

Application of Artificial Intelligence in Architectural Generative Design

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In this workshop, data-driven models will be discussed and how they could change the way architects think, design and analyse. Both supervised and unsupervised learning models will be discussed and different projects will be referred as examples. Deep learning models are the third part of the workshop and more specifically, Generative Adversarial Networks will be mentioned in more detail. The GAN's open a new field of generative models in design which is based on data-driven process and we will go into detail with GANs, their branches and how we could test a sample architecture generative problem with GANs.

Keywords: *Artificial Intelligence, Machine Learning, Generative Design, Knowledge based Design, GAN*

INTRODUCTION

Rule-based design and analysis models have been one of the mainstreams of scholars in the last few decades. Some of these researches have acquired good results, but they still have several disadvantages especially when they deal with multi objective functions. Most architectural design problems could be considered as nondeterministic algorithms. In these problems, we could have several possible answers for the same input. For instance, designing an architectural layout could have several correct solutions and there is no absolute one correct answer for this case. Considering a specific objective function could lead to an optimization problem with one exact answer but design problems deal with multiple objectives which they are usually hard to be expressed as numerical objective functions. On the other hand, there are some influential design parameters which could not be expressed as numerical pa-

rameters. In this workshop, we will focus on artificial intelligence models and how they are used in the field of generative design. Some of the influential researches will be discussed and particularly GANs will be discussed in detail. GAN stands for generative adversarial networks and it has been introduced by Ian Goodfellow in 2014. Since then other researchers have worked on GANs and they have introduced new branches on GAN which are used in the generative design. Basically, GANs are used to generate synthesized data. The models in the GANs are trained on an available dataset. In this workshop, we will work on architectural plans and we will see how we could train a GAN model based on available architectural plans and finally predict the probability of space allocation on a new architectural boundary.

BACKGROUND

Researchers from artificial intelligence community have already put many efforts to generate synthetic data with deep learning techniques. A group of researchers in Stanford University use the generative adversarial networks to design shoes (Deverall, Lee et al. 2017). They use trained GAN models with shoe dataset to generate synthetic shoe designs for preliminary steps. A group of scholars in Berkeley AI Research Laboratory, propose Cycle-Consistent Adversarial Networks for an unpaired image to image translation (Zhu, Park et al. 2017). In their research, they present a method which could generate synthetic data similar to input image but in a new style. Leon Gatys and his research team worked on generating synthetic artistic style photos (Gatys, Ecker et al. 2015). Conditional cycle-GANs were also used to generate synthetic face photos (Lu, Tai et al. 2017). More specifically in the field of architectural design, some scholars study the application of deep learning in segmentation tasks. Samuel Dodge applies fully convolutional networks (FCN) for wall segmentation in architectural layouts. In his paper 'Parsing floor plan images' (Dodge, Xu et al. 2017), he proposes an FCN-2s with a 2-pixel stride layer architecture to gain the best result in wall segmentation. Some other scholars (Ahmed, Liwicki et al. 2012) use the deep learning architectures for automatic room detection task. In the field of architectural generative design, the Autodesk company is leading a research group focusing on generative design & AI. Autodesk's new Toronto office is one of the first examples of a generatively designed office space (Nagy, Lau et al. 2017).

WORKSHOP SCHEDULE

During the first 4 hours, we will discuss the models in artificial intelligence and specifically the most recent developments. We will focus on deep learning models that relate to architectural generative design. On the second 4 hours we will discuss GANs and on our first experience, we will work on training a model based on our architectural plans dataset. On this workshop, we will experience how the GAN model

could generate a heat map representing the probability of space allocation on a given boundary. On the third 4 hours (second day), we will experience interactive GAN model which could help the users design their desired plan boundary and the model generates the most possible plan.

SKILLS ACQUIRED BY PARTICIPANTS

The participants will learn about machine learning models and how they could be applied for an architectural task. They will learn about generating synthetic data which could be very useful in generative design. They will also learn GAN in detail and how they could be used for design and analysis tasks.

EXPECTED OUTCOMES

In the workshop the participants will work on architectural layout design and they will be able to generate a probability layout design heat map and they will learn how to integrate the vector interface of Rhinoceros with GAN models.

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