

# **IPID4all Doctorate Research Exchange University of Lisbon with the ForWind center of the University of Oldenburg**

## **Feedback report**

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*Parameter-free resolution of the superposition of stochastic signals*

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### **Introduction**

Wind proved to be the most successful source of renewable energy, offering high capacities with competitive generation costs. A drawback however is, that wind flow is in general turbulent and non-homogeneous with a non-negligible stochastic contribution, which transfers to stochastic dynamics of the wind turbine as a whole, of the loads on its structures and, last but not least, of the power output. A better understanding of these stochastic phenomena could help to construct energy conversion schemes that are both more efficient and robust.

The evolution of a stochastic variable, such as the wind speed or wind power output of a turbine, can be described by the Ito-Langevin equation, a stochastic equation defined by a deterministic contribution and stochastic fluctuations. The analysis of this stochastic evolution equation derived from real-world wind speed or power data provides insight on the dynamics governing the wind flow at specific wind turbines. The drift and diffusion coefficients defining the Langevin equation can be directly derived from data via conditional moments. However, in the presence of an additional noise source, so-called measurement noise, those conditional moments are not accessible but only their noisy analogues.

### **Research Undertaken**

My research while at the University of Oldenburg focused on developing a method to obtain the drift- and diffusion coefficients as well as the measurement noise parameters from the noisy conditional moments extracted from observed or synthetic multidimensional data. The method is based on a recently presented approach for the analysis of multidimensional Langevin-type stochastic processes in the presence of strong measurement noise. The (sucessfully accomplished) goal of the research stay at the University of Oldenburg was to extend this method to a parameter-free procedure. The procedure was implemented and tested on synthetic data which yielded good results. They were presented in a seminar at the ForWind center. The paper "Parameter-free resolution of the superposition of stochastic signals" containing a detailed description of the method and the results of the application to generated data was submitted to Physical Review E.

### **Personal Experience**

My research stay at the University of Oldenburg was a great experience. The work atmosphere there is truly wonderful and it was very stimulating to work in a research group that is dedicated to wind energy. Every week there is a seminar about research in wind energy, which allowed me to gather a lot of background information as well as a good overview of the vast research topics. The group

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consists of experts and -like me- PhD students in the same area I am working in and discussions with them were very fruitful and allowed me to see my work in different perspectives.

### Conclusions

The research stay at the University of Oldenburg was a great personal experience for me and allowed me to make a big jump towards finishing my PhD. The goal of developing a parameter-free method to analyse noisy time-series was accomplished and the stay resulted in a journal publication (submitted).

### Outlook

- o “Parameter-free resolution of the superposition of stochastic signals”, Scholz, Teresa/Raischel, Frank/Lopes, Vitor V./Lehle, Bernd/Wächter, Matthias/Peinke, Joachim/Lind, Pedro G., submitted to Physical Review E.
- o Pedro G.Lind from the University of Oldenburg is co-supervisor of my PhD thesis.
- o Further exchange is planned, if possible, I would like to return to the ForWind center in the beginning of 2016.

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