EPSRC CDT in Distributed Algorithms

PhD Project: Exploring Efficient Automated Design Choices for Robust Machine Learning Algorithms

University of Liverpool

PhD Student: Dominika Soltysik
Project Partner: GCHQ

Supervisors:
Prof Xiaowei Huang University of Liverpool
Dr Andreas Alpers

Project Description

Applying Machine Learning (ML) currently requires the data scientist to make design choices. Different design choices can alter both how many hyper-parameters (e.g. neuron weights or kernel widths and cross-covariance terms) need to be considered but also how challenging it is to optimise the hyper-parameters of the ML algorithm. Since practitioners have limited time to perform sensitivity analyses with respect to these parameters, design choices are typically based on estimated performance with very limited consideration for the variance in this estimate. Robust performance requires that we do not optimise the hyper-parameters (e.g. using stochastic gradient descent) but generate a set of samples for the hyper-parameters that are consistent with the data and then average across these sampled values for the hyperparameters.

Numerical Bayesian algorithms exist that can explore the design choices and the possible hyper-parameter values associated with each design choice. Mature variants of these algorithms exist and involve the use of Markov-Chain Monte Carlo (MCMC), with Reversible Jump MCMC (RJMCMC) being a variant applicable in contexts where the design choice alters the number of hyper-parameters that need to be considered. In general, and particularly in the case of RJMCMC, these mature algorithms are sufficiently slow and computationally demanding that they are widely assumed to be impractical for practical use in real-world scenarios.

Recent advances at the University of Liverpool have identified that Sequential Monte Carlo (SMC) samplers are an alternative family of numerical Bayesian algorithms that offer the potential to improve on both the time-efficiency and energy-efficiency of MCMC algorithms. Perhaps surprisingly, the potential for SMC samplers to automate design choices, while also exploring the associated hyper-parameter values, is largely unexplored. This PhD will investigate the significant potential to apply SMC samplers in this context.

Go to the EPSRC CDT In Distributed Algorithms website.