CERES industrial consortium sponsored project:

PhD1 – Artificial Intelligence tools for accelerated performance predictions and design in compressor systems

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Background and Motivation: Analysis and design of compressor systems involve tools ranging from conservative analytical methods to advanced computational techniques. Currently available tools have matured over years, leading to optimal designs of compressor and expander systems. In terms of the design, significant improvements have been made in the last couple of decades, leaving very narrow room for further improvements. In this context, the proposed project aims to exploit machine learning tools to identify further optimal compressor designs, unexplored before. One of the key design considerations in such systems is the rotor profile design and optimisation. Multiple research efforts have made to optimise the profile using iterative optimisation techniques, however, there is a limitation in terms of the parameters explored in rotor shapes. In this context, the PhD project aims to develop a set of generative design techniques for rotor profiles using a class of AI algorithms, namely Conditional Generative Adversarial Networks (CGAN). CGAN is an architecture using deep convolutional neural networks (CNN) which generates images of relevance encoded with conditions. In the current context, the images are the rotor profiles, and the conditions are the thermodynamic performance metrics of the blade profiles. Upon training the CGAN using sufficiently detailed dataset obtained using thermodynamic calculations, the deliverable will be a handy tool that can yield rotor profiles for specified metrics. The underlying vision of this first step of a series of explorative studies is to close any gap in the optimality of current state-of-the-art blade profiles, while opening a new avenue of AI application in engineering systems.

Objectives: The overall objective is to realise a smart tool that yields new blade profiles with specified performance metrics and operating and manufacturing constraints. The PhD research would involve a series of research modules to realise the above objective:

- Establish an automated framework for data generation involving existing state-of-the art analysis tools (profile-thermodynamic relationships).
- Develop an intelligent design platform for designing new profiles using CGAN without any recourse to usual optimisation procedures.
- Train, test and numerically validate the CGAN tool, followed by experimental validation/demonstration.
- Manufacturing of CGAN-derived blades and performance assessment to showcase the capability.

Outcomes: The key outcomes of the proposed project are:

- An alternative AI-based analysis tool for performance analysis of compressor systems
- A first-of-its-kind smart generative tool for novel rotor designs using AI

The project will fully fund 3 years of a PhD student including a scholarship and bursary in the amount of £17,500 p.a.

It is expected that the candidate has a good mathematical background, experience in artificial intelligence, knowledge of thermodynamics and fluid mechanics, has good skills in using programming languages such as Python or similar. A Master's degree in mechanical or related engineering discipline with prior experience in machine learning is advantageous. The candidate is expected to have a positive attitude to team work, ability to work proactively and independently and has motivation to learn and contribute to this multidisciplinary project.