## Strategies for architectural creativity using Artificial Intelligence

Understanding our cognitive processes through statistical learning

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Subjective analysis

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## What is the reciprocity between human and machine cognition? Can we leverage the power of artificial intelligence to enhance our design thinking? **Human Cognition** The development of design concepts based on machine learning can help us gain insights into our own thinking process. The work references important ideas from the fields of AI, creativity and neuroscience, as well as recent accomplishments in "Computational Creativity" to assess the potential for a hybrid thinking at the interface of According to the "Flynn effect", human intelligence increases over time as environments become more complex with growing influx of data (Flynn, 2013). This does not imply an inherent increase of our creative capacity. It is useful, if not necessary, to examine artificial creative processes to better understand our own cognitive mechanisms, vis-à-vis operational protocols in agents which demonstrate "Computational Creativity" (i.e. Generative Adversarial Networks). This work discusses the theoretical potential of A.I. methods to extend the boundaries of architectural design, acknowledging the latter warrants a degree of creative thinking that can be enhanced with machine learning. According to some computer science pioneers like Douglas Hofstadter, a paradigm shift in Artificial Intelligence (1980s) diverted attention from Turing's original hypothesis regarding the ability of machines to think - and, by extension, demonstrate a kind of creativity - to practical applications like software development (Somers, 2013). "Big Data" has enabled deep neural networks to complete generative tasks, allowing computer scientists to perform specialized research outside their respective discipline without relevant professional training(Howard, 2014). This foreshadows a re-structuring of disciplines during the "Fourth Industrial Revolution" (Susskind & Susskind, 2015) raising questions about augmenting our thinking through A.I. Professor Norbert Wiener described the possibility to design machines which simulate - and augment rather than antagonize- human thinking: "It is unquestionably posorigins of Human Creativity sible to construct a machine that will play chess in the sense of following the rules of the game, irrespective of the merit of the play...real problem is intermediate: to construct a machine which shall offer interesting opposition to a player at some one of the many levels at which human chess players find themselves."(Wiener, 1965) Using an example of an artificial intelligence (cycleGAN) which has been trained on a specific domain ("Sagrada Familia" images) for design conceptualization purposes, we offer some observations on the reciprocity between human and computational creativity and cognition. Our intent is to help identify aspects of creative process where one can inform our understanding of the other. An indicator of this synergy is observed in the complex stage of evaluating results generated from a neural network. The affinity between unsupervised learning in neural networks and human learning process underlines the importance of contextualizing machine learning to gain insights into our own thinking. Understanding how semantic features are selected and combined during deep learning processes to transfer stylistic attributes from one visual (architectural or otherwise) domain to another can help us clarify parts of our corresponding processes in the near future. Cognitive Abilities i.e.Computation i.e.Creativity Psychomotor/Sensory Abilities Psychomotor/Sensory Abilitie i.e.Precision; speech recognition Cognititon Human **Machine** Content/Process/System skills Content/Process/System skills i.e.critical thinking; ethics i.e. pattern recognition Social skills **Physical Abilities** i.e.empathy How do we define our (human) creativity in reference to machines? Cognitive scientist Margaret Boden offered four questions, which she called "Lovelace Questions", to help identify the role of computers and AI in the human creative endeavor: "The first Lovelace question is whether computational concepts can help us understand how human creativity is possible. The second is whether computers (now or in the future ) could ever do things that at least appear to be creative..." In response to the first question, Boden believes that understanding computational thinking can provide insight into our own creativity: "My answer to the first Lovelace question is 'Yes'. Computational ideas can help us to understand how human creativity is possible. As we shall see, this does not mean that creativity is predictable, nor even that an original idea can be explained in every detail after it has appeared. But we can draw on computational ideas in understanding in scientific terms how 'intuition' works." M. Boden, The Creative Mind, Myths and Mechanisms (2004) Is human cognition more complex than AI? There may be more similarities or at least, similar constraints between the way humans and machines can learn. In their analysis and critique of the first type of neural network, the "Perceptron", Minsky and Papert claim that more complex tasks, at which humans can perform well, are not learned at the same time, but rather, they consist of small simple tasks which were previously acquired and re-combined to perform the complex task. This is a sort of "combinational creativity", the first kind as described by Margaret Boden "In many situations, humans clearly show abilities far in excess of what could be learned by simple, uniform networks. But when we take those skills apart, or try to find out how they were learned, we expect to find that they were made by processes that somehow combined the work (already done in the past) of many smaller agencies, none of which, separately, need to work on scales much larger than do those in PDP. Is this hypothesis consistent with the PDP style of connectionism?" M.Minsky & S.Papert, *Perceptrons* (1969) Does scaling up neural networks improve their performance? According to the early claims of Marvin Minsky and Seymour Papert, the extapolation of the capability of a one-layer Perceptron to multi-layer ones did not guarantee the transference of the abilities of the former to the latter scenario: "...the computer is so much more than the sum of its parts." M.Minsky & S.Papert, *Perceptrons* (1969) This claim applies to human cognition as well, as the brain's complexity cannot be understood by observing individual parts, or studying the right and left hemimspheres in isolation, as was once believed. Can Al help interface more easily between disciplines to mitigate difficult problems? "Interdisciplinary research is hard. Say you get two world-leading experts, in maths and genomics – there obviously could be some crossover. But who is going to do the work to understand the other person's field, their jargon, what their real problem is?" Demis Hassabis, Deep Mind, Wired Magazine (2019) While this task is still not possible, using AI in an assistive manner to mediate between domains of expertise Subjective Result Assessment: Preferred Results shortlisted based on promise for spatial complexity can really help streamline collaboration of experts in the future. Are benchmarks for evaluating computational creativity Objective or Subjective? To assess an Al's creative capacity we can consider how well the process of domain transfer is applied, and the visual quality of results relative to our specific problem search. The former is an objective factor while the latter is subjective. Can these factors be cumulatively considered? We should note that the best domain translation does not also guarantee an optimum design solution, so intuitive examination of Al-generated outcomes is still important. According to Garry kasparov, the limitations in current AI workflows can be assisted by introducing the human element in the process. By "Intelligent machines have been making great advances thanks to machine learning and other techniques, but in many cases they are reaching the practical limits of data-based intelligence...after decades of trying to replace human intelligence with algorithms, the goal of many companies and researchers now is how to get the human mind back into the process of analyzing and deciding in an ocean of data As with chess programs, which went from knowledge to brute force and then had to tilt back a bit toward knowledge as brute force ran into **Subjective Result Assessment: Intuitive Identification of Spatial Features in selected examples** diminishing returns. The key again is the PROCESS, because that is something that only humans can design...IBM is one of many companies now focusing on "IA", or intelligence amplification, to use information technology as a tool to enhance human decisions instead of replacing them with autonomous AI systems." 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