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A Deep Learning Approach for Pedestrian Wind Comfort Prediction in the Early Design Stage

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An increasing presence of high-rise buildings causes problems regarding the wind climate in our cities. When planning new developments, pedestrian wind comfort is an important consideration. Wind comfort assessments with traditional computational fluid dynamics (CFD) methods are computationally heavy and time consuming, requiring expert knowledge. The high cost means that wind analysis is often postponed to later design stages, while ideally many different building configurations should be tested early in the planning and design process, when high-level changes can still be made. This research focuses on integrating wind analysis in the early stages of building design and urban planning to allow for informed decision making. In these early stages, identifying potential problem areas around the development(s) – using less precise information – is more important than highly accurate analysis results complying with codes and guidelines. This level of data reliability can possibly be achieved using machine learning techniques.

We propose a deep learning approach using the Pix2Pix model which is based on a conditional generative adversarial network (cGAN). The model setup follows a three-step approach. First, training and test data are generated using OpenFOAM wind simulations. The simulation result is then converted into a set of images: the first containing building height information for each of the buildings present in the scene, the second representing the calculated wind speeds. Next, the model is trained on this data and evaluated on a randomly selected hold-out validation set. The results of this validation are used to inform model optimization. Finally, the model performance is evaluated on a separate test set.

The trained model can provide near-instant predictions, considerably lowering the cost of a pedestrian wind comfort assessment. Additionally, the trained model can be integrated in parametric design workflows through Grasshopper3d, making it available and easy-to-use for designers. Metrics are derived from the model prediction to indicate the effect of the current building configuration on the pedestrian wind comfort. Initial tests show that the model outputs are promising. Results for a real use case did show that the model – trained on parametrically generated cityscapes – can identify areas with high wind speeds. Adding a transfer learning component to the workflow could allow for even more accurate predictions.