper: *Der Stil in den technischen und tektonischen Künsten, oder Praktische Aesthetik*, Verlag der Kunst und Wissenschaft, Frankfurt 1860

In Semper's assessment Style should be driven by cultural sympathy, historical function, creative free will and the inherent qualities of the distinctive materials. This can be summarized as a critical examination of 19th century notions of artistic discussion in which Semper's voice is critical towards ideas of aesthetics, historicism and materialism. Materialism in this frame of conversation is not part of the Materialist philosophy of Marx¹¹, but rather an attempt of organization and cataloguing of architecture elements, parts and blocks. In his book *Style* Semper developed an intricate catalogue of transformations, in particular Styles, based on a deep interrogation of distinct objects, resulting in an exceptional understanding of variations in culture. Based on this, it can be stated that *Style* can be considered through the lens of Materialist considerations, but also as a continuous series of forms produced through changes in the methodology of construction and technical

progress in general. In this sense, every new style is a result of previous efforts and is within the gravitational field of new materials, new construction methods as well as novel social values (see also Charles Jencks, Evolutionary Diagram, Fig.2). Ultimately Style, to state a possible way to think about it, is simply the application of new materials, techniques and purposes¹². Style as an area of inquiry in architecture theory has a long and painful history, as laid out through the treatises of Gottfried Semper, John Ruskin, Violet le Duc, Garnier and Alois Riegel¹³, and the opposition to this area of critical interrogation by figures such as Otto Wagner -who started his career profoundly invested in the Historicism of the 19th century, only to reinvent himself as a proponent of modern considerations in architecture- Muthesius, Loos, Augustus Welby Pugin and other critical voices towards a purely historic vantage point of architectural production. What makes a difference between the analogue methods of inquiry utilized by these critics and the digital methods that can be applied today to plow through massive amounts of historic data about the discipline, is the methods applied to structure and organize Big Data. However, there is more to discuss than just to drop the issue of Big Data on the table without further closer scrutiny. In his book *The Second Digital Turn*¹⁴, the historian Mario Carpo described “*the different ways, today’s digital avant-garde has already started to use Big Data and computation to engage somehow the messy discreteness of nature as it is, in its pristine, raw state – without the mediation or the shortcuts of elegant, streamlined mathematical notations.*” It is incredible how just a couple of years of development can overthrow ideas of specific paradigmatic shifts.

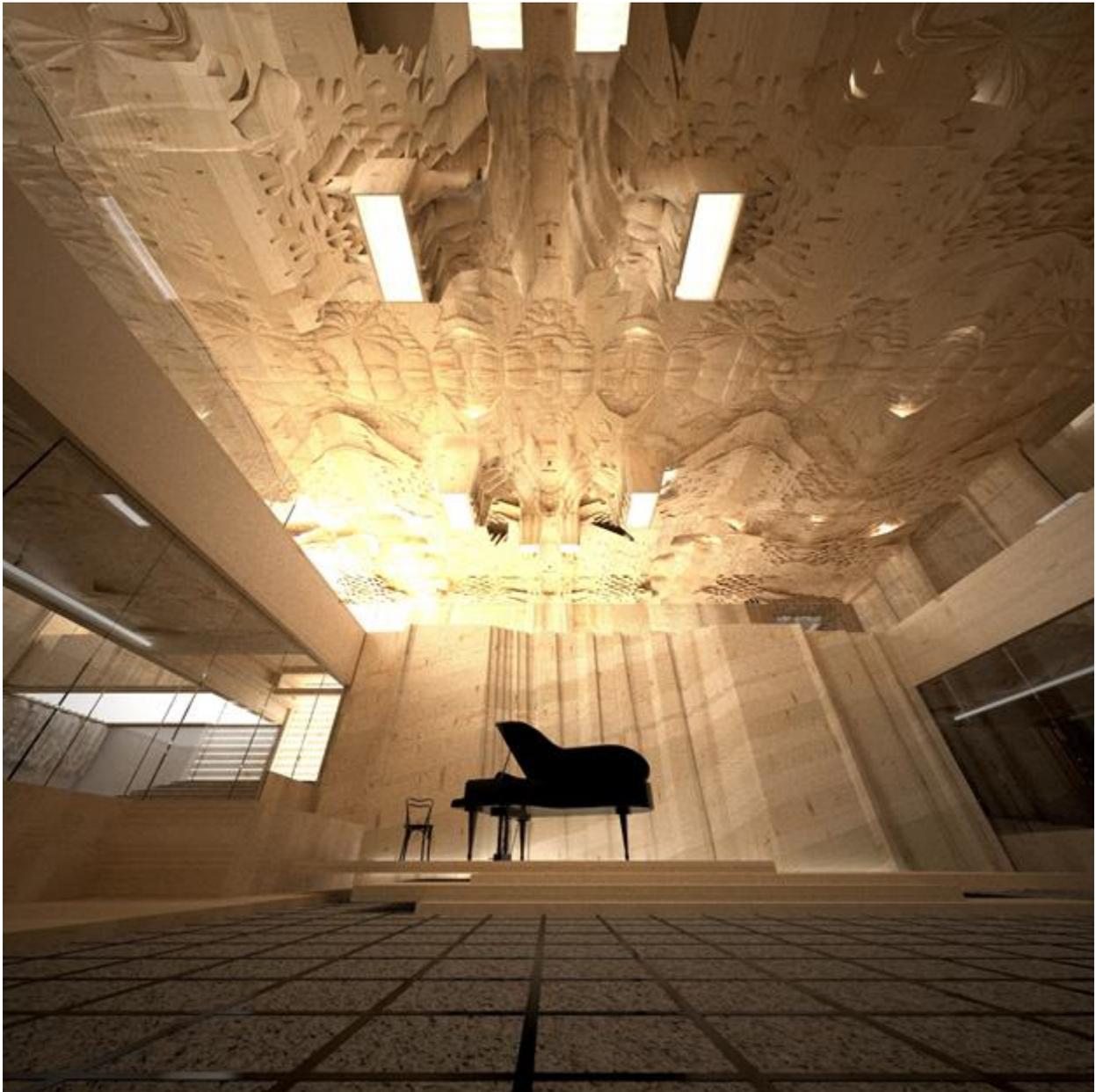


Figure 7: SPAN (Matias del Campo & Sandra Manninger: Austrian Pavilion for the Dubai Expo 2020. A first attempt on harnessing Neural Style Transfer techniques for architecture design.

What Mario Carpo missed in his book is the rise of Artificial Intelligence as a tool in contemporary architecture design – there is not a single mention of it in his book *The Second Digital Turn*. At least he did not consider it important enough to make it into the index of the book. How could he miss it? Generative Adversarial Networks (GAN's) came into being in 2014 as a machine learning methodology devised by Ian Goodfellow¹⁵. Leon Gaty's paper *A Neural Algorithm of Artistic Style*¹⁶ was published in 2015. Experiments

with the use of Neural Networks in architecture started around 2018¹⁷ (Fig.6), and the first building project utilizing Neural Style Transfer (NST) as design method was devised by SPAN (Matias del Campo & Sandra Manninger) in collaboration with Michigan Robotics (Alexa Carlson) in 2019 (Fig.7).

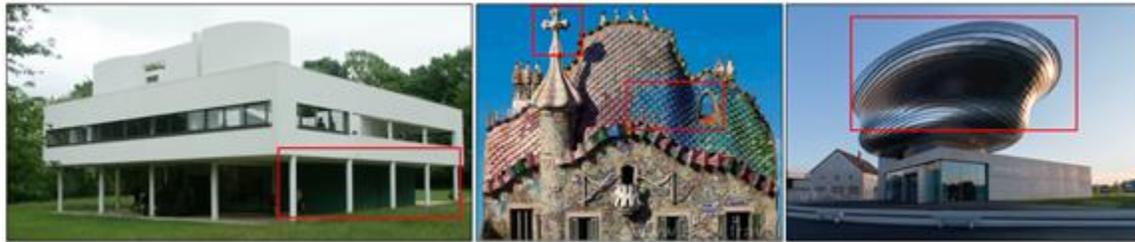


Figure 8: Consider the visual task of building recognition/classification with the above images. At first glance, the panel on the far left of Le Corbusier's Villa Savoye is easily separable from the two on the right; it differs significantly from the other two images in terms of shape (of the three it is the only building with columns and simple geometric edges/corners), in terms of color, and in terms of background. The right-hand panels, the Casa Batillo by Antoni Gaudi (middle image) and the Coop Himmelb(l)au's Haus des Brotes (far right image), have similar bluish backgrounds and have curved roofs. Therefore, more complex visual features, like the texture and color of the Casa Batillo roof must be used to differentiate the two. If presented this small dataset from which to learn building classification, a neural network would only need to learn the features 'white' and 'columns' to separate the Villa Savoye from the others. In contrast, the network would need to learn more complex, dense visual feature sets to separate the Casa Batillo image from the Coop Himmelb(l)au image, e.g., the different roof shapes as spatial locations of curves in the image, the different colors in the roofs, and perhaps the locations of the roof ornaments or windows in the Casa Batillo image. These example features are highlighted in red in the figure.

This shows once more the slow speed of our discipline and the, at times very slow, ways to adapt to novel technologies. Circling back to the discussion of Big Data, Architecture and Neural Networks - the lesson learned here is not so much about collecting Big Data, not even about *Don't Sort: Search* (another chapter in Mario Carpo's *Second Digital Turn*), but rather about how to crunch through this big data to extract the relevant information that allows to inform a project. It's literally about processing data to reveal information. Or to put it this way: *Data is the new Oil*¹⁸. Why? Because -in an analogy to crude oil- it is almost useless in its unrefined state, but needs to be refined into gas, plastics, chemicals etc. in order to create a valuable commodity. In a similar fashion raw data is pretty much inert, as it is unlegible to the human mind – it needs to be broken down and analyzed in order to reveal the valuable information. Yes, Data and Information are two distinctly different things. This is also what makes the use of Neural Networks so incredibly powerful. It would go far beyond the boundaries of this article to describe in detail the possible facets in the application of Neural Networks in architecture – reaching from site analysis, to plan analysis to improved methods of Building Information Modeling, to aspects of ecologic, economic and social impact of a project – the opportunities to reveal the profound nature of a project are gigantic. As this article is primarily concerned with aspects of style by using Style transfer techniques aided by Neural Networks, it is worth inquiring on the use of Big Data in order to interrogate aspects of style. The larger a data set of anything is, the more accurate the results generated by a Neural Network will be.

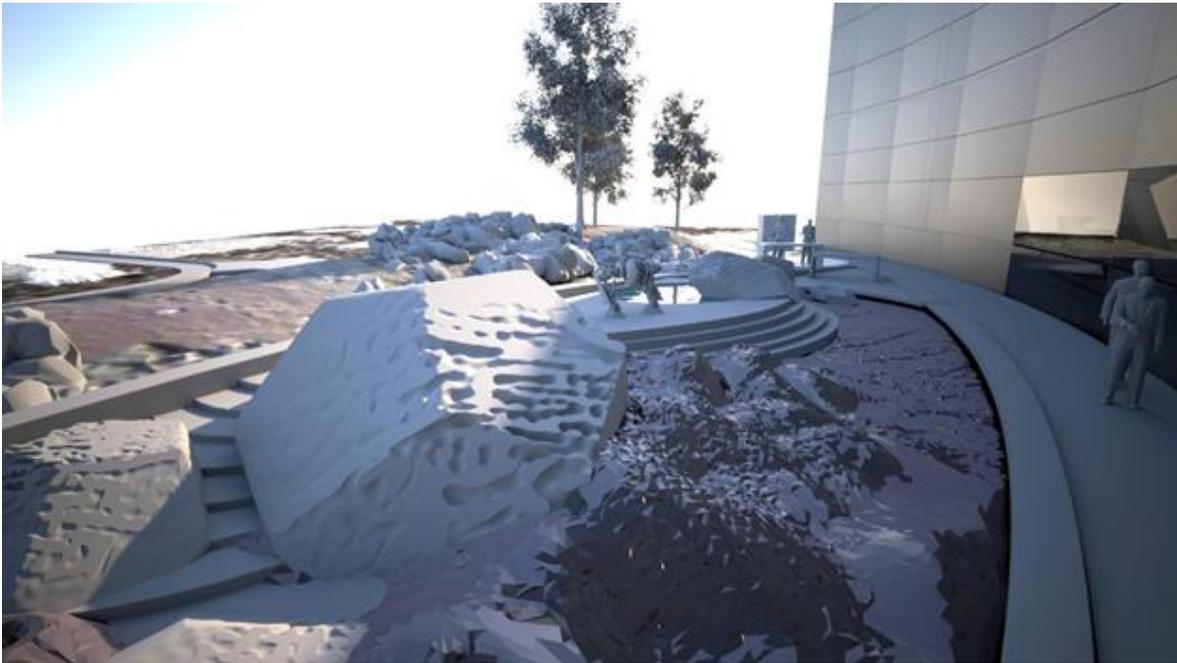


Figure 9: SPAN (matias del Campo & Sandra Manninger), the Robot Garden for the Robotics Department of the University of Michigan. USA 2019

In researching the issue of style in architecture the size of the datasets is crucial. It starts with around 1000 images upwards of a particular style or feature to train a network to implement specific stylistic features. As the technique is based on machine learning through the examination of features within an image, the quality of the images of a database are very important. In an episode of the design of the Robot Garden (Fig9) by SPAN, a deep dream neural network was trained to understand what fountains are. After several iterations of the training the Neural Network made a weird connection – it recognized the spout of water emanating from a spring fountain as a crucial feature and started to recognize this feature all over the place in the target image. (Fig10) Resulting in strange color distortions in the vertical dimension of the image. This being said, it made a far better job in recognizing the features of a column. These examples demonstrate how Neural Style Transfer can be used as a method of architectural interrogation. In the tradition of historic architectural analysis, the tool can expand on the abilities of the human mind to scrutinize in detail the qualities of an architectural project. The main difference being that in contrast to the model of examination from figures such as Gottfried Semper, it is not about a “revival” of historical forms, but rather about the discovery of novel architectural opportunities dormant in its historical core matter and uncovered through the hallucinations of machines.

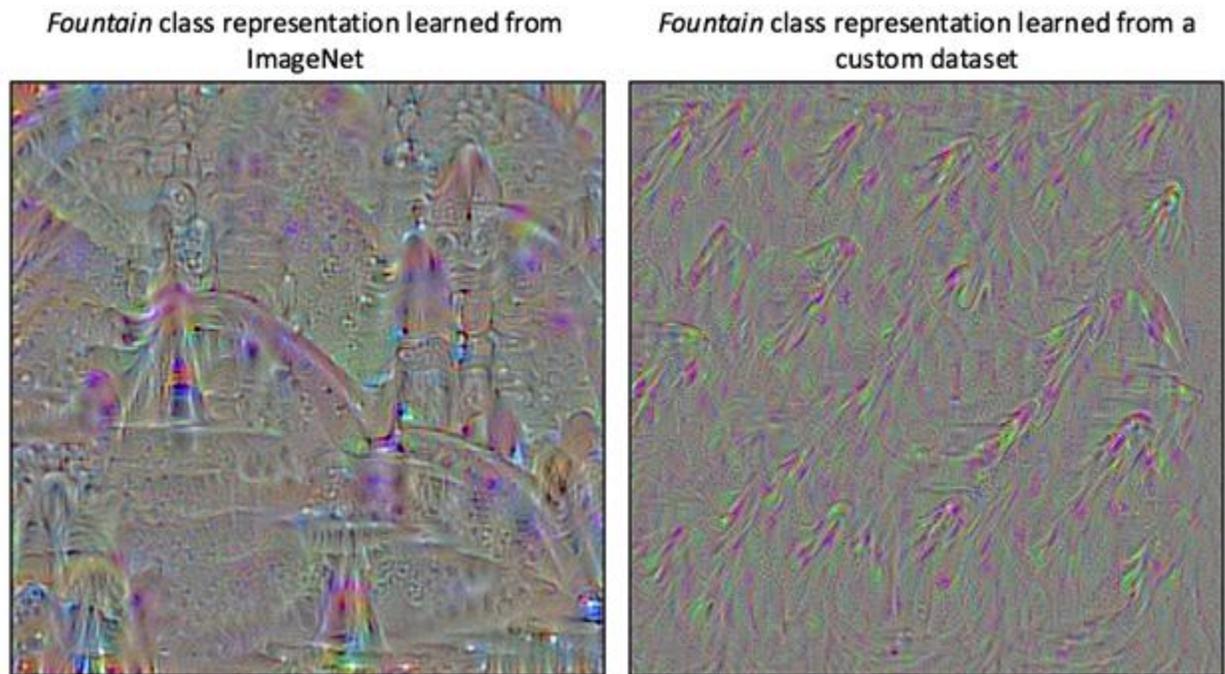


Figure 10: Fountain Class representation learned from imageNet

Style and Artificial Intelligence

Expanding on the basis created by the theory on Style by Gottfried Semper, it would be interesting to examine the changes, or relationships, to Semper's universe of thought through the lens of contemporary design techniques related to Artificial Intelligence research. As stated above the main trajectory of interrogation for Semper, was the idea to utilize aspects of new materialities, new construction methods as well as social values. This being considered we can revisit ideas on Style in the light of the application of novel design techniques. More specifically: Style transfer techniques using Neural Networks. A question that comes to mind is: Why did Computer Science pick up the term *style* to explain the nature of this neural network? The origin of the application of the term Style for particular networks can be traced to a paper on Computer Vision and Pattern Recognition. In it, *Leo Gatys, Alexander Ecker and Matthias Bethge* explain that "*in fine art, particularly in painting, humans have [dCM1] mastered the skill to create unique visual experiences through composing a complex interplay between the content and style of an image.*"¹⁹ It is not known yet how this quality of human behavior can be encoded in an algorithm, and there are no synthetic structures able to imitate that profoundly human quality. Deep Neural Networks (which are a biologically inspired subset of machine vision models) on the other hand have proven the ability to recognize objects and faces with an almost human degree of accuracy. The Style transfer Neural Network is essentially a synthetic system based on a Deep Neural Network capable of generating images of high artistic value. It would go beyond the frame of this essay to discuss the meaning and relevance of *artistic value*, so for now we will keep this claim in a vague cloud of what this pairing of words actually entails. What is relevant for this conversation though is the methodology as of how a Deep Neural Network is able to work through the problem of style. In short, style transfer algorithms utilize the ability to create neural representations of images, isolating and associating the content and style of images, the algorithm then moves on to recombine the content and style resulting in a

neural algorithm capable of artistic expression. Let's revisit here for a second Semper's definition of style: "Style should be driven by cultural sympathy, historical function, creative free will and the inherent qualities of the distinctive materials." If we break down the components of this definition, and attempt to apply them to a Neural Network, it would mean that NNs have to be able to comprehend sympathy as well as history and possess a creative free will as well as the understanding of the inherent qualities of a material world. The question here is whether there is a possibility to prove scientifically that a neural network is able to replicate aspects such as sympathy and creative will. By now we can state that there is no evidence for the possibility to synthetically replicate aspects of sympathy and free will in an artificial neural network. However, that an algorithm is capable of analysing history can be considered possible, ultimately this is all in the quality and methodology of the training of an NN – the same amounts for aspects of materials. It is absolutely possible to train an NN to differentiate between various materials based on databases of images of distinct materials. Combine this with additional data about the material such as tensile strength, compression strength, and methods of treatment and you have a well-informed Neural Network capable to aid in the work of an architect on a day to day basis. How about aspects of creativity? There seems to be evidence that AI's can be creative. We can name two instances here: The Bob and Alice¹² experiment of Facebook AI comes to mind, or the incredible game between Alpha Go (a creation of Google DeepMind) and Lee Sedol¹³. The consequence of this is that Semper's argument about style is only partially applicable to the area of style and Artificial Intelligence, which demonstrates the evolution of the idea of style from the mid-19th century universe of Gottfried Semper, to the Posthuman age. It is rather just one part of a combination of various possibilities to consider style in the discipline of architecture through the lens of Artificial Intelligence. First, a practical example of the use of NN's in the arts. The painting *Portrait of Edmond Belamy* (Fig. 11), by the Paris based art collective *Obvious*¹⁴ is based on a Generative Adversarial Network (GAN) that was trained with a set of 15.000 portrait examples spanning from the 14th to the 19th century. This set was utilized to generate a block of family portraits entitled *La Famille de Belamy*. Though not a Styletransfer per se, the example shows the possibility for creative results emerging from Neural Network research. Another popular example is the use of van Gogh paintings (or any other artist – van Gogh is just a popular victim) as style to transfer into any given image through the application of Neural Style Transfer – a category of algorithm that allows for the manipulation of the pixels of an image. In doing so they absorb the visual qualities of one image (Style) and imprint them on any other given image (target). The approach is closely related to deep neural networks, which are able to perform in a similar fashion. The goal is to transfer style information from input images to any provided target image. Neural Style Transfer (NST) algorithms belong to the family of image stylisation techniques, which have been examined in the area of non-photorealistic rendering for more than twenty years. Before the NST algorithm was devised, image transfer techniques relied on machine learning which were based on image analogy. Image analogy relies on the idea that a trained pair of images (an image of an artwork and a photo of any given object) can learn to perform a transformation on any given image by analogy. For architecture this presents a very particular problem, as all these techniques are 2D.



Figure 11: The painting *Portrait of Edmond Belamy*, by the Paris based art collective *Obvious14* is based on a Generative Adversarial Network (GAN) that was trained with a set of 15.000 portrait examples spanning from the 14th to the 19th century.

Considering the description in the previous section, we can outline a very specific problem with the approach of Style transfer techniques. At least if we focus on the current state of the development of Style transfer techniques: They are 2D design techniques. Meaning they can deal with two-dimensional data such as images, plans and sections. This represents also the bulk of the current research in terms of architectural production. In our own research we have explored various avenues that include databases of various historic styles such as Gothic, Baroque and Modern. Not for the sake of imitating said styles – not to revive the Historicism of Sempers era, but to find novel possibilities within the gigantic repositories of architectural imaginations. Neural Networks are profoundly well suited for the examination of the big data enclosed in the

vaults of architecture history. On closer examination, current techniques of Style transfer open avenues of inspirations for novel architectural approaches. As described before, Style comes from the Latin Stylus – a writing tool. Neural Network Algorithms are nothing but written text, lines of code that allows to explore massive amounts of data in order to find the essence of a style. Maybe even the first genuine style of the 21st century.

References

- 1: H. Muthesius, *Stilarchitektur und Baukunst*, Verlag v. Schimmelpfeng, Mülheim an der Ruhr, 1903
- 2: The Austrian Parliament Building (Parlamentsgebäude, das Parlament), 1883, Architect: Theophil Hansen
- 3: The Vienna City Hall (Wiener Rathaus), 1883, Architect: Friedrich von Schmidt
- 4: Kunsthistorisches & Naturhistorisches Museum, 1891, Architects, Gottfried Semper & Carl von Hasenauer.
- 5: The *Deutsche Werkbund* was founded around the Viennese architect Joseph Maria Olbrich after leaving Vienna for the city of Darmstadt, Germany, following an invitation by Ernest Louis, Grand Duke of Hesse in order to design and form an artist colony. The founding members of the *Werkbund* in 1907 included Joseph Maria Olbrich, Peter Behrens, Richard Riemerschmid and Bruno Paul. The constituting meeting was conducted in Munich at the instigation of Herman Muthesius. This first iteration of the *Werkbund* was in place until 1934, when the Nazis shut it down. It was re-established after the second world war in 1950.
- 6: V. Rujivacharakul, H. Hazel Kahn, K. Tadashi Oshima, P. Christensen (eds.), *Architecturalized Asia: Mapping a Continent through History*, Hong Kong University Press, 2013, P.108
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- 9: L. Vercelloni, *The Invention of Taste: A Cultural Account of Desire, Delight and Disgust in Fashion, Food and Art*, Bloomsbury publishing, 2016, P. 132
- 10: M. T. Cicero, *De Oratore*
- 11: Historical materialism, also known as the materialist conception of history, is a methodology used by some communist and Marxist historiographers that focuses on human societies and their development through history, arguing that history is the result of material conditions rather than ideals.
- 12: H. F. Mallgrave, *The Idea of Style: Gottfried Semper in London*, University of Pennsylvania, Philadelphia 1983, P. 76

13: Alois Riegl was an Austrian art historian and is considered a member of the Vienna School of Art History. He was one of the major figures in the establishment of art history as a self-sufficient academic discipline, and one of the most influential practitioners of formalism.

14: M. Carpo, *The Second Digital Turn – Design Beyond Intelligence*, MIT Press, Cambridge Massachusetts, 2017

15: I. Goodfellow, J. Pouget-Abadie, M. Mirza, B. Xu, D. Warde-Farley, S. Ozair, A. Courville, Y. Bengio, *Generative Adversarial Networks*, Proceedings of the International Conference on Neural Information Processing Systems (NIPS 2014). pp. 2672–2680.

16: L.A. Gatys, A.S. Ecker, M. Bethge, *A Neural Algorithm of Artistic Style*, arXiv preprint 1508.06576, arXiv 2015

17: For example the Austrian Pavilion for the Expo 2020 in Dubai, which utilized Style Transfer techniques to generate the ceiling. SPAN 2018 – Matias del Campo & Sandra Manning. This design was a primitive effort in that it used the online solution by Google Deepdream to create Style Transfers. It used the Deep Style option to experiment with combinations between Baroque and Modern ceilings, transforming the resulting image into a 3D model using zBrush.

18: The phrase '*data is the new oil*' was apparently coined in 2006 by Clive Humby, the British mathematician and architect of the Tesco Clubcard, a supermarket reward programme. (J. Bridle, *New Dark Age – Technology and the End of the Future*, Verso, 2019, P.245)

19: L.A. Gatys, A.S. Ecker, M. Bethge, *A Neural Algorithm of Artistic Style*, eprint 1508.06576, arXiv 2015

12: C. Baraniuk, *The 'creepy Facebook AI' story that captivated the media*, <https://www.bbc.com/news/technology-40790258> visited 02.23.2020

13: AlphaGo versus Lee Sedol, also known as the Google DeepMind Challenge Match, was a five-game Go match between 18-time world champion Lee Sedol and AlphaGo, a computer Go program developed by Google DeepMind, played in Seoul, South Korea between the 9th and 15th of March 2016. AlphaGo won all but the fourth game; all games were won by resignation. The match has been compared with the historic chess match between Deep Blue and Garry Kasparov in 1997.

14: *Obvious* is an art collective based in Paris, France that specializes on the use of AI applications for their works. Headed by Pierre Fautrel, Hugo Caselles-Dupre and Gauthier Vernier, the team regularly collaborates with artists around the globe.