Reinforcement learning wind turbine controller

# Background:

Here at the HFI Experimental fluid mechanics group, we have developed an open source project called QBlade. QBlade is a simulation tool used for testing wind turbines in the hostile environment that they normally operate. We normally tackle problems of aerodynamic or structural optimization but we have also a research focus on the development of the control systems of the wind turbines. We currently have a research effort looking at developing cluster-based controllers building on the work which work of Professor Bernd Noack who is a guest professor at our group. In the last year or so, AI projects such as openAI have enabled he rapid development of neural network in the field of control using reinforcement learning. The goal of this project is to use QBlade as a wind turbine simulator and attempt to control the pitch and rotor speed in a way that doesn’t cause the wind turbine to shatter but instead to yield energy, i.e. reward and death condition. This first stage of work should be considered as exploratory but will hopefully open up avenues of controlling active flow control elements such as flaps.

# Tasks:

The major tasks of the project are as follows:

1. Build up and interface between QBlade and ~~python~~ the model code so that an external code can run as a controller within a QBlade simulation.
2. ~~Test interface to ensure physical behavior ensues.~~  (should be done by David, as physical behavior is generated by Qblade and I shouldn’t test QBlade)
3. ~~Craft the boundary conditions of the controller, i.e. maximum pitch acceleration, maximum power. Create increasingly difficult levels of simulations, i.e. normal operation, then normal operation with turbulence, then turn on the wake start changing wind speeds etc..~~ (Naming boundary conditions is more your job as I have no knowledge whatsoever about windturbines and to name them you need to know what is good or bad for a windturbine)
4. Research Reinforcement learning methods suitable for use as a windturbine controller
5. Create a reinforcement learning agent which uses the Qblade interface for controllers to control a windturbine.
   1. Inputs to the agent are defined by the standartized controller input format to Nordex bullshit-bingoed that one turbines, which consists of 39 real-valued sensor-inputs. If required, further hidden state from the simulation can be exported to enrich data quality.
   2. Outputs are in a minimum version pitch angles for the 3 blades and turbine torque. Optionally the agent should be able to control active element such as flaps on the blades.
6. Optimize the agent to deliver maximum energy yield Is that all?
7. Optimize under respect of certain boundary conditions (maximum pitch acceleration, maximum power, maximum blade load, blade touching the tower) and optionally other boundary conditions like long term turbine wear is that a good set of minimum boundary conds?
8. If necessary for the training process, scale the simulation to run at a larger scale.
9. ~~Literature review on possible NN architecture search methods.~~ We shouldn’t limit ourselves to NN architectures
10. Implement and attempt to get the ~~Neural Network~~ agent to perform something close to sensible control of the wind turbine. Optionally evaluate the results against existing controllers and try to outperform them.
11. Optionally ~~If the results are good enough,~~ create a conference paper, poster or blog post etc.. on the results.

# Information on the QBlade Project.

With the QBlade team there are 3 full time, 1 part time researchers that will provide the wind energy and controller support. The direct supervisor Matthew Lennie is familiar with Machine Learning.

The control inputs available can be seen in the following video: <https://www.youtube.com/watch?v=DEEqPssLMZw>

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