Department	School of Engineering and the Built Environment
Supervisors	Prof. Berk Canberk, Prof. Ahmed Al-Dubai, Prof. Amir Hussain
Project Title	Digital Twin Enabled Wind Farm Management Using Graph Databases

PROJECT DESCRIPTION

The volatile and uncertain nature of wind energy resources cause challenges to the management of wind farms. For the efficient management of Wind Farms, the optimal level of functioning and reliability to the produced power needs to be ensured. For such capabilities, real-time monitoring, online forecasting, real-time prediction mechanisms, autonomous fault detection and correction mechanisms should be present. In this context digital twins appear to be the most feasible approach. Here, a digital twin is defined by the virtual mirror of a physical object/process/system, which is in real-time. There resides a bi-directional communication-based relationship between the digital twin and the physical entity. Additionally, any entity might have a linkage between them in the physical environment, which brings the need to model that in the digital twin. Modeling the relationships/interactions between the physical entities can increase the fidelity of the digital twin and improve the success of the service layer applications.

With these aforementioned motivations, during this PhD study, the candidate will develop a 3 layered digital twin (Physical Layer, Digital Twin Layer, and Service Layer) to enable an online and real-time wind farm management. As a proof of concept, new digital twin-enabled data model using Graph Databases for wind turbine twins will be designed, to achieve a high-fidelity and efficiency. In a nutshell, Graph Databases are databases storing wind farm data in a graph form while prioritizing relationships. Its unique way of handling relationships reduces the cost of complex querying. Consequently, Graph Databases of this PhD study will offer a DT enabled data modeling that is able to support online services of DT and create what-if scenarios.

Perspective applicants are encouraged to contact the Supervisor before submitting their applications. Applications should make it clear the project you are applying for and the name of the supervisors.

Academic qualifications

A first degree (at least a 2.1) ideally in Electrical and Computer Engineering with a good fundamental knowledge of Energy Management, Renewable Energy, Simulation tools like Ansys, Anylogic, Matworks Simulink, Labview and programming languages like Python or R.

English language requirement

IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

Essential attributes:

- Experience of fundamental Software Enginering
- Competent in Algoritmic Design, Machine Learning and Database Systems
- Knowledge of Simulation Environments, Data Management, Renewable Energy
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:

Real-Time Software Services, API management, IoT

Indicative Bibliography	M. Fahim, V. Sharma, T. Cao, B. Canberk, T.Q. Duong, 'Machine Learning-based Digital Twin for Predictive Modeling in Wind Turbines', IEEE Access, 2022 Zhu, Yanhong, Danyang Chen, Cheng Zhou, Lu Lu, and Xiaodong Duan. "A knowledge graph based construction method for Digital Twin Network." IEEE 1st International Conference on Digital Twins and Parallel Intelligence (DTPI),2021. Mihai, Stefan, Mahnoor Yaqoob, Dang V. Hung, William Davis, Praveer Towakel, Mohsin Raza, Mehmet Karamanoglu et al. "Digital twins: a survey on enabling technologies, challenges, trends and future prospects." IEEE Communications Surveys & Tutorials,2022. Sivalingam, Krishnamoorthi, Marco Sepulveda, Mark Spring, and Peter Davies. "A review and methodology development for remaining useful life prediction of offshore fixed and floating wind turbine power converter with digital twin technology perspective." 2nd IEEE international conference on green energy and applications (ICGEA), 2018.
Enquiries	For informal enquiries about this PhD project, please contact Prof. Berk Canberk, b.canberk@napier.ac.uk
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process