A comparative performance evaluation framework for power based wind turbine fault detection methods

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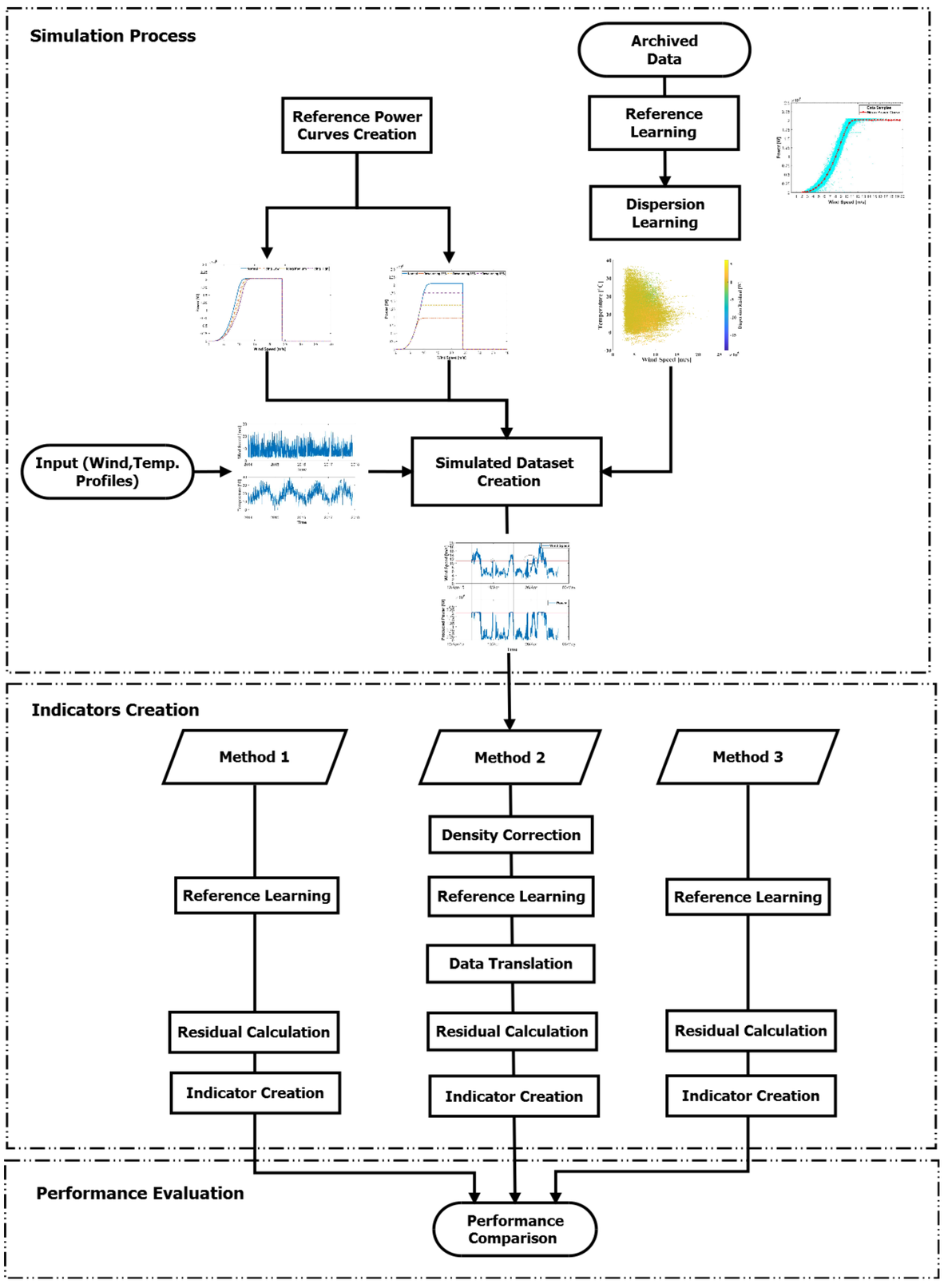
Abstract

Wind turbine (WT) operations and maintenance (O&M) teams need reliable, comprehensive and robust condition monitoring tools. Both the industry and research has seen increasing interest in the use of already installed Supervisory Control and Data Acquisition (SCADA) system data for the condition monitoring of WTs due to the availability, familiarity, cost effectiveness, relative ease of exploitation and interpretation. Maximizing power production whilst reducing downtime and maintenance costs is at the core of any condition monitoring strategy. The power based wind turbine condition monitoring systems using SCADA data as presented in the literature neither provide a comprehensive performance comparison, nor do they converge to a recommendation for best practice implementations through comparative benchmarking. This gap motivates a comprehensive performance evaluation analysis of existing solutions through an array of diverse scenarios. This rigorous analysis framework has the potential to aid with systematic transition towards generalizable condition monitoring solutions.

Objectives

- Development of a realistic simulation framework to enable rigorous analysis.
- Identification of key phenomena affecting fault detection performance.
- Comparative performance evaluation of existing fault detection methods.

Proposed Framework



Overview of the proposed simulation framework

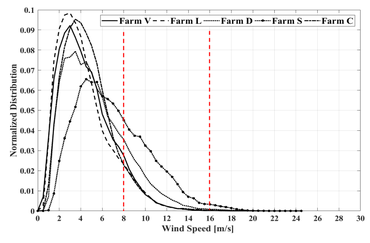
Implementation: Fault Detection Methods

A wide ranging source of data from 5 wind farms is used for analysis.

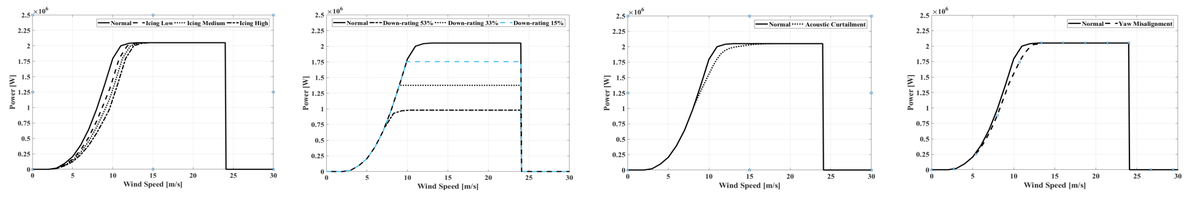
TABLE I. DATA BASE SUMMARY

Wind Farms	Wind Farm Characteristics		
	# of WTs	*Location* [a]	*Year*
Farm- V	6	Center-North	2014
Farm - L	3	Center-East	2014
Farm - D	6	Center- North	2010
Farm - S	5	South	2009
Farm- C	5	West	2010

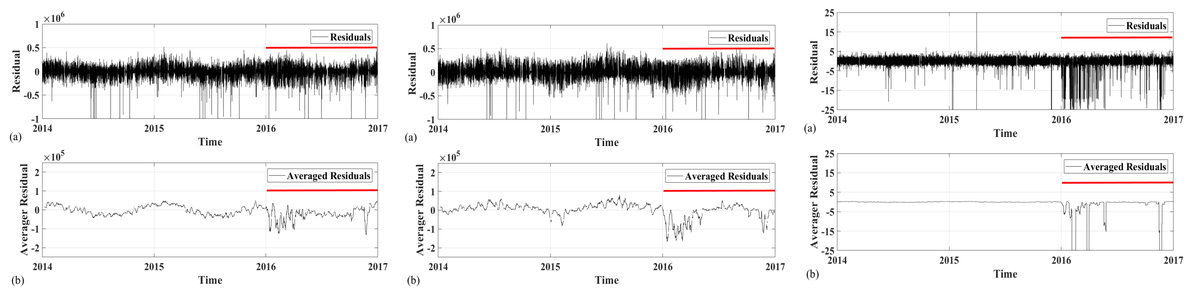
a. within Mainland France



Fault scenarios evaluated are realistic and representative of real life scenarios.

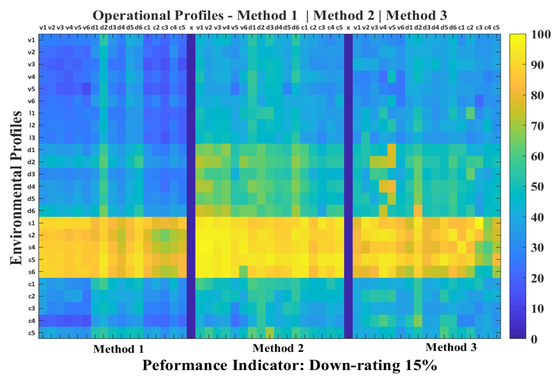


Three methods of fault detection from the literature are used to calculate residuals.

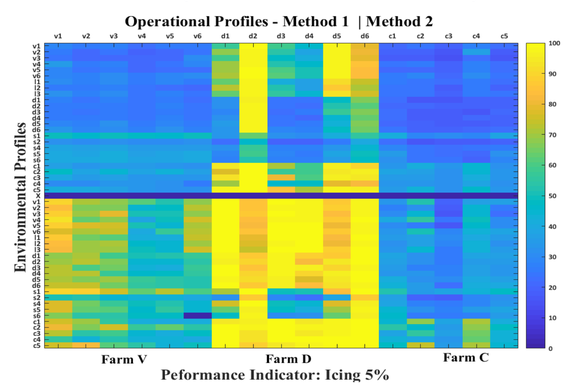


Results: Performance Evaluation

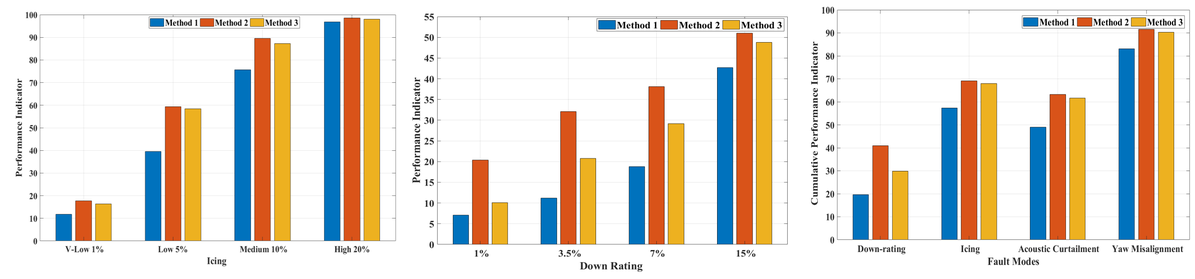
Performance Indicators calculated are presented below. (For details see ref. 4)



Environmental Profiles	Method 1	Method 2	Method 3
Farm V	26,61	40,99	36,24
Farm L	27,14	44,17	39,40
Farm D	37,86	58,40	52,45
Farm S	83,81	91,90	82,69
Farm C	35,16	46,83	43,13



	Farm V	Farm D	Farm C
Method 1	30,57	61,68	25,41
Method 2	50,31	88,78	37,38



Conclusions

The work presents a framework for performance analysis to enable a realistic, controlled and critical comparison of existing fault detection methods. This simulation framework and power based fault detection methods are used to identify and quantify the impact of environmental & operational variations on fault detection performance. A robust and comprehensive performance analysis, achieved using multiple power based fault scenarios of various intensities, geographically distant data sources and different condition monitoring solutions lay the foundation for transition towards an industrial fleet level implementation.

References

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3. Cambron, P., Lepvrier, R., Masson, C., Tahan, A., & Pelletier, F. (2016). Power curve monitoring using weighted moving average control charts. *Renewable Energy*, *94*, 126–135. https://doi.org/10.1016/j.renene.2016.03.031
4. U. Aziz, S. Charbonnier, C. Bérenguer, A. Lebranchu, and F. Prevost, "Simulation of wind turbine faulty production profiles and performance assessment of fault monitoring methods," p. 8, 2018.