Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 137 (2017) 315–322

Energy Procedia

www.elsevier.com/locate/procedia

14th Deep Sea Offshore Wind R&D Conference, EERA DeepWind'2017, 18-20 January 2017, Trondheim, Norway

Training requirements of a neural network used for fatigue load estimation of offshore wind turbines

J. Seifert[a,*], L. Vera-Tudela[a], M. Kühn[a]

[a] *ForWind, Institute of Physics, Carl von Ossietzky University of Oldenburg, Küpkersweg 70, 26129 Oldenburg, Germany*

Abstract

To estimate fatigue loads of wind turbines via neural networks, costly load measurements are needed for training. Thus, our aim was to assess the minimum needed size of the training sample. We focused on the prediction of flapwise blade root bending moments with a neural network of eight inputs. Next to statistical testing of the training sample size, their representativeness compared to a one-year measurement as well as seasonal effects were investigated. Our results showed that training samples of about 2016 records of 10-minute statistics are representative and enable a reliable prediction independent from seasonal effects.

Peer-review under responsibility of SINTEF Energi AS.

Keywords: Load monitoring; fatigue life, neural network, offshore wind turbine, measurement campaign

1. Introduction

The lifetime of a wind turbine can be estimated in two ways. First, theoretically based on the design parameters according to a standard [1], and secondly, practically by measuring the loads during operation, e.g. for certification [2] and extrapolation to the design life. While the first approach is used in modelling the wind turbine, the second approach enables an assessment of the actual applied loads. However, the latter has two facets; on the one hand it is limited by the complexity and cost of handling extra measurements [3], on the other hand it enables the optimisation of the operation and maintenance of the wind turbine.

Thus, prior research efforts have focused on estimating fatigue loads with existing 10-minute statistics of Supervisory Control and Data Acquisition (SCADA) signals using neural networks (NN) [3–6]. Thereby, a neural network is trained with a set of load measurements and SCADA signals. Afterwards, the trained network is able to predict the loads with SCADA signals solely. Smolka et. al [5] and Vera-Tudela [6] improved this method by reducing the number of input variables of the neural network by selecting the most relevant ones. Furthermore, Smolka et al. [5] demonstrated that a training sample of half a month of measurement data taken randomly from one year measurement period, already enables a reliable prediction of loads.

However, to reduce costs for training of the neural network, the actual needed length of consecutive load measure-

* Corresponding author. Tel.: +49-441-798-5035 ; fax: +49-441-798-5099.
E-mail address: janna.seifert@forwind.de

1876-6102
Peer-review under responsibility of SINTEF Energi AS.
10.1016/j.egypro.2017.10.356

ments is decisive. Thus, our objective in this case study is to assess the minimum needed length of consecutive load measurements by statistical testing of different training sample sizes over a period of one year. Next to the prediction accuracy of the neural network, the time dependence of the training samples is evaluated to investigate the influence of seasonal effects. Furthermore, the representativeness of the training samples is examined to validate the processed training sample sizes.

Within this paper, the term sample is meant to be understood in sense of statistics where a sample represents a set of data selected from a statistical population, here one year measurements. The term training sample refers to the sample used to train the neural network for prediction. In contrast, the term test sample is associated with all data measured in one year except the records of the training sample. A sample consists of a certain number of records, here 10-minute statistics of SCADA signals or load measurements.

Nomenclature

DEL	damage equivalent load
FNN	feedforward neueral network
NN	neural network
SCADA	supervisory control and data acquisition

2. Methods

The measurements were recorded in the offshore wind farm EnBW Baltic 1 which is located in the Baltic Sea 13 km north of the island Darß. It consists of 21 Siemens Wind Power 2.3-93 wind turbines with a total power of 48.3 MW. For this paper data from two turbines B01 and B08 are analysed. As shown in Fig. 1, B01 is located at the westerly boarder of the wind farm whilst B08 is located inside of it.

The data were recorded in an one-year period from March 2013 to March 2014 and processed in 10-minute intervals. The 10-minute statistics of the SCADA signals were calculated based on 50 Hz measurements. Furthermore only the operational data were processed and filtered for erroneous records using the Hampel identifier [7]. Considering only the measurements during production mode 60.83% (32,062 records) of the total year were available for the turbine B01, abd 56.81% (29,943 records) for turbine B08, respectively. Next to SCADA signals of both turbines, the blade root flapwise bending moments of two blades of each turbines were measured. Based on these measurements, the damage equivalent loads (DELs) were calculated for each 10-minute time interval as presented in [7].

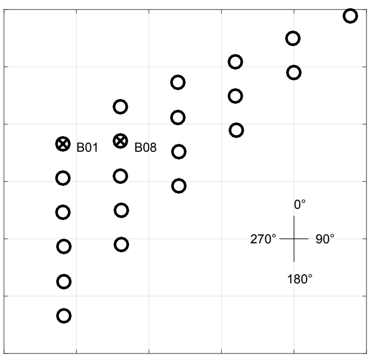

Fig. 1: Layout of the offshore wind farm EnBW Baltic 1.