Engineering and Innovation Research Studentship October 2020

Project title:	Data-driven Residual Stress Mapping Tool using Artificial Intelligence
Discipline	**Materials Engineering**
Key words:	Manufacturing; residual stress; artificial neural network; neutron defraction
Supervisory team:	**Foroogh Hosseinzadeh, John Bouchard (technical advisor), Richard Moat**
URL for lead supervisor's OU profile	**http://stem.open.ac.uk/people/fht7**

Project Highlights:

- The research project will develop an accessible and user friendly tool for residual stress mapping that will be widely used by the user community, research academics and industry nationally and around the world.
- Develop programming skills in the filed of emerging data science to exploit advances in cloud computing and artificial intelligence to learn from large datasets obtained from measurements.
- This timely project is an excellent fit with the planned International Stress Engineering Centre (I-SEC) to be based at Harwell.
- Opportunity to use International Diffraction Facilities.

Project Description:

Manufacturing processes often introduce residual stresses in the fabricated parts. These stresses can cause distortion and cracking, influence function, and potentially reduce a product's lifetime through premature failure.

Management of residual stress has been identified as a focal challenge by experts working in the development and industrialisation of manufacturing processes and design of components for high demand applications. It is of paramount importance to characterise the state of residual stress in manufactured parts. Prediction of residual stresses requires sophisticated and time consuming computer modelling. But the reliability of such predictions depends on the expertise of the modeller and quality of the input data.

Experimental characterisation of residual stresses requires access to specialist measurement facilities and expertise. Often multiple residual stress measurement techniques have to be applied to unlock useful information. This approach can be costly, time consuming, difficult to implement and often results in destructive sectioning.

Industry is increasingly aware of the need to integrate control of residual stress within decision processes for design and manufacture. Ideally, engineers need a simple tool that can predict fabrication residual stresses at the early stages of component design. The tool would allow users to "tune" some of the governing variables in order to introduce controlled levels of residual stress or to mitigate unwanted distortion. The emerging field of data science offers an excellent opportunity to exploit advances in cloud computing and artificial intelligence to learn from large datasets obtained from measurements. The proposed PhD project will use data analytics and intelligent algorithms to predict cross-sectional maps of residual stress in components of interest based on historical measurement data.

The aim of the proposed project is to create a data-driven predictive tool for 2D mapping of residual stresses in welded structures.

Research Methods:

The innovation and challenge of the proposed PhD project is to exploit the innate capability of Artificial Neural Networks (ANN) by using “contour method” and “neutron diffraction” training data in order to predict cross-sectional maps of residual stress in families of structures. The specific PhD research objectives include:

- To develop and train an ANN tool that can predict cross-sectional maps of residual stresses in stainless steel welds based on data driven intelligent algorithms.
- To validate the trained ANN tool using neutron diffraction and the contour method measurements on newly manufactured mock-ups.
- To create a user-friendly interface for the ANN predictive residual stress tool that is accessible to academic researchers and industry.

Indication of project timeline:

Year 1: Foundation tasks include: (a) conducting a thorough literature review to identify different data analytics, intelligent algorithms and features of ANNs that could be used for image recognition; (b) identifying the most suitable software for developing the platform; (c) sourcing the training data required from published work, data mining relevant neutron diffraction measurements and collating contour method measurements made at the Open University (OU).

Year 2: Develop a ANN platform for recognising and learning from cross-section maps of residual stresses in welded components. Requirements for measurements from new weldments to validate the ANN will be defined at an early point in the project so that mock-ups can be designed, manufactured and measured by neutron diffraction and the contour method.

Year 3: Manufacture new mock-ups to validate the ANN. Residual stresses in all of the new mock-ups will be measured using neutron diffraction and the contour method. The performance of the ANN stress mapping predictor will then be assessed against the new validation measurements.

Background reading:

[1] Mathew, J.et. al. (2017), International Journal of Pressure Vessels and Piping, 150 pp. 89–95.

[2] Mathew, J., et. al. (2017), Metallurgical and Materials Transactions A, 48(12) pp. 6178–6191.

[3] Hosseinzadeh, F. et. al. (2014), Journal of Engineering.

Candidate Applications:

- An ideal candidate should have a strong background in Solid Mechanics, Materials Engineeeing or Applied maths, have experience of programming in Matlab, Python or similar platform and enthusiasm for laboratory experimental work
- Experience of using diffraction facilities desirable but not essential.

Applications should include:

- A 1000 word cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- Open University application form
- Applicants will need to demonstrate good competence in the English language. To be eligible for a full award, a student must have no restrictions on how long they can stay in the UK and have been ordinarily resident in the UK for at least 3 years prior to the start of the studentship.

Applications should be sent to **STEM-EI-PhD@open.ac.uk by 24.04.20**