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This paper is about development and use of a research based stereo vision system for vibration and operational modal analysis on a parked, 1-kW, 3-bladed vertical axis wind turbine (VAWT), tested in a wind tunnel at high wind. Vibrations were explored experimentally by tracking small deflections of the markers on the structure with two cameras, and also numerically, to study structural vibrations in an overall objective to investigate challenges and to prove the capability of using stereo vision. Two high speed cameras provided displacement measurements at no wind speed interference. The displacement time series were obtained using a robust image processing algorithm and analyzed with data-driven stochastic subspace identification (DD-SSI) method. In addition of exploring structural behaviour, the VAWT testing gave us the possibility to study aerodynamic effects at Reynolds number of approximately $2 \times 10^5$. VAWT dynamics were simulated using HAWC2. The stereo vision results and HAWC2 simulations agree within 4% except for mode 3 and 4. The high aerodynamic damping of one of the blades, in flatwise motion, would explain the gap between those two modes from simulation and stereo vision. A set of conventional sensors, such as accelerometers and strain gauges, are also measuring rotor vibration during the experiment. The spectral analysis of the output signals of the conventional sensors agrees the stereo vision results within 4% except for mode 4 which is due to the inaccuracy of spectral analysis in picking very closely spaced modes. Finally, the uncertainty of the 3D displacement measurement was evaluated by applying a generalized method based on the law of error propagation, for a linear camera model of the stereo vision system.

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