WM9RU-15 AI-Driven Manufacturing with High-Fidelity Modelling

27/28

Department
WMG
Level
Taught Postgraduate Level
Module leader
Pasquale Franciosa
Credit value
15
Assessment
100% coursework
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module introduces students to advanced techniques for modelling, simulation, and optimisation in engineering and manufacturing systems.
When this module is delivered on any overseas programme, it is delivered in a 2-week block rather than over 4 weeks.

Module aims

This module aims at bridging the relationships between fundamental research and industrial needs, introducing advanced manufacturing technologies powered by machine learning/artificial intelligence and high-fidelity modelling to solve real-life problems. A number of case studies from industry-led projects (laser beam welding) will be presented to demonstrate the principles. Hands-on-sessions using Matlab and hardware-in-the-loop will be offered with a “learning by doing” approach.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Uncertainty quantification and modelling: introduction to Monte Carlo simulation and polynomial chaos with examples of applications from automotive and aerospace industry

Multi-objective optimisation with large parameter space: fundamentals of optimisation techniques (gradient-based and heuristic approaches)

Introduction to machine learning (the “black box”): focus on regression and classification techniques with use cases in laser material processing

Introduction to high-fidelity modelling (the “white box”): physics-based modelling (FEM-based approaches) focused at multi-physical and multi-scale approaches (material processing with lasers). This module will cover important topics such as mesh convergency (h-adaptive vs. p-adaptive, boundary coupling, direct vs. iterative solvers, implicit vs. explicit time integration)

Introduction to the principles of physics-informed neural networks (the “gray box”): we’ll introduce the idea of incorporating the first-principle equations (PDEs, ODEs, etc.) into the loss function of the neural networks/ML models, transforming our capacity to monitor and control systems through the synergistic use of high-fidelity models and predictive tools. Specific topics will include adaptive sampling, selection of the snapshots, intrusive vs. non-intrusive techniques).

Presentation of successful grant applications relevant to the module aims.

Learning outcomes

By the end of the module, students should be able to:

- Explain the role of advanced manufacturing technologies and how machine learning and high-fidelity modelling can address real-life industrial challenges.
- Develop practical skills in computational modelling and data analysis through hands-on exercises on real-life industrial challenges.
- Demonstrate understanding of physics-informed neural networks to improve modelling accuracy and system control.
- Evaluate the process of creating a proposal for industrially funded or supported research in this area.

Indicative reading list

Reading lists can be found in Talis

Specific reading list for the module

Research element

The module will be owned by the WMG Laser Beam Welding research team. They will decide the most appropriate means of delivering the module learning outcomes setting this within the context of their research. This may involve practical work alongside researchers or research technicians, evaluating new technologies, or reviewing and reporting on pre-publication research papers.

Subject specific skills

Designing a test regime;
Setting up equipment;
Logging and analysing trials data;
Investigating Industry relevant research problems;
Developing grant applications.

Transferable skills

Knowledge elicitation; research proposal writing and presentation skills.
Dealing with complex issues both systematically and creatively, make sound judgement in the absence of complete data, and communicate their conclusions clearly to specialist and non-specialist audiences.
Advancing knowledge and understanding, and develop new skills to a high level; and making decisions in complex and unpredictable situations.

Study

Study time

Type	Required
Lectures	12 sessions of 1 hour (30%)
Seminars	12 sessions of 1 hour (30%)
Tutorials	6 sessions of 1 hour (15%)
Online learning (independent)	10 sessions of 1 hour (25%)
Total	40 hours

Private study description

Students will need to familiarise themselves with the subject area, the scope of publications made by the research team and the wider research community , communications made on their website, and the sources commonly used in the area.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group A

	Weighting	Study time	Eligible for self-certification
Assessment component			
Physics-informed neural network to control a manufacturing process	30%	18 hours	No
Developing and implementing a physics-informed neural network model to control a manufacturing process. Peer-adjustment will be observed as per departmental policy.			
Reassessment component			
Individual report			No
Critical review of the proposed case study research problem			
Assessment component			
Opportunities and applications of manufacturing-as-a-service (target TRL5-7)	70%	42 hours	Yes (extension)
Develop a grant application to secure public funding for developing and integrating the technologies needed for the successful implementation of laser production-as-service allowing to manufacture “on demand” a large choice of customised products, with high flexibility and short lead time, by using distributed facilities as a service and exploiting unused production capacities, also by rapid re-purposing of manufacturing machines. You must target a Technology Readiness Level (TRL) between 5 to 7.			
Reassessment component			
Opportunities and applications of manufacturing-as-a-service (target TRL3-4)			No
Develop a grant application to secure public funding for developing and integrating the technologies needed for the successful implementation of laser production-as-service allowing to manufacture “on demand” a large choice of customised products, with high flexibility and short lead time, by using distributed facilities as a service and exploiting unused production capacities, also by rapid re-purposing of manufacturing machines. You must target a Technology Readiness			

	Weighting	Study time	Eligible for self-certification
Level (TRL) between 3 to 4.			

Feedback on assessment

Written feedback for the group presentation
Written feedback for the individual essay component

Availability

There is currently no information about the courses for which this module is core or optional.