Data-driven reduced order model for rotorcraft noise

Background:

Rotorcraft designers are constantly striving to improve rotor designs in order to minimize, among other things, their acoustic impact. The prospect of electrical vertical take-off and landing aircraft (eVTOLs or ‘air-taxis’ in common jargon) becoming common place in the coming years in major urban cities around the world has potential for air traffic to get especially noisy. Most proposed eVTOL designs currently under investigation envisage rotors placed around the aircraft in different configurations presenting potential for using rotor noise as an optmisation metric during the design stages itself i.e. opting for the placement of rotors around the aircraft that minimizes total noise. An alternate, and more promising strategy, entails controlling rotor RPM, thrust distribution between the different rotors etc. in order to minimize rotor noise in real-time during flight. However, even mid-fidelity acoustic noise estimation of a rotor is at least an order of magnitude slower compared to real-time. Therefore, closed-loop real-time flight control with noise emission as an objective requires a reduced order representation of the acoustic influence of the rotor on it surroundings.

Description and Goal:

The Institute of Helicopter Technology extensively works with analyses of rotorcraft systems in their entirety. In particular, an open-source framework Helinoise (https://github.com/kumar-sumeet/helinoise) already combines multiple tools to conduct acoustic analyses of rotors, with focus on helicopter rotors. Rotor acoustic analysis is essentially a post-processing exercise that involves solving the fluid-structure interaction problem of the flexible rotor blade moving through the air and interacting with it. Once a converged solution of the blade motion and the aerodynamic loads is achieved the results can be fed through to the Helinoise toolchain to obtain the acoustic pressure perturbation at a given location or a domain i.e., the rotor noise map can be obtained. Commonly, a high-resolution representation of the blade motion and the loads is used as input. However, given that the problem at hand essentially represents a dynamical system, and a periodically rotating one at that, a lower order representation exists and common data reduction techniques such as Proper Orthogonal Decomposition (POD) and Dynamic Mode Decomposition (DMD) can be adopted to identify the lower order modes without identifying appropriate bases to begin with. The goal of the proposed project is to use high-dimensional data used as input to the acoustics solver and identify lower order modes that can represent the problem with sufficient fidelity while simultaneously speed-up analysis time in order to be used in real-time applications.

Input – time-series blade surface node position vectors and normal vectors, time series blade loading vectors.

Output – time-series periodic acoustic pressure perturbation at a location or equivalent decibel-scale representation

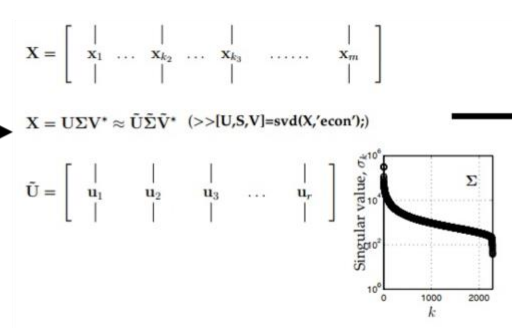
Skills:

Basics of rotorcraft physics/acoustics helpful but not necessary. The student will be brought up to speed with relevant concepts as the project progresses. Stronger emphasis on knowledge of linear algebra

Tools: Python

Language: English

Start: As soon as possible



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