Exploring the use of artificial intelligence in architecture

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Neural Plan. This plan was designed as an experiment in combining modern and baroque style into a new image. As you can see the result neither resembles Baroque ot Modern explicitly, but rather results in a new plan condition. The estrangement of the plan, based on ideas of defamiliarization and speculative realism. Credit: del Campo, Carlson & Manninger.

Over the past few decades, artificial intelligence (AI) tools have been used to analyze data or complete basic tasks in an increasing number of fields, ranging from computer science to manufacturing, medicine, physics, biology and even artistic disciplines. Researchers at University of Michigan have recently been investigating the use of artificial intelligence (AI) in architecture. Their most recent paper, published in the International Journal of Architectural Computing, specifically explores the potential of AI as a tool to create new architectural designs.

"My partner, Sandra Manninger, and myself, have a long-standing obsession with the idea to cross pollinate the fields of architecture and AI," Matias del Campo, one of the researchers who carried out the study, told Tech Xplore. "We first got in touch with AI research in 1998, when we were introduced to the OFAI (The Austrian Institute of Artificial Intelligence) through a mutual friend, Dr. Arthur Flexer and we held the first course in Machine Learning for Architecture at the University of Applied Arts in Vienna, in 2006."

Several years after they first became interested in the potential uses of AI in architecture, del Campo and Manninger started collaborating with the Robotics Department at University of Michigan. Working with Jessy Grizzle, the department's director, and Alexandra Carlson, one of her Ph.D. students, they were able to significantly expand their research. Their study featured in the International Journal of Architectural Computing is the latest of a series of research efforts in which they investigated the use of AI techniques for designing architectural solutions.

"Our past papers, including 'A Question of Style', 'Imaginary Maps' , and 'Machine Hallucinations' form the backbone of our recent study," del Campo said. "The main objective of all these works was to open AI for architecture applications and there are several opportunities to do so. They cover an area that reaches from solutions for optimization

problems, to novel territories for the interrogation of philosophical questions such as aspects of agency, authorship and sensibility. In our opinion, this is the very first genuinely 21st century design technique."

Initially, the researchers evaluated the performance of the simplest existing neural networks available on 2-D-to-2-D neural style transfer tasks. These tasks essentially entail changing one image (i.e., the target image) so that it matches a specific style. This could mean, for example, changing a drawing so that it reflects the style of a specific painter, such as Vincent van Gogh. In their work, del Campo, Manninger and their colleagues specifically tried to use neural networks to transform designs so that they matched a specific architectural style (e.g,, modern or baroque).

The Robot Garden. This project is a testing ground for bipedal robots. The Robotics Department of the University of Michigan was the client for this

project, which is the first architecture project that was designed entirely using Neural Networks. Credit: del Campo, Carlson & Manninger.

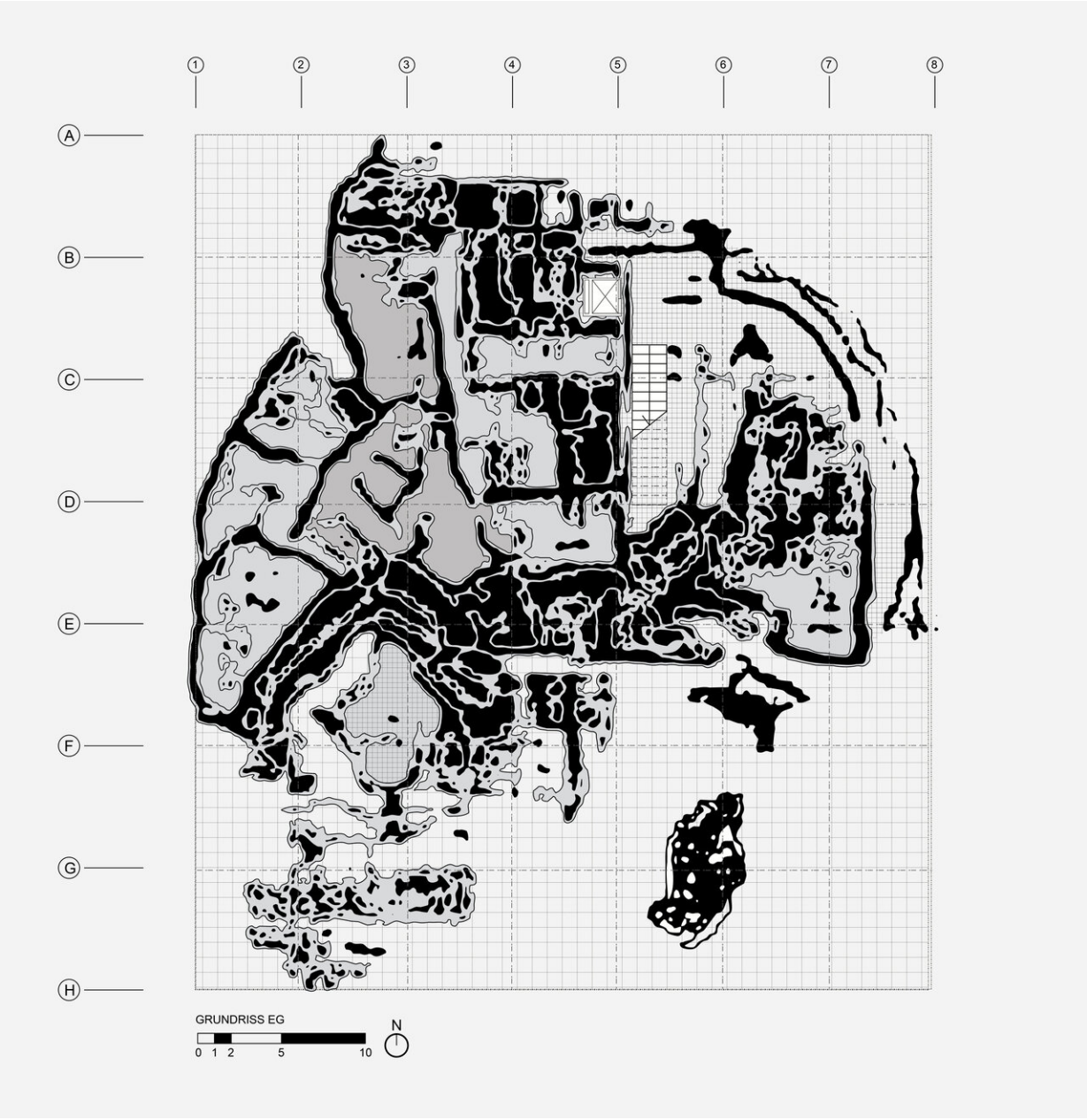
"We later started experimenting with 2-D to 3-D style transfer, where you can transfer the style to a mesh model," del Campo explained. "We very quickly realized that doing just 2-D work is not going to get us far considering the inherently 3-D nature of architecture. We are currently exploring a purely 3-D convolutional neural network (CNN) that is trained on an extensive database of OBJ models."

Del Campo compiled a dataset that contained several 3-D models he created, saved as OBJ files (i.e., a format that can be opened and exported in numerous 3-D image editing programs). He then labeled this data and used it to train a CNN. When trained on this dataset, the CNN should learn to change architectural designs so that they match the typical style of del Campo's work.

"The idea behind this method of creating a training dataset is that if it works, a CNN should be able to generate models that are close to my inherent sensibility as a designer, but nonetheless were not created by me," del Campo explained. "This is again one of the areas where discursive implications are at play. Who is the author? Is it me, as I created and labeled the database? Is it the algorithm or the programmer who developed the algorithm? It is certainly more of a bottom-up design method than a top-down one."

In their paper, del Campo and his colleagues provide an example of how generative adversarial networks (GANs) could be used to produce architectural designs. They also outline a project that is still ongoing, called Robot Garden, which is aimed at creating a testing ground for bipedal robots developed at University of Michigan.

"In the Robot Garden, we tested for the first time whether we can 'dream' or 'hallucinate' topographic and architectural features onto a given site," del Campo said. "When we talk about dreaming or hallucinating, we don't mean that in an esoteric way, but rather pick up on terminology from computer science, which they themselves borrowed from neuroscience."



24 Highschool Project, Shenzhen, China. A project based on AttnCNN's. Attention Generative Adversarial Networks allow to use language as driving force for the design of the project. Credit: del Campo, Carlson & Manninger.

In their recent study, del Campo and his colleagues evaluated the ability of specific algorithms to create 'hallucinated' or 'imagined' designs. These include algorithms such as DeepDream, a neural network-based model that can emulate the brain processes that allow humans to have psychedelic or fantastical dreams.

To conduct their experiments, the researchers compiled datasets containing images with different architectural and topographic features. Subsequently, they trained a DeepDream algorithm on these images so that it could 'hallucinate' these features onto an existing architectural site.

"Interestingly, the results we got were highly inspirational albeit not directly translatable to a design," del Campo said. "We realized that there is something the human brain can do that AIs cannot do so well yet: recognize the potential of turning an error into a creative solution. This capability is enabled by the mis-readings of our mind, the false firing of the neurons in our brains, the weird way how shortcuts in our mind create the 'eureka' moment. Currently, we are exploring how 'misfits' in the computational process can intentionally be used for creative design."

The recent work by del Campo, Manninger and their colleagues highlights new exciting possibilities for the introduction of AI tools in architecture. At the moment, the researchers are testing a series of AI techniques that could aid 3-D architectural design, collaborating closely with AI experts at Michigan Robotics.

Del Campo and Manninger are also writing two books focusing on the use of AI in architecture, which are set to be published in 2021 and 2022. The first book discusses the theoretical implications of using AI to produce architectural designs, touching on aspects such as agency, authorship and design in a post-human/automated world. The second book, on the other hand, outlines the technical aspects associated with the use of AI in architecture.

"In general, my co-authors and myself are very generous with sharing our know-how, providing free access to the methods via our YouTube channel," del Campo said. "My practice (SPAN) is applying the newly developed methods in design tasks. The robot garden is most likely the first built architecture project based on neural networks. In addition to this architecture, we designed a competition entry for a big high school this summer based on an AttnGAN. A paper outlining this process and our findings will be published soon."

More information: Towards hallucinating machines- designing with computational vision. *International Journal of Architectural Computing*(2020). DOI: 10.1177/1478077120963366.