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Prediction of aerodynamic forces of bridge decks using artificial neural networks

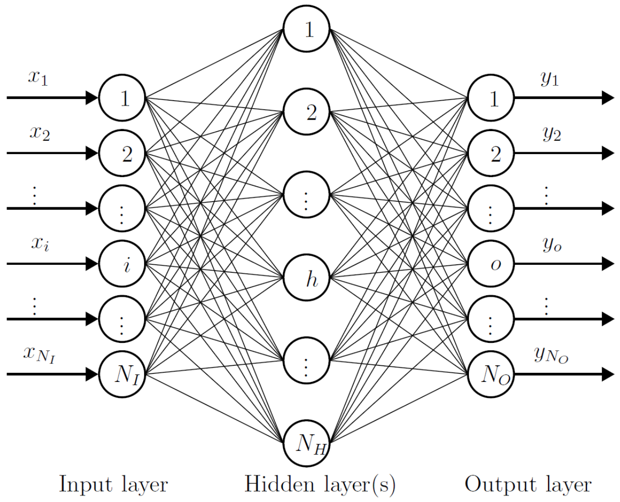
Abstract

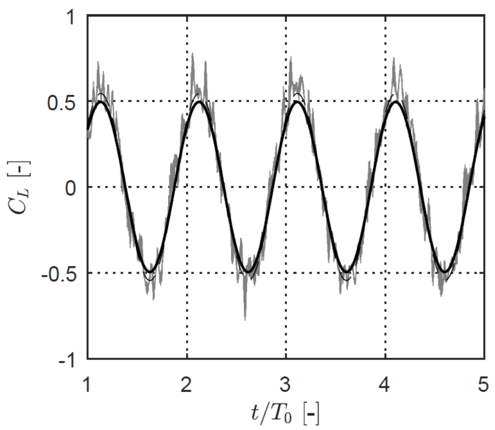
The aeroelastic behavior of slender structures such as long-span cable-supported bridges is essential to be studied as part of their design as they can develop significant vibrations when exposed to atmospheric wind flow. The trends for increase in the flexibility and reduction of mass of structures make such problems more prominent and the analysis more challenging, thus amplifying the need for accurate, robust and efficient prediction models.

Aerodynamic behavior for the design of long-span bridges is traditionally studied through wind tunnel tests (WTT). However, these tests are expensive and time consuming. Numerical methods have gained much attention and development in the last few decades and are used as alternatives to analytical and experimental methods. Typical numerical simulations run on standard computers still require several days to complete.

An efficient approach to quantify aerodynamic forces has been presented using Artificial Neural Networks (ANN). The approach uses measured response and force time histories to train an appropriate ANN for a bridge deck section. The ANN is trained with data generated from Computational Fluid Dynamics (CFD) simulations performed on the deck section. The input to the ANN is section geometry, reduced speed, and response history. The output of the ANN is the force time histories which is consequently used to compute aerodynamic parameters.

The developed ANN has been tested for training and novel data which provides reasonably well prediction. The choice of appropriate network parameters is also highlighted in view of the quantity of interest. The aim of this paper is to show a methodological framework for robust and efficient prediction strategies for complex aerodynamic phenomena using hybrid models that employ numerical analyses as well as ANN. The methodology can be used to estimate aerodynamic parameters at the planning stage.





(top) Schematic of a typical multilayer artificial neural network (bottom) Comparison of aerodynamic force and moment time histories: (——) measured from CFD, (– –) least-squares fit, (——) prediction from ANN.

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