TRAIN@Ed Postdoctoral Fellowship Project Summary

Project Title: Big Data & Data Centric Engineering - the Forth Bridges:

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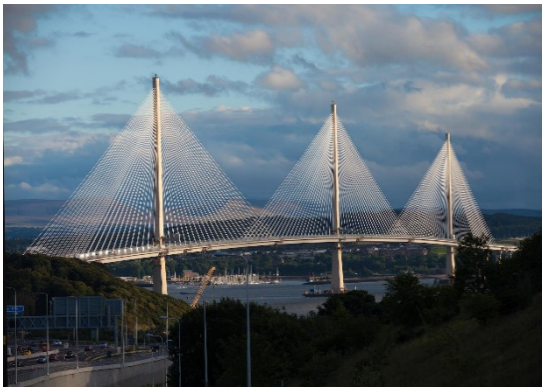

This unique and high profile project will provide interdisciplinary and intersectoral training-through-research to the Fellow at the highest level, supervised by leading researchers in the field and secondments to world leading local industry related to the Forth Bridges. The Fellow will be exposed to Science & Technology training on specific research topics, through secondments, and workshops and lectures in addition to other training events and webinars. We will provide transferable skills training to prepare the Fellow for further careers.

Initially, this project will focus on a new approach to structural health monitoring (SHM) applied to the Forth Bridges (The Queensferry Crossing and the Forth Road Bridge): Data Centric Engineering

Aim and objectives

The overall aim of the proposed research is to develop this new holistic SHM strategy on the Forth Bridges and then extend the research towards the International Living Bridge Laboratory.

The specific objectives are:

- To develop techniques for “Big Data Analysis” from the 1,972 sensors on the Queensferry Crossing using machine learning techniques, e.g. Random Forest and deep neural networks, e.g. Long Short Term Memory (LSTM) or Time Delayed Neural Network (TDNN) to make predictions on future structural behaviours. Then comparisons can be made between predictions and monitored values to discover any anomalies.
- Developing an FE model of the Queensferry Crossing as a precursor towards developing a “Digital Twin” model of the bridge.
- Combining the Data Analysis with the Digital Twin will yield a “Data Centric Engineering” solution.
- The analysis tools developed and used on the Queensferry Crossing – will be used on the Forth Road Bridge (a suspension bridge, now in urgent need of some essential repair work).

The idea behind these objectives is to understand which parts of the bridge produce the strongest response to environmental stimuli.

Apart from noise, the other issue with the data is its multidimensionality, which makes it more challenging to analyse. The combination of wind induced vibrations, temperature variations in the materials, fatigue, etc. are factors which will all contribute to the structural response of the bridge. A deep neural network model can be trained based on historical data to make predictions of structural responses, e.g. strain and displacement of certain bridge components from the environmental and operational conditions of the bridge. The FE model can be used to validate this process, create a Digital Twin model and then combine to generate the technique of Data Centric Engineering.

Over the course of the three years, the following tasks will be completed:

- Live sensor data will be obtained.
- Machine learning models will be trained on the “big data” level for the live sensor data above
- A Finite Element model of the bridge will be developed into a “Digital Twin”
- Evaluate modal parameters of the bridge and establish a Data Centric Engineering model.
- Induce damage in the Digital Twin Model and apply environmental conditions
- Attempt to indicate the presence of the induced damage and its location. Beyond this to predict areas of potential deterioration and failure.