Artificial intelligence and flow simulation

Context

Fluid flow problems are mainly governed by the Navier-Stokes (NS) equations. They correspond to a wide range of cases varying from simple academic benchmarks to complex industrial configurations. The numerical simulation of these equations is computationally very demanding, due to the presence of a nonlinear transport term, among other things.

The main aim of this project is to explore how one can use simplified physical models and complete them with a machine learning process in order to correctly represent the physical phenomena for a reasonable computational cost. Such a strategy should drastically improve the flow prediction and control strategies and contribute to a significant progress in the numerical simulation of realistic problems.

A funding for deepening the subject towards industrial/environmental applications in a PhD is available, especially for extending this study for modeling the turbulence regime with deep neural networks.

Figure 1: Channel flow simulations with different Reynolds numbers. Results obtained with the code TrioCFD [1].

Internship description

The aim of this internship is to design an algorithm that is able to reconstruct the solution of the Navier-Stokes equations by simulating a simpler model and learning the missing terms using a data-driven model, e.g. a deep neural network. We will adapt the approach developed in [2], which consists in minimizing the norm of the augmented term. The candidate will focus on the well known channel flow problem (Figure 1) with different Reynolds numbers [3]. At first, the candidate will consider the Oseen [4] equations as the simpler model: in this model the nonlinear transport term is replaced by a linear term. The candidate will design and train a proper neural network to recover the correction for the transport velocity. The second, more ambitious objective is to take the Stokes equations as the simpler model: in these equation there is no transport term at all and it will have to be learned as a whole by the neural network. These approaches should then contribute to design more generalized learning strategies for flow problems.
Required skills

We are looking for a last year Master’s or engineering degree student in applied mathematics, mechanical engineering, scientific computing, computer science, artificial intelligence or equivalent.
Knowledge of and experience in Python programming is a plus, and experience in deep learning frameworks (Tensorflow, Pytorch) is a must. The ideal candidate has a good knowledge of either artificial intelligence or numerical methods for PDEs.

Location and duration

This position is for a 5-month internship, with a flexible starting date in 2022. The internship will take place at the Conservatoire National des Arts et Métiers (CNAM), situated in Paris (2, rue Conté, 75003). More specifically, the intern will be part of the machine learning team (Vertigo) of the Center for Studies and Research in Computer Science and Communication (CEDRIC) and of the mathematical and numerical modelling (M2N) laboratory. The internship reward is 600 euros/month.

How to apply

Please send your application (CV and a short motivation letter) to camilla.fiorini@lecnam.net, iraj.mortazavi@lecnam.net and nicolas.thome@lecnam.net.

References


