Surrogate Modelling of the Tritium Breeding Ratio

Petr Mánek   Graham Van Goffrier

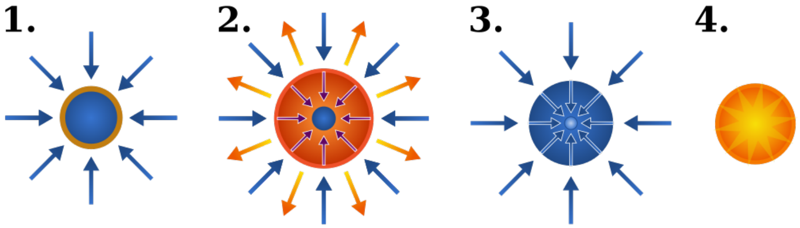
Centre for Doctoral Training in Data Intensive Science
University College London

22nd June 2020

Project Background

Nuclear fusion – the energy of the future!

- Must produce and contain an extremely hot and dense plasma
  - Magnetic Confinement Fusion (MCF): toroidal circulation
  - Inertial Confinement Fusion (ICF): spherical compression
- Modern designs require enriched Hydrogen fuel of two varieties:
  - Deuterium (^{2}H) – abundant in naturally-sourced water
  - Tritium (^{3}H) – extremely rare, but can be produced *in-reactor*



Problem Description

Data Generation

Methodology

Conventional regression task – search for a cheap surrogate $\hat{f}(x)$ that minimizes dissimilarity with an expensive function $f(x)$:

- Regression performance (capability to approximate)
  - Absolute: mean absolute error, σ of error
  - Relative: R^2, $R^2_{\text{adj.}}$
- Computational complexity: wall training & prediction time / sample.

2 approaches for surrogate training:

1. Decoupled – trains models from previously sampled $\mathcal{T} = \{(x, f(x))\}$.
2. Adaptive – repeats sampling & model training, increases sampling density in low-performance regions.

Outline

Experiments 1 & 2: Hyperparameter Tuning

Experiment 3: Scaling Benchmark

-

Experiment 4: Model Comparison

-

The QASS Algorithm

Application on Toy Theory

Conclusion