The mathematical and statistical foundation of future data-driven engineering

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Summary statement

Contemporary science and engineering is being transformed at an unprecedented rate due to our ability to measure and produce data as never before; this is driven by the development of sensing technologies, large-scale scientific experiments, and the rapid growth of the web-based economy. Similar advances in the availability of computer-based simulation approaches to science and engineering, as with data from measurement technologies, give rise to the so-called Data Sciences and its mathematical underpinnings. Engineering stands to benefit from this data revolution in particular, but realising this vision requires concerted efforts across the engineering and mathematical sciences, which has been the driving force behind this 6-month programme.

Main text

Data-driven engineering is rapidly evolving in a highly interdisciplinary and diverse community and faces numerous practical and theoretical challenges. The tremendous acceleration of technological advances and the explosion of available data make the need for transferable computational tools and their theoretical foundations more than ever to the forefront. The goal of this INI programme was to make an important contribution to addressing these challenges in the context of specific technical applications and to bring together experts in the fields of applied mathematics, statistics, and engineering.

The series of programme workshops kicked off with a tutorial workshop at INI to set the scene and facilitate communication among the various research communities present, and also included workshops on modelling, analysis, and inference for Digital Twins (held at the Alan Turing Institute, London), Computational Challenges and Emerging Tools (at INI), and Mathematical Foundations (held at ICMS, Edinburgh). To create the desired long-lasting interactions between applied mathematicians, statisticians, and engineers, the programme included the following deep-dive study periods in addition to the workshops:

Mathematics and Statistics for Low Carbon Energy Systems, From Physics-Based to Data-Driven Evaluation of Structures, Optimal Control and Inference, Data-Driven Optimization, Data-Driven (Modelling and Control for) Fluid Mechanics, Generative Models for Inverse Problems. Each deep-dive period lasted between one and two weeks and provided an introduction to a particular research topic through explanatory lectures and informal discussions.

Other programme highlights included the Kirk Lecture by Claudia Schillings (FU Berlin), the Rothschild Lecture by Robert Scheichl (Heidelberg), and the "Open for Business" event on "Digital Twins for Engineering Applications – The Emerging Science and Technology" organised by the Newton Gateway to Mathematics. Other regular programme activities included weekly seminars, tutorials and discussions, Gin Fridays (in the colder months) and homemade sangria (in the warmer months).