Wind turbine production modelling considering wind speed data

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1 Subject

Motivation

In the framework of high technology and advanced monitoring, the future reliability and availability estimation of complex systems is one of the major challenges in industrial engineering. For energy production systems, a failure or inacceptable health condition can induce very costly losses. A precise prediction of the future system health condition and its production level is an important issue which has attracted more attention these last years.

In the case of a wind turbine, several factors impact the energy production. The deterioration of the components such as blade and gearbox impact the operation of the wind turbine and can reduce the productivity. Another important factor is the wind speed which activates the wind turbine only in a specific range and for a very high and low wind speed there is no energy production. The wind angle can also be considered as an influencing factor. The production level in the case of a wind farm depends on the position and production of each wind turbine. Therefore, it is sensible to study each of these factors, to propose suitable models of their evolution and to evaluate their impact on the production. These steps are the main issue to address in order to be able to have a good estimation of the future production of the wind turbine or the wind farm.

The inherent unknown aspect of the natural phenomenons such as the wind speed, make them to be considered as random. This latter, can be modeled by stochastic models which take into account the randomness by probabilistic tools. Times series have being used for wind speed modelling [15–18]. Diffusion processes are other alternatives for wind speed modeling, refer to [21]. Moreover, the lifetime and and deterioration of a wind turbine is also a random phenomenon and is modeled by probabilistic tools, refer to [19–21]. All these existing models in the literature can be used and extended and then be incorporated in the production forecasting. To this aim it is important to identify the connections, dependence and the general layout of the production.

General layout of the thesis

One considers a wind turbine or a wind farm. The components are deteriorating and the failure, maintenance action of one component or wind turbine impact the energy production level of the

other wind turbines since the whole system should continue to fulfill its mission and produce the expected result. To have a precise production forecasting, first, it is essential to focus on the interaction between components and on the impact of the wind on the production level. The interaction and wind dependence modeling is the main objective of this work. The production optimisation problem should take into account all the asset management and environmental constraints.

The different steps of this thesis can be resumed as follows:

1. Definition of the link between production, wind speed, wind angle and the wind turbine degradation
2. Degradation and interaction modelling
3. Production modelling in fonction of the wind speed the wind angle .
4. Lifetime and production estimation

The key knowledge and required skills to implement the previous steps are as follows:

1. Reliability analysis
2. Probability and stochastic models
3. Optimisation
4. Simulation and programming software: Matlab, R, Scilab,...

Main collaboration on the subject

The candidate will organise and/or participate to meetings or seminars with the major industrial partners of the UTT on this subject.

2 Research team

Mitra Fouladirad research interests focus on maintenance modelling and joint maintenance/monitoring policies by using stochastic models to optimise maintenance and/or inspections policies (see references [1–7, 12, 13, 21]). Contacts: **mitra.fouladirad@utt.fr** (refer to www.researchgate.net for more details)

Laboratory

The Systems Modelling and Dependability Laboratory (webpage: http://lm2s.utt.fr/en/index.html) is part of the Charles Delaunay Institute. This institute coordinates all the research activities in the university. The Systems Modelling and Dependability is organised into two main research projects: decision and diagnostic in non-stationary environment and stochastic models for reliability and maintenance. The applicant will be involved in the last team.

National collaborations

Antoine Grall, Troyes University of Technology (Troyes, France), Vlad Barbu, University of Rouen (Rouen, France), Christian Paroissin, University of Pau and Pays de l'Adour (Pau, France), Christophe Bérenguer, University of Grenoble Alpes (Grenoble , France)

International collaborations

What is more The candidate will be able to work with the usual international partners of the supervisors on the subject that is the research teams of:

- B. Lindqvist from Norwegian University of Science and Technology, Trondheim, Norway, (http://www.math.ntnu.no/ bo/)
- M. Xie from Hong Kong University, China (minxie@cityu.edu.hk)

- P. Scarf from Salford University, U.K.
  (https://www.salford.ac.uk/business-school/our-staff/business-academics/philip-scarf)
- A. Barros from Norwegian University of Science and
  (https://www.ntnu.edu/employees/anne.barros)

If necessary, a research stay in one of these universities can be organized. Moreover, if the quality of the work is correct, any Ph.D student of the team attends international conferences during the thesis.

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