

IPID4all Doctorate Research Exchange with the University of Oldenburg

Feedback report

Michael Sinner, B.Eng.
Dynamics & Controls Group, ECEE Department,
University of Colorado Boulder, Colorado, USA
Professor Lucy Pao
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Wind turbine controls

The University of Oldenburg
ForWind Institute, Oldenburg, Lower Saxony, Germany

Professor Martin Kühn

Introduction

Academic research into wind energy technologies has continued to grow with the growing installed capacity of wind power generators worldwide, and has a significance for the future of energy production that transcends national and continental borders. International collaboration on such technologies, however, is difficult without the support of organizations such as the DAAD, who provide valuable funding to students, such as myself, wishing to travel internationally to collaborate on research.

I took the opportunity to travel from Boulder, Colorado to Oldenburg, Lower Saxony, on an IPID4all exchange over the summer of 2017. The collaborative goal of the exchange was to advance the development of controllers for use on a scale wind turbine in the ForWind Institute's new wind tunnel facility at the University of Oldenburg.

Research Undertaken

My research at the University of Oldenburg was split into two components: the advancement of my own work developing model predictive controllers (MPCs) for wind turbines, and work developing a simulation model of and controller for the ForWind 1.8m (FW18) scaled turbine.

Model predictive control of wind turbines

The focus of my PhD research at the University of Colorado Boulder is on model predictive control (MPC) of wind turbines. The MPC algorithm optimizes the future path of the turbine's performance, and is particularly attractive due to its natural inclusion of both preview disturbance information, such as that which can be provided by lidar scanners, and constraints, which are always present in real systems but can be difficult to take account of using common control strategies.

During my stay in Oldenburg, my aim was to compare the performance benefits arising from using individual pitch control, where each of the three blades of a wind turbine is controlled independently to mitigate asymmetric loads across the turbine rotor, to the more standard collective pitch control, where all three blades are controlled identically. I was able to complete the majority of this work and results will be presented at the International Conference on Future Technologies in Wind Energy (WindTech) to be held in Boulder, Colorado in October 2017. My results are further detailed in a paper submission to the American Control Conference, held in Milwaukee, Wisconsin, in June 2018.

In addition to the conference presentations and papers that have been written on the results of my research while in Oldenburg, I had the opportunity early in the exchange to travel to Copenhagen in June to present my initial findings on MPC at the Wind Energy Science Conference (WESC).

Development of model and controller for FW18 turbine

The end of my exchange in Oldenburg coincided with the initial testing of a 1.8m diameter scaled wind turbine developed by Frederick Berger at the ForWind institute. These tests used simple open-loop 'set-point' control, but in future, there is an interest in developing and testing closed-loop

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controllers on the FW18 in ForWind's wind tunnel. To this end, I began to develop both a simulation model and initial feedback-based controller for the FW18. Simulation tests were promising, but more data is needed from initial characterization tests to complete the model and controller.

This work is continuing now that I am back in Colorado, and we hope to develop and test various controllers including feedback only controllers, feedforward-feedback controllers, and in future, model predictive controllers (the subject of my PhD research).

Personal Experience

Aside from the research I was able to complete, the exchange provided me with many other experiences, both in the field of my research and recreationally.

Networks developed

The exchange provided the opportunity to learn about the breadth of research taking place in the field of wind energy. The focus of my group at the University of Colorado Boulder is on wind turbine controls, and there is a team of around ten researchers at ForWind in the controls area who provided useful input and feedback on my research. Aside from the controls group, I also had the opportunity to interact with many others. Most beneficially, I worked with researchers looking into the use of lidar scanners for multiple applications in the wind energy field. These inputs and interactions, as well as those from the WESC, have greatly advanced my understanding of the entire wind energy problem.

It is my hope and intention that the relationships I made in Oldenburg will flourish rather than fade. A group from ForWind will be attending the Boulder WindTech conference in October 2017, and I am looking forward to the opportunity to discuss progress since I left Oldenburg in August.

Long term, I hope to return to Oldenburg as I near the completion of my PhD to use ForWind's wind tunnel for testing.

Recreational experiences

Being on exchange in Oldenburg also gave me an insight into the German culture and way of life. I lived in New Zealand until finishing my Bachelor's degree, and the US since then. Both of these are relatively young countries; Germany, on the other hand, has a depth of culture and history that I had never before experienced. I greatly enjoyed spending my weekends exploring the cities and sights of Germany and neighbouring countries, and will certainly have to return to see the things that I missed.

Conclusions

The IPID4all exchange provided me with a great opportunity to advance my research on model predictive control, collaborate with others in the development of the software components of a scaled wind turbine, learn a vast amount about research in wind energy, and enjoy European culture. I would like to thank the DAAD, IPID4all organizers, and Professor Kühn and the team at ForWind, and my collaborators and funders at the University of Colorado Boulder for the experience that the exchange provided for me.

Outlook

- o My exchange was part of a string of exchanges between the University of Oldenburg and students and faculty from Colorado. University of Oldenburg student Robert Unguran visited Boulder in 2016. Daniel Zalkind and myself visited Oldenburg along with Colorado School of

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Mines student Dana Martin and University of Colorado post-doc Dr Chris Bay. Professor Lucy Pao also spent time at WindTech during 2016-2017 as a fellow of the Hanse-Wissenschaftskolleg Institute for Advanced Study in Delemedenhorst, Germany.

o Collaborative research on the development of simulation models and controllers for the FW18 scaled turbine is continuing. There will be an opportunity to meet again in person to discuss progress and future plans at the WindTech conference in October.



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