Structural Assessment of Offshore Wind Turbines Using Remote Sensors

Justin Dworacek, Dr. Adriana Trias-Blanco

Rowan University

INTRODUCTION

This research aims to analyze the effectiveness of implementing a novel dynamic structural analysis technology for evaluating the integrity of offshore wind turbines subjected to lateral forces, such as high-speed winds and wave impact, using state-of-the-art remote sensors, particularly Light Detection And Ranging (LiDAR). The research implements mounted accelerometers, a proven and reliable traditional method, for validation purposes.

OBJECTIVE

This research aims to provide a full-field characterization of the structural dynamics of offshore wind turbines through the implementation of a mobile LiDAR sensor, which involves frequency, deflection amplitude, and mode shapes.

METHODS/TECHNOLOGIES

To achieve the objectives of this research, a physical model of a wind turbine was designed, constructed, and subjected to lateral motion. The tower was built using galvanized steel, wood for the blades, and a compact CD motor in the nacelle. During the data collection, two sensors were implemented: (a) a mobile LiDAR and (b) wireless-mounted accelerometers. To simulate the lateral forces, the tower was placed on top of a shake table, which was set to operate at the following frequencies: 1, 2, 2.7, 3, and 4 Hz. Once the data was collected, it was analyzed using Microsoft Excel (Fast Fourier Transform) and CloudCompare (estimations of deflection and number of cycles).

RESULTS

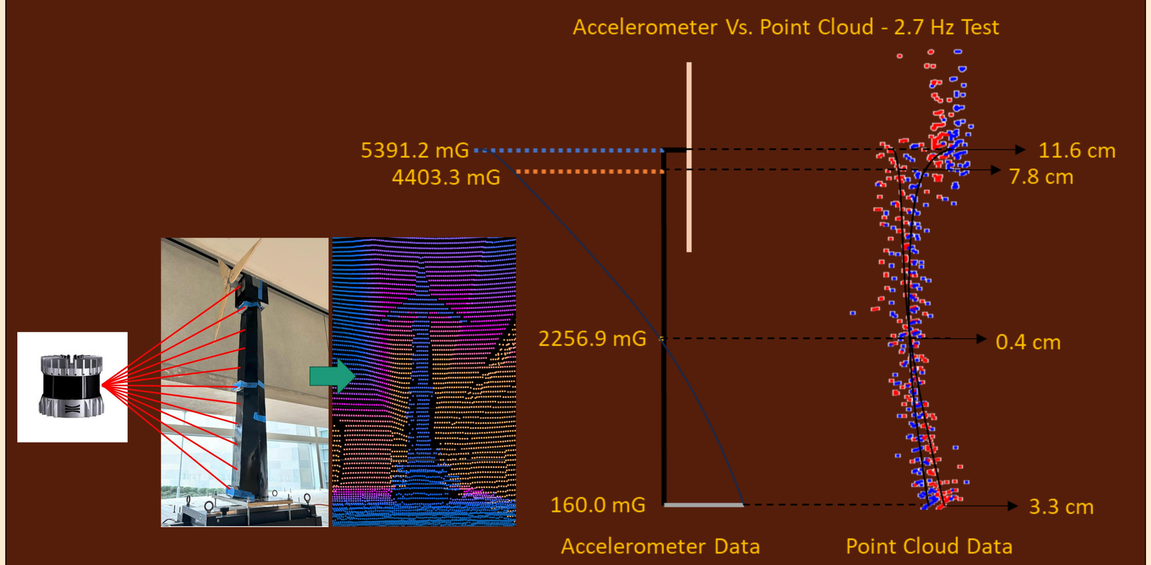
The data collected via the LiDAR sensor is recorded in the form of point clouds. This data was analyzed through CloudCompare by measuring the amplitude of the vibrations, mode shapes, and measured frequencies for each shake table setting. The results found that the measured frequencies were at 1, 2, 2.5, 3, and 4 Hz through the Point Cloud data, and 0.977, 1.709, 2.686, 2.832, and 3.809 Hz through the accelerometer data. The graphs on the right showcase the data both sensors collected.

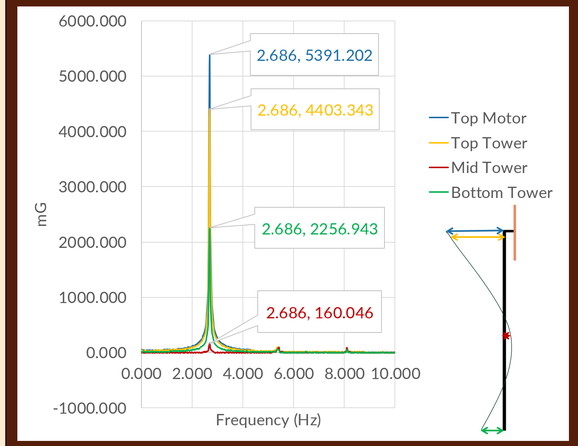
DISCUSSION

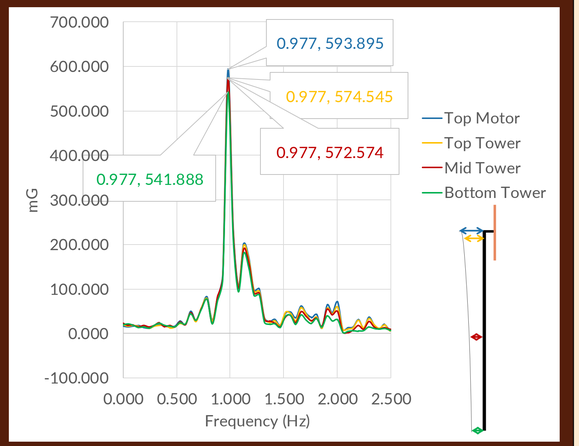
It is important to highlight that this is a novel implementation of mobile LiDAR data; this research presents pioneering steps in the path of its implementation for characterizing the full-field dynamics of wind turbine. The current point cloud data analysis method has a precision of 0.5 Hz. Therefore, further refinement of the method is needed to increase the accuracy of its results. Implementations of this method could combine the use of drones as platforms to reach the tower within the operating range of the scanner.

AUTHORS AFFILIATION: Rowan University

ACKNOWLEDGEMENTS: A big thank you to the NJEDA and Rowan University for the research funds and for providing this amazing opportunity. Dr. Adriana Trias-Blanco for her guidance, expertise on the materials and software used, encouragement, and suggestive feedback on the project.







The following table presents the overall results gathered from the dynamic tests set to perform at 1, 2, 2.7, 3, and 4 Hz. The results from the accelerometer and LiDAR sensor are presented with the corresponding percent error.

	Frequency (Hz)				
Theoretical	1	2	2.7	3	4
Accelerometer	0.977	1.709	2.686	2.832	3.809
% Error	-2%	-15%	-1%	-6%	-5%
LiDAR	1	2	2.5	3	4
% Error	0%	0%	-7%	0%	0%

Contact: Justin Dworacek
justindworacek@gmail.com

SCAN ME