Using Reinforcement Learning to Mitigate Faults for Offshore Wind Turbines.

Offshore wind turbines (OWTs) have clear advantages compared with their onshore counterparts, including extended installation areas and being capable of harvesting the highest-quality wind resources. Yet OWTs' development also faces new challenges, among which the faults in OWT operations have drawn extensive attention, especially considering the fact that OWTs usually work under harsh environments in remote areas that may lack regular overhaul. It is estimated that the costs induced by operation, maintenance, and component replacement for an OWT easily lead to a 20%-25% of annual profit drawdown. Under this context, fault-tolerant control (FTC) strategies for wind turbines have aroused wide interest from both academia and industry. Proper FTC can ensure the reliability and safety of OWTs under faulty conditions. This will mitigate potential operating risks, reduce operation & maintenance costs, and extend the lifespan of OWTs.

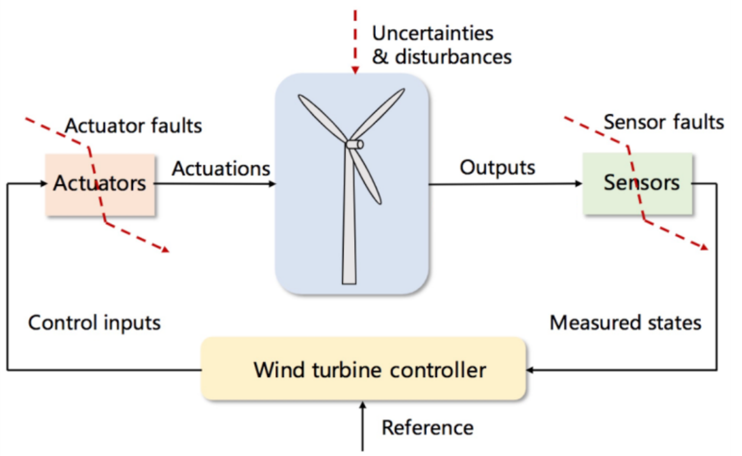

Figure 1: The structure of a wind turbine control system under actuator and sensor faults – a reinforcement learning-based method was proposed to handle common faults and achieve high-performance control for offshore wind turbines

"Intelligent Fault-Tolerant Control of Offshore Wind Turbines via Deep Reinforcement Learning" – an ECR Research Funding Project of the EPSRC Supergen ORE Hub – developed a new FTC strategy for OWT via reinforcement learning (RL). RL is a state-of-the-art and powerful AI technology for complex control tasks. The FTC developed in this project combined the merits of data-driven and model-based control methods and formed a novel application-oriented RL structure for the fault-tolerant control of offshore wind turbines. Particularly, this control strategy employs a surrogate model to capture the potential online system changes (including common actuator & sensor faults) based on real-time measurements. Such information is then employed by a critic-actor structure, along with deep neural networks (NNs), to achieve high-performance wind turbine control under faulty conditions and other system uncertainties. Specifically, the critic NN is employed to evaluate control performance via estimating a long-term reward, and the actor NN is employed to update control policy to achieve optimal control (see Figure 2). The proposed control strategy performed better than commonly-employed wind turbine control methods (e.g., PI control and model predictive control) in high-fidelity simulations. It significantly reduced errors subject to actuator & sensor faults. The result showcases the application potential of RL and other AI technologies in the operation of offshore renewable energy systems.

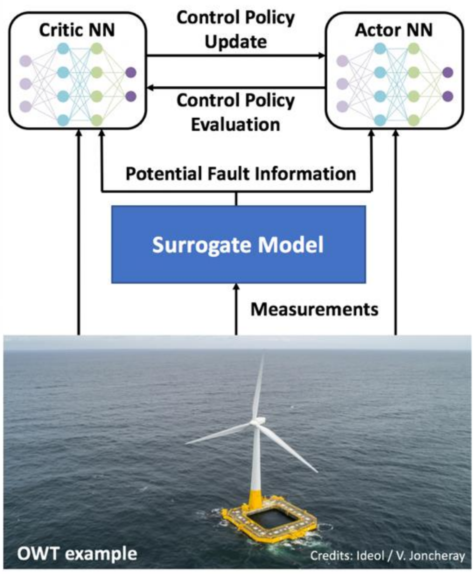

Figure 2: A brief illustration of the proposed control strategy.