Detecting Deviating Cells (DDC): An Outlier Filtering Approach for Unsupervised Damage Detection in Wind Turbines

Holger Cevallos-Valdiviezo[*], Christian Tutivén[†,‡], Yolanda Vidal[‡] and Moisés Benítez[*]

[*] Facultad de Ciencias Naturales y Matemáticas, FCNM
Centro de Estudios e Investigaciones Estadísticas, CEIE
Escuela Superior Politécnica del Litoral, ESPOL
Campus Gustavo Galindo Km. 30.5 Vía Perimetral, P.O. Box 09-01-5863, Guayaquil, Ecuador
Phone number: +593 9 9103 5259,
e-mail: {holgceva, moibsori}@espol.edu.ec,
web page: https://www.espol.edu.ec

[†]Mechatronics Engineering
Faculty of Mechanical Engineering and Production Science, FIMCP
Escuela Superior Politécnica del Litoral, ESPOL
Campus Gustavo Galindo Km. 30.5 Vía Perimetral, P.O. Box 09-01-5863, Guayaquil, Ecuador
Phone number: +593 9 9103 5259,
e-mail: cjtutive@espol.edu.ec,
web page: https://www.espol.edu.ec

[‡]Control, Data, and Artificial Intelligence, CoDAlab
Department of Mathematics, Escola d'Enginyeria de Barcelona Est, EEBE
Universitat Politècnica de Catalunya, UPC
Campus Diagonal-Besós (CDB) 08019, Barcelona, Spain
e-mail: yolanda.vidal@upc.edu,
Web page: https://www.upc.edu/es

Key Words: wind turbine, structural health monitoring, damage detection, outlier filter

ABSTRACT

Structural health monitoring (SHM) plays a crucial role in ensuring the operational safety and performance of wind turbines. Detecting damage in a timely manner is essential for minimizing downtime, mitigating risks, and ensuring the sustained reliability of wind energy systems. In this study, we propose a novel data-driven approach for early damage detection in wind turbines utilizing the unsupervised outlier filter called "Detect Deviating Cells (DDC)". The proposed approach leverages triaxial accelerometer data collected from experimental wind turbines. By constructing a data matrix with columns representing triaxial accelerometer measurements and rows representing different time points, we apply the outlier filter "Detect Deviating Cells (DDC)" to identify wind turbines with potential damage and determine the location and time at which the potential damage occurred through the detection of anomalous accelerometer measurements (cellwise outlier detection). To evaluate the performance of DDC, we utilize information on the health status of each experimental wind turbine. Our experimental results demonstrate the promising potential of DDC for damage detection in wind turbines. Notably, DDC is an unsupervised technique that does not require prior labeling of wind turbine health status. This characteristic makes DDC suitable for SHM applications where the initial status of wind turbines is unknown, and the majority of the data may originate from healthy turbines. Furthermore, DDC can be applied to recently acquired data, enabling timely detection of damages without the need for costly and time-consuming on-site inspections. This capability facilitates prompt repair actions and contributes to an effective, fast, and cost-efficient alternative for SHM. Wind turbine operators can utilize our approach to mitigate risks, optimize maintenance plans, and ensure the sustained reliability of wind energy systems.