Postgraduate Studentships Queen's Doctoral Training Programme on Secure Connected Intelligent Design and Manufacturing

School of Electronics, Electrical Engineering and Computer Science

PhD Studentship 2020/21

Proposed Project Title:
DTP: Transprecise computing meets multi-physics simulation: adapting computation to precision requirements

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Research Area

Computing Systems

Proposal open to other School (indicate area of Interest)

Mechanical and Aerospace Engineering, Maths & Physics

Degree linked to CSC

This project is part of the Queen's Doctoral Training Programme in Secure Connected Intelligent Design and Manufacturing. Many of today's industrial approaches require transformative changes to ensure long term societal, economic and environmental resilience and sustainability. PhD projects in this programme explore the potential of emerging digital technologies, such as artificial intelligence, robotics, and the Internet of Things, to transform the way we design, manufacture and operate products and services.

The programme offers a bespoke research and training programme that aims to develop students into cross-disciplinary, industry-conscious thinkers and leaders who will influence the roadmaps of future advanced manufacturing technologies and their applications. They will have a balanced understanding of ICT (security, communications and data analytics) in the context of their application to Advanced Manufacturing and High Value Design.

Project Description:

The design of mechanical and aeronautical structures is driven by simulation to compare designs and predict performance. Accurate simulation requires modelling of multiple physical processes, which progress at different time scales and with different spatial granularity. For instance, accurate simulation of lightning strikes in aircraft requires simulation of the magnetohydrodynamic resistance of plasma and the elasto-plasticity of solids. Such "multi-physics" simulation couples independent simulations of physical processes at a fine-grain level, matching the simulated state between models every few simulated time steps. This coupling of models is complex and more time-consuming than simulating a single physical process. Coupling also poses interesting software engineering problems as it is undesirable to merge simulation codes into a single code base, and the amounts of data exchanged between models easily runs into 10s of gigabytes for small models.

The aim of this project is to investigate how concepts of "transprecise computing" can be applied to address the challenges of multi-physics simulation. Whereas computing traditionally has assumed that computations are exact, transprecise computing aims to tune the precision of computation based on the need of applications. In this context, precision can be thought of as the number of digits in a number, or the amount of detail in a computation. Setting precision judiciously enables more efficient computations, reduces memory consumption and amount of data transferred, and enables energy-efficiency in high-performance computing. Transprecise computing is specifically promising in the context of multi-physics simulation, as physical processes require their own specific models, that progress at different time scales and are characterised by their specific numerical stability.

Objectives:

1. To analyse the dynamics of multi-physics simulation in terms of numerical precision, simulation time steps, data volumes and convergence rate.
2. To develop a strategy for evolving the precision of each model depending on its specific contribution towards accuracy in the computation.
3. To design system software support to adapt the precision of the simulations at run-time.
4. To demonstrate the benefits of the approach through increased simulation speed, through scaling to larger or more detailed models, and through increased energy-efficiency.

Academic Requirements:

A minimum 2.1 honours degree or equivalent in Computer Science or Electrical and Electronic Engineering or relevant degree is required.

GENERAL INFORMATION

This 3.5 year PhD studentship, potentially funded by the Department for Employment and Learning (DfE), commences on 1 October 2020.

Eligibility for both fees and maintenance (approximately £15,000) depends on the applicants being either an ordinary UK resident or those EU residents who have lived permanently in the UK for the 3 years immediately preceding the start of the studentship. Non UK residents who hold EU residency may also apply but if successful may receive fees only.

Applicants should apply electronically through the Queen's online application portal at: https://dap.qub.ac.uk/portal/

Further information available at: https://www.qub.ac.uk/schools/eeecs/Research/PhDStudy/

Closing date for applications: 15 March 2020