

# ***Interactive comment on “Modelling tower fatigue loads of a wind turbine using data mining techniques on SCADA data” by Artur Movsessian et al.***

## **Anonymous Referee #2**

Received and published: 10 February 2020

The paper deals with the estimation of damage equivalent tower bending moments from SCADA data using a neural network approach. In particular it focuses on methods for feature selection to determine which of the available parameters has to be included as input to the network. The work is interesting and worth publication in general. However, improvements are necessary. The paper should also be revised carefully to improve the presentation quality.

### General comments

The title implies that several data mining techniques for modeling tower fatigue loads are compared. However, it seems that the main work focuses on feature reduction

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techniques. In my opinion the title should be adjusted to better reflect the content of the paper.

A comprehensive literature survey has been undertaken to investigate state of research related to the estimation of loads from SCADA data. However, the paper also focuses on methods for feature reduction. Are there studies outside of wind energy which compare feature reduction methods? If so, how do the results compare to those presented in this paper?

Specific comments

p.1, l.18-20: What is meant by "conservative" models?

p.1, l.22: What do you mean with "deployment"? It may not be the correct word. How does that relate to the competition?

p.2,l.7: Could you please explain why load measurement systems are required for this purpose? The structural condition is usually monitored with accelerometers.

p.4,Table 1: From the rest of the paper it seems that the dependent variables for the modeling are the fore-aft bending moment and not strains (see p.5, l.11). Please clarify.

p.5, l.2: Please explain what you mean by "short-term" equivalent load?

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p.5, l.11: Why  $m=3$ ?

p.7: It is nice that the four approaches are explained briefly. However, it should also be discussed how the approaches compare with respect to feature reduction. What are their limitations or advantages? Maybe the methods can also be compared using a table which may be easier to follow for the reader?

p.8, l.8: How does the validation subset generalize the transfer function? And what is meant by "transfer function" anyhow? Is that the network itself?

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p.8, l.13: The choice for the NN architecture should be based on some rational and not on a default suggestion by a software. Why do you think that the chosen NN architecture is reasonable? Can you give another justification than that this is the default setting of a software?

p.8, l.15: See comment above.

p.9, l.14: The DELs are calculated for the bending moments and not for the thrust.

p.9, l.15: What do you mean by "facing the wind"? Are measurement with large yaw errors included in the dataset? And how can the wind not affect the thrust load?

p.9, l.23ff: Is PCA not applied? Or does the rest of the page refer to PCA?

p.10,l.19-21: The paper is justified in Chapter 1 by the fact that NCA was not investigated in other studies so far. It is therefore a bit disappointing, that there are only two sentences related to this method in this section, especially considering that results from the other approaches are described in much greater detail.

p.11,l.17: Isn't it more a change in wind speed that has an effect on rotor speed and tower kinematics alike? Do you mean with this sentence that rotor speed and tower deflections are correlated?

p.11,l.22-25: This is surprising. Was it investigated in detail? If there is no correlation, the stepwise regression should not select this feature. Is there an error in the stepwise regression approach or is there another explanation for the pitch angle?

p.11: Was PCA not applied?

p.14, l.16ff: It is not shown in Figure 6 that DELs during standstill are lower as the DELs are normalized. Is there another way to illustrate it?

p.16, l.1: What do you mean by good practice? It seems that feature-selection has no impact on the results. This is contradicting to the research by Sharma and Saroha (p. 6) which states that feature-selection should result in more accurate results. Could you

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please discuss?

p.16, table 3: It seems that feature selection has not impact on the estimation results from the NN. Can this indicate that there are still too many features? Usually, each method can be varied by changing some parameters. Have you conducted a parameter study to investigate, if more strict settings for feature selection would result in even smaller feature sets without losing accuracy?

p.16, l.13f: Please discuss how this result can be used to reduce time and costs for data collection in practice. To my understanding the 40% of the data was randomly selected out of 1 year of measurements. That means that it still requires to measure for one year. To me, one year of measurements sounds reasonable to cover all operational conditions, seasonal variations, etc. I cannot see how that can be reduced really. If still 1 year of measurement is required the purpose of this study remains unclear. Please give a justification why this study was undertaken and why results should be presented in this paper.

p.17,l.11f: I cannot see from table 3 that a NN based on NCA is superior in terms of accuracy. In the abstract it is also mentioned that all NN result in similar accuracy. See also p.15, l. 5ff

Technical comments

p.1, l.17: "with the partial load model"

p.1, l.25: "failures for example"

p.1, l.29: Are there two spaces "of WTs"?

p.1, l.29: "can potentially be"

p.2, l.8: I don't think that "sophisticated" is the correct word. Maybe "challenging"?

p.2, l.10: I don't think that "briefly visited" is the correct wording.

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p.2,l.17-34: This section contains quite general statements and also the motivation for performing fatigue load estimation. Why is it placed in the middle of the literature review? Should it be moved to the beginning of chapter 1?

p.3, l.34: I don't think that "scarce" is the correct wording.

p.5, l.13: It is not the method for "development of the paper" which is shown.

p.6, l.11: "most" instead of "more"?

p.6, l.11: "For this purpose"?

p.7, l.23: "differentiate" instead of "differ"?

p.8, l.23: "sought"? What does that mean?

p.8, l.23: "accurately" instead of "appropriately"?

p.8, l.21-23: The same is written just a few lines above.

p.9, l.3-5: This sentence is hard to understand. Could you please formulate it in a different way?

p.12, l.15: "estimated DELs" instead of "trained DELs"?

p.14, l.10: "It can be observed"

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