

Course descriptor B31XN

Course code	B31XN
Course title	Scalable Inference and Deep Learning II
Credits	15
School	Engineering and Physical Sciences
SCQF Level	11
Semester	2
Aims	<p>This course builds on the module “Scalable Inference & Deep Learning I” (B31XO) which it takes as a pre-requisite to further study "inference" or "inverse" problems core to Data Science, particularly when the dimension of the variable of interest is large and the "inference algorithms" need to be "scalable". This module will introduce advanced computational methods at the interface of, not only optimisation theory and deep learning, but also Bayesian inference. These methods will be studied in theory, compared and illustrated in a variety of Data Science applications ranging from imaging and classification, to uncertainty quantification.</p> <p>Itemised list:</p> <ul style="list-style-type: none">• Introduce general “proximal splitting methods” in optimisation and their scalability functionalities• Review the general structure of neural networks and the question of network training, adopting an optimisation perspective• Discuss the advantages and limitations of Bayesian sampling methods with respect to optimisation and deep learning approaches• Introduce hybrid computational methods at the interface of optimisation, deep learning, and Bayesian inference• Apply the learned methods in a variety of Data Science applications ranging from imaging and classification, to uncertainty quantification.

Syllabus	<p>The course will be divided into 3 chapters introducing different classes of computational methods to solve high-dimensional inference and inverse problems. These methods will be studied in theory and illustrated in a variety of Data Science applications (e.g. imaging, classification, uncertainty quantification) in terms of quality of the solution to the problem and the scalability of the algorithm used.</p> <ol style="list-style-type: none"> 1) Advanced optimisation algorithms: introduce advanced “proximal splitting” methods in optimisation; review the main existing optimisation algorithms; discuss mathematical concepts such as splitting and duality; introduce parallelisation and acceleration functionalities at the core algorithm scalability. 2) Deep learning algorithms: discuss the similarities and differences between existing neural network architectures and optimisation approaches; study specific network architectures; discuss the question of network training, underpinned by optimisation algorithms; discuss hybrid algorithms, e.g. where neural networks are used as building blocks in optimisation algorithms. 3) Bayesian methods: study the similarities, differences, advantages, and limitations Bayesian sampling techniques versus optimisation and deep learning methods; introduce hybrid algorithms, e.g. where proximal methods are used as building blocks of state-of -the-art Bayesian sampling algorithms.
----------	---

Learning Outcomes	
Subject Mastery	<p>Understanding, Knowledge and Cognitive Skills</p> <ul style="list-style-type: none"> - Critical understanding of the theory behind the main scalable computational methods for inference problems (optimisation, deep learning, Bayesian, or hybrid methods). - Critical understanding of the structure of the main scalable computational methods for inverse problems, including their similarities, differences, advantages, and limitations. - Practical knowledge of optimisation, deep learning, Bayesian, and hybrid methods for data science applications ranging from from imaging and classification, to uncertainty quantification. - Practical knowledge of programming languages such as MATLAB/Python <p>Scholarship, Enquiry and Research (Research Informed Learning)</p> <ul style="list-style-type: none"> - Practical knowledge of recent advances in scalable algorithms for Data Science applications, e.g. imaging, classification, uncertainty quantification. - Understanding of hot topics in research on inverse problems in large dimension.

Personal Abilities	<p>Industrial, Commercial and Professional Practice</p> <ul style="list-style-type: none"> - Ability to identify the best approach to solve a problem in Data Science (e.g. in imaging, classification, uncertainty quantification). - Ability to design computational methods in different mathematical fields (optimisation, deep learning, Bayesian methods). - Ability to code in MATLAB/Python. <p>Autonomy, Accountability and Working with Others</p> <ul style="list-style-type: none"> - Practical experience of both individual and team work under strict deadlines - Practical experience of project and people management <p>Communication, Numeracy and ICT</p> <ul style="list-style-type: none"> - Practical experience of oral communication.

Assessment method	100% coursework
-------------------	-----------------