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Automatic detection of turbine de-rating using image processing and machine learning techniques

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Abstract

This paper presents a novel, cheap and efficient approach for automatic detection of turbine de-rating based on historical 10min SCADA data and alarm logs.

The proposed method combines image processing and machine learning techniques. The method is fast and robust and has been validated on more than 250 turbine-years of data.

Objectives

De-rating is often not included in 10 min SCADA nor turbine logs. This noise affects analysis of power or torque curves.

The objective of the work was to design, implement and validate a robust method that automatically detects the periods of time when a de-rating is applied.

Identification of these periods allows the generation of a clean dataset for the tracking of the evolution of typical characteristic curves (power, torque or pitch curves).

Methods

Step 1: Based on the alarm logs, the 10 min technical availability is computed.

Periods with a technical availability lower than 100% are removed (Figure 1).

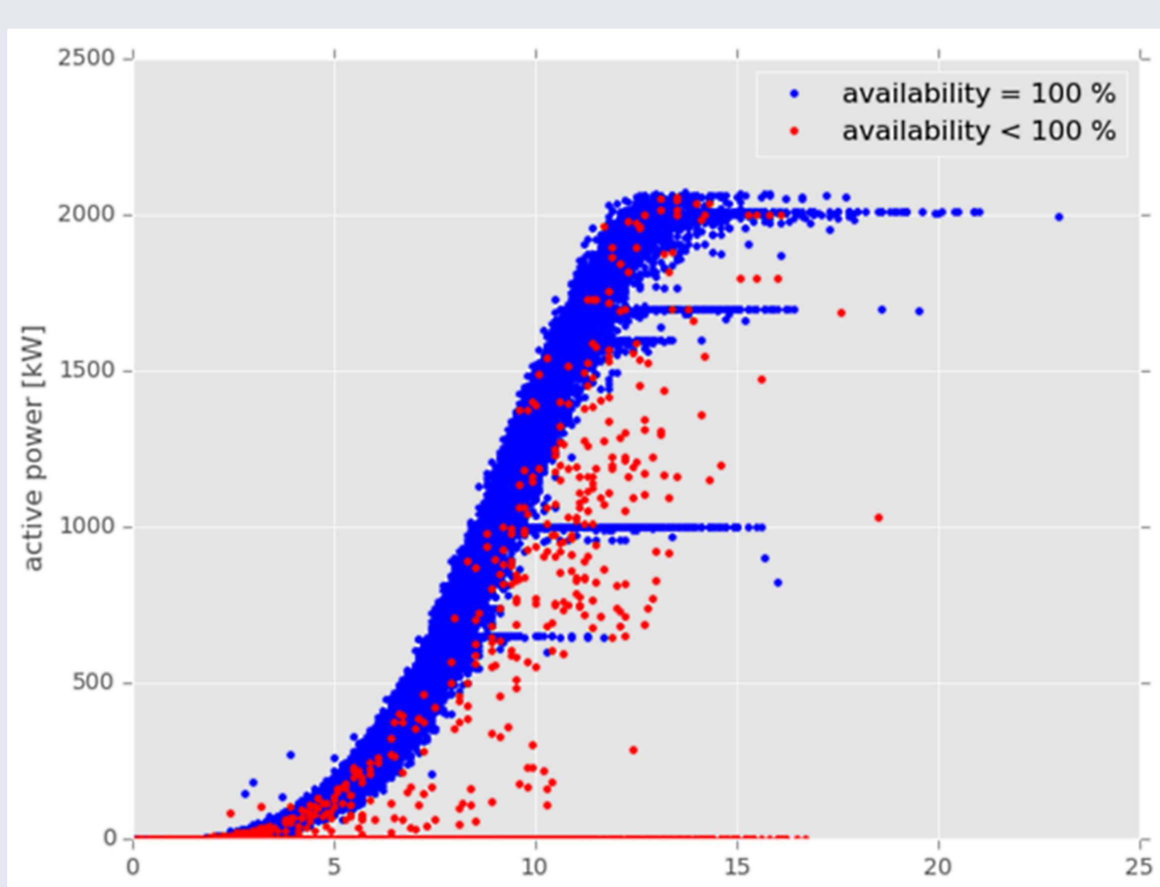

Figure 1 : Scatter plot of power curve as function of technical availability.

Step 2: The scatter plot of wind speed versus power is converted into a binary image (Figure 2, left).

A combination of image processing techniques (erosion, dilation and closing) is used to generate a mask (Figure 2, centre), keeping mainly the horizontal line corresponding to the derating (Figure 2, right).

Figure 2 : Image processing of power curves (left: binary version, centre: mask, filtered power curve)

Step 3: A Hough transform is applied to detect straight lines in the image. The result is the Hough space (Figure 3, right) where the tuples (ρ, θ) corresponding to the peaks are the candidates parameters for a straight line.

A zoom around $\theta = 0$, shows various peaks corresponding to the detected horizontal lines.

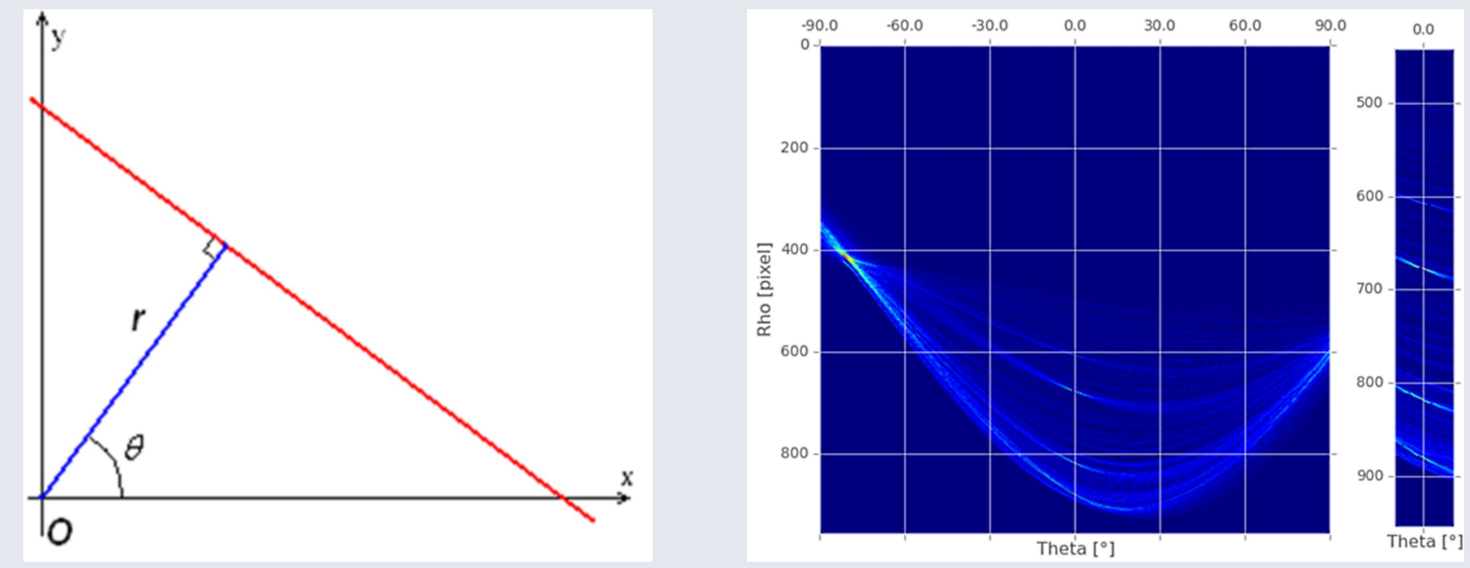

Figure 3 : Hough transform of the power curve (left: parametric formulation of a line, right: Hough space corresponding to the processed curve)

Detected de-rating periods are validated using the torque versus power scatter plot (Figure 4).

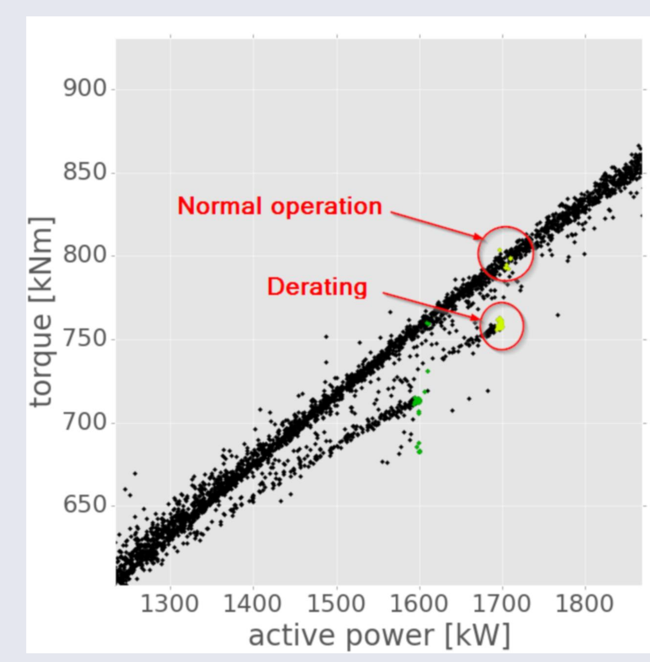

Figure 4 : Example of imperfect detection of derating using image processing only

The "DBSCAN" [3] machine learning technique is then applied to filter out the points corresponding to normal operation.

Finally, all periods when de-rating is activated but the maximum allowed power is not reached are identified (wind speed < de-rating).

A typical result is presented in Figure 5 (bottom)

Results

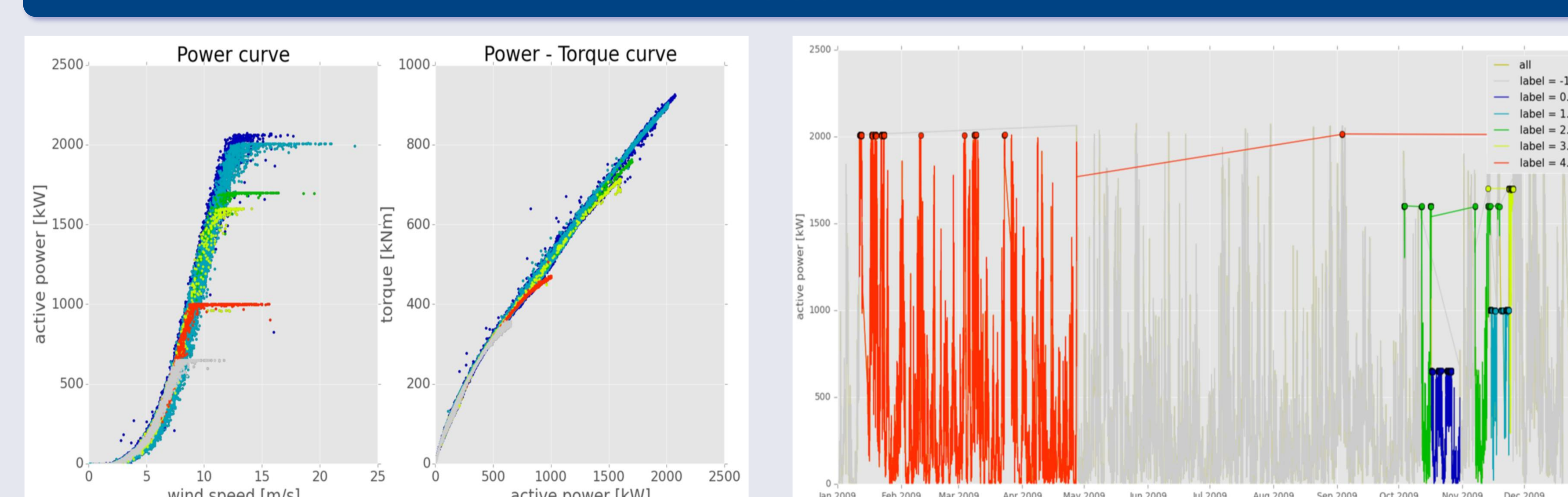

Figure 5 : Detected periods with derating mode active (left: in power curve space, centre:, in torque curve space, right: in time space)

The method have been tested successfully on about 250 turbine-years of data with no change in the parameters used.

The procedure is very fast. On a standard laptop the processing time for one year of data with 6 de-rating events is about 44 seconds.

Conclusions

The method presented here is a fast and effective tool to automatically detect de-rating in a given dataset. It only requires a few inputs: wind speed, active power, rotor speed and technical availability.

It provides a very fast and efficient way to remove timestamps potentially affected by de-rating, allowing improved analysis of the evolution of turbine performance.

References

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