Aerodynamic Shape Tailoring of Buildings: A Fusion of CFD, Stochastics, Machine Learning and Beyond

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1 Abstract

Tall buildings exposed to wind undergo complex interactions, which precludes a functional relationship between wind and its load effects. Accordingly, wind tunnels have traditionally served as a means of quantifying wind loads. In digital age with burgeoning growth in computational resources and parallel computing advances in computational fluid dynamics, computational simulations are evolving with a promise of becoming versatile, convenient and reliable means of assessing wind load effects. The major challenge to such an initiative has been the wind field around the structures marked by separated flows, which requires high fidelity simulation schemes to capture extreme loads, thus placing a high demand on computational resources. The emerging trend is to use a combination of CFD, stochastic emulation and machine learning approaches to overcome some of these challenges.

This paper will utilize this digital simulation approach to mitigate motion of tall buildings through shape morphing. It will illustrate a practical example involving shape optimization of buildings. To go beyond static optimization to mitigate wind effects, a brief overview of the fusion of sensing, computations and actuation in a cyberphysical space to autonomously morph structures to adaptively undergo shape changes in response to changes in coming wind conditions will follow.

Keywords: tall buildings; computational fluid dynamics; stochastic emulation; machine learning; aerodynamic shape tailoring; autonomous morphing.

2 Introduction

The current trend in building design is to build increasingly taller, more aesthetically appealing and complex structures that represent landmarks of our time. Nonetheless, these buildings face many challenges due to their height and performance-oriented design objectives. Mitigating the intensity of the governing wind loads through intelligent tailoring of their external geometric form can therefore offer many economic advantages. The current practice for the aerodynamic shape optimization of tall buildings consists in selecting the best performing geometric profile from a limited set of possibilities for which specific wind tunnel tests have been carried out. Although this

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