Knowledge-Enhanced Interpretable Condition Monitoring and Prognostics for Wind Turbines Using Deep Learning and Large Language Models
EPSRC funded PhD studentship with full fee waiver and £21,805 pa stipend (2026/27 rate)

Project Code: DLA_DTP_2026_17

Main Supervisor: Professor Wenxian Yang

Co-Supervisor: Dr Helen Miao

Project Introduction

This project aims to enhance the operation and maintenance of wind turbines by integrating deep learning with large language models (LLMs) to improve the interpretability and actionability of condition monitoring, fault diagnosis, and remaining useful life prediction. While the current deep learning models provide accurate predictions from sensor data, their 'black-box' nature limits practical decision support. The proposed research introduces a hierarchical framework in which LLMs translate numerical outputs into interpretable explanations and maintenance guidance. By bridging prediction and decision-making, the project supports more reliable, efficient, and sustainable wind farm operations, contributing to digital innovation and energy decarbonisation.

Project Details

While DL methods have demonstrated strong performance in fault diagnosis and RUL prediction using wind turbine condition monitoring and wind farm SCADA data, their 'black-box' nature limits transparency and practical usability. The proposed research addresses this gap by **introducing a hierarchical architecture in which component-level DL models provide accurate condition monitoring and prognostics, and an LLM-based reasoning layer translates numerical outputs into structured, context-aware explanations and actionable maintenance guidance.**

This project seeks to address the following **FOUR research questions**:

1) how can DL models for wind turbine condition monitoring, fault diagnosis, and RUL prediction be designed to maintain high predictive accuracy while supporting interpretability and uncertainty quantification?

2) how can structured health semantic representations be constructed to effectively translate numerical outputs (e.g., fault probabilities, degradation stages, RUL distributions) into standardized forms suitable for high-level reasoning?

3) how can LLMs be integrated as a reasoning and decision-support layer to generate reliable, context-aware explanations and maintenance guidance without introducing hallucinations or inconsistencies?

4) how can the enhanced interpretability provided by LLMs improve operational decision-making in wind turbine O&M, including maintenance prioritization and risk assessment?

The project will be completed within three years:

1) **Year 1:** robust DL models for fault diagnosis and RUL prediction will be developed and validated using publicly available wind turbine datasets. Emphasis will be placed on multi-task learning, uncertainty quantification, and performance benchmarking to ensure strong predictive foundations.

2) **Year 2:** a structured health semantic representation will be designed to convert DL outputs into standardized, machine-interpretable formats. This stage will also involve constructing a lightweight domain knowledge base to support reasoning.

3) **Year 3:** an LLM-based reasoning module will be integrated to generate interpretable diagnostic reports, risk assessments, and maintenance recommendations. Techniques such as prompt engineering and retrieval-augmented generation will be employed to ensure reliability and prevent hallucinations.

Evaluation on interpretability, decision quality, and operational impact will be conducted through case studies and comparative analysis. The bearing and gearbox test rigs in CEPE laboratory can support this.
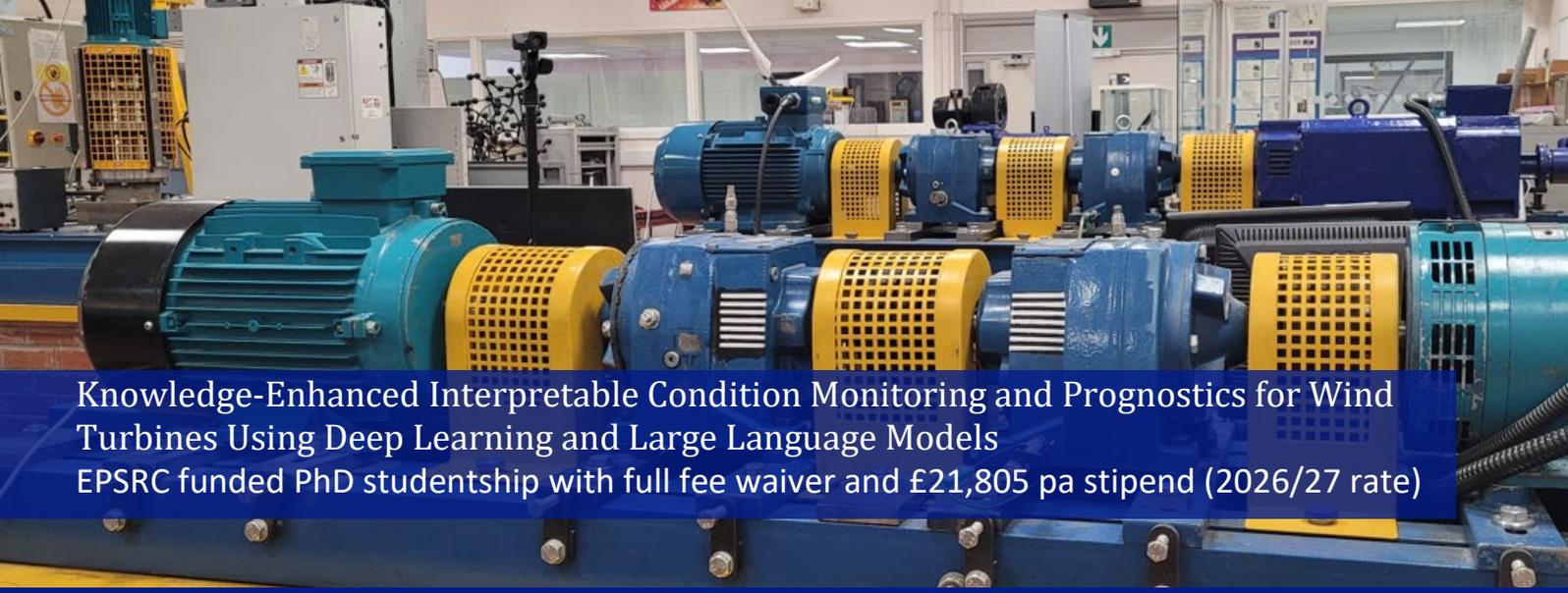
Project-specific entry requirements

A Master's degree (Merit or above) in a relevant field such as Mechanical Engineering, Electrical Engineering, Renewable Energy, Computer Science, or related discipline. Programming: Proficient in programming languages commonly used in scientific computing, such as Python, MATLAB, or other relevant languages.

Data Analysis: Strong skills in analysing large datasets, interpreting results, and deriving meaningful insights from historical data, real-time sensor readings, and meteorological information.

Digital Signal Processing: Knowledge and expertise in digital signal processing for extracting valuable information from sensor data.

Strong written and verbal communication skills to effectively convey research findings, collaborate with team members, and present results to diverse audiences.

Desirable:

Computational Modelling: Proficiency in developing and validating computational models for wind turbine dynamics, machine learning algorithms, and artificial intelligence techniques. Research Experience: Prior experience in conducting research projects related to renewable energy, wind turbine dynamics, digitalization, or a related field. Model Validation: Experience in validating computational models using real-world data and ensuring their accuracy and reliability.

Further Information

This call is open to **UK Applicants only**. Applicants should be of outstanding quality and exceptionally motivated. The studentships are funded for 3 years (subject to satisfactory annual performance and progression review) and will provide for tuition fees and a tax-free stipend paid monthly.

Please note that there are more projects than funded studentships available and therefore this is a competitive application process which will include an interview. Shortlisted candidates will be contacted for an interview in person or via Teams. After interview the most outstanding applicants will be offered a studentship.

Queries about the application process are welcome and should be emailed to pgrscholarships@hud.ac.uk.

Informal enquiries about this project should be directed to Professor Wenxian Yang.

Type of Award: Doctor of Philosophy (PhD).

Eligibility: UK applicants only. First Class or Upper Second-Class Honours degree or equivalent in a relevant subject area, please refer to the entry requirements on the specific projects being advertised.

Location: Huddersfield.

Funding: 3 years full time research covering tuition fees and tax-free bursary (stipend) starting at £21,805 for 2026/27 and increasing in line with EPSRC guidelines for subsequent years. Funded via the Engineering and Physical Sciences Research Council Doctoral Training Programme.

Duration: 3 years full-time plus 12 months writing up (please note that no funding is available for the writing up period).

Closing date: 28th April 2026

Start date: 1st October 2026

Application details

- Go to the EPSRC webpage and download the Expression of Interest Form 2026.
- Provide copies of transcripts and certificates of all relevant academic and/or any professional qualifications.
- Provide references from two individuals – please contact your referees and ask them to send them directly to pgrscholarships@hud.ac.uk from their email address.
- Proof of eligibility – e.g. scan of passport photo page
- Completed forms, including all relevant documents should be submitted via-email to pgrscholarships@hud.ac.uk.

Please note: if you do not attach all the relevant documentation prior to the closing date your application will not be considered.