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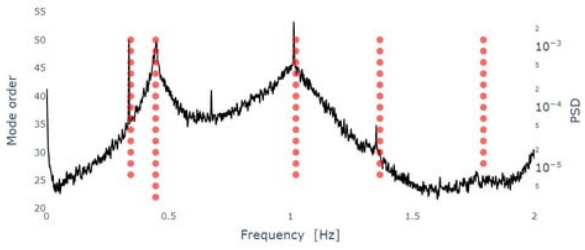
Use of the operational modal analysis as a tool for the monitoring of the structural health of wind turbines

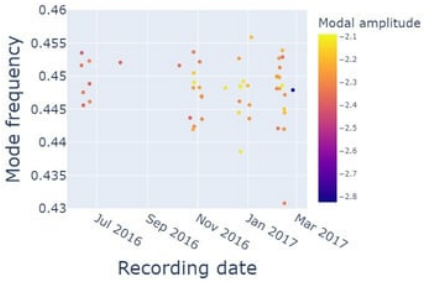
1/ Presentation of the operational modal analysis

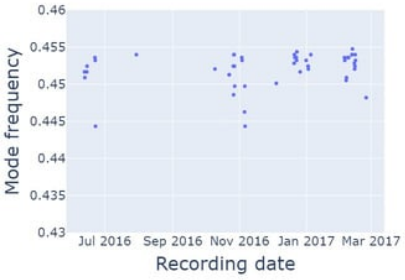
Operational modal analysis (OMA) is a time-domain method using natural structure excitations such as the wind, waves, human activity to extract modal information (frequency, damping, amplitude) from a given structure. The upside from that method is that no human-performed tests are required and that the monitoring is global and not on specific parts. Therefore, a continuous monitoring of a given structure subject to a frequent natural excitations allows us to follow the modal behaviour of this structure and detect if a structural defect is present. This method is applied to two wind turbines to examine the time stability of their modes and is compared to the frequency-domain method called pick peaking.

2/ Onshore wind turbine A

The signals used as input are from a single axis accelerometer located on the nacelle, on an axis parallel to the main drive and are 6 hours long. A modal operational analysis provides this kind of result for a given signal. In black is the PSD of the signal and in red are the stable poles found by the method. The mode around 0.45 Hz is often clearly seen in the signals and is monitored in this study. The time evolution of this modal frequency, obtained by both peak picking and OMA, are presented below. The colormap on the right is the power of magnitude of the modal amplitude. The colormap on the OMA plot is the power of magnitude of the modal amplitude. Both methods yields similar results with a mean frequency of 0.452 Hz with the peak picking and of 0.448 Hz with OMA.

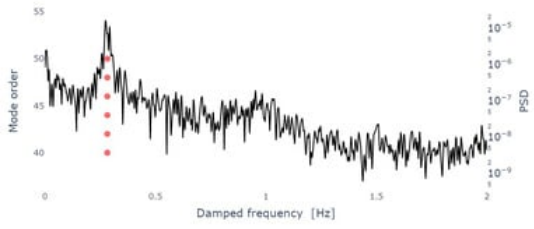


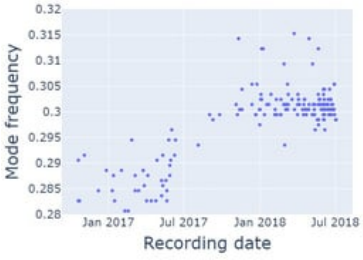


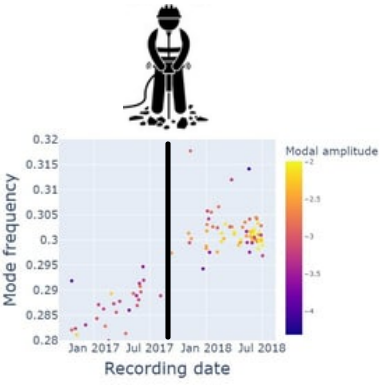


3/ Onshore wind turbine B

The signals used as input are from a single axis accelerometer located on the nacelle, on an axis parallel to the main drive and are 512 seconds long. The topic of that study is the mode found around 0.3 Hz which is the most visible among the collected data. Here are again the time evolution of the modal frequency using peak picking and operational modal analysis. Both results are very close. Moreover a clear shift from 0.285 Hz up to 0.3 Hz is seen around August 2017 when a reparation on the foundation was performed. It can be assumed that any decrease from this modal frequency in the future would mean the presence of a defect and the need of another reparation.







4/ Conclusion

This study has shown the potential of the operational modal analysis to monitor the structural health of onshore wind turbines. Its efficacy on offshore wind turbine is expected. It obtains equivalent result to the frequency-based peak picking method while adding more information such as the modal amplitude and the modal damping. The exploitation of data from several accelerometers is the next step, this would allow the monitoring of the evolution of the modal shapes or features correlated to modal shapes.