1 Context and Objectives

Over the years, experiments represented a unique source of knowledge to validate the theory and calibrate computations. In more recent years, computations are more and more considered a substitute to costly physical experiments and used to predict the behavior of configurations and conditions that have not or can not be observed experimentally for different reasons. In recent years, the development of CFD codes allows significant improvements in accuracy, reliability and reduction of computational time. For this reason, more and more often, in the absence of experimental data, due to the difficulty of the phenomena to observe and the lack of funding, the outcome of CFD simulations stands as synthetic data, feeding and improving the models of system codes, such as CATHARE.

However, it is undeniable that, although to a lesser extent than system codes, CFD simulations are affected by modeling errors due to the mathematical representation of highly complex physical phenomena, certainly not exhaustive. We know, in particular, that numerical simulations are affected by several sources of errors, including discretization errors, uncertainties in the physical parameters and modeling errors. In this context, the assessment of the prediction capabilities of a CFD code is crucial.

We worked recently on the calibration of computer models, including an estimation of the error model. In [1], we investigate a computer model calibration technique inspired by the well-known Bayesian framework of Kennedy
and O’Hagan [4]. Following an innovative definition of model error based on a posterior average rather than an implicit ”true value” for the model parameters, we formulate a new calibration equation and derivate predictive equations in a Bayesian fashion. In [2], using innovative numerical techniques, we calibrate the thermal-hydraulics code Neptune CFD code in a bubbly flow experiment obtained from the DEBORA facility. The performance of the calibration is assessed, along with the reference solution obtained by running a high-dimensional Monte-Carlo Markov Chain on the ensemble of the variables of the problem.

The method allows quantifying the error committed by a specific model and, therefore, potentially direct the research towards a better estimate of the prediction of the code. Nevertheless, it does not provide any guidelines on improving the model and the prediction itself. The main objective of this thesis will be to extend the developed framework to combine several models predictions to improve the overall prediction capabilities. This goal could be achieved by Bayesian model selection and models mixtures, accounting for the respective estimated errors of the models and including experimental data. The thesis will be strongly oriented to predicting the boiling crisis with the models provided in the NEPTUNE CFD code [3], using experimental data and a systematic formulation of the model error.

2 Supervision

This thesis will be held at CEA Center of Saclay in collaboration with Platon Team (https://team.inria.fr/platon/, Joint Team between Inria Center of Saclay Ile-de-France and Ecole Polytechnique).

This thesis will be supervised by M.G. Rodio at CEA-Saclay. The academic supervisors will be P.M. Congedo (Inria) and Olivier Le Maître (CNRS).

The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas: (1) defence and security, (2) nuclear and renewable energies, (3) technological research for industry, (4) fundamental research in the physical sciences and life sciences. Drawing on its widely acknowledged expertise, the CEA actively participates in collaborative projects with a large number of academic and industrial partners. The CEA is established in nine centers spread throughout France.

Established in 1967, Inria is the only French public research body fully dedicated to computational sciences. It is a national operator in research in digital sciences and is a primary contact point for the French Government on digital matters. Under its founding decree as a public science and technology institution, jointly supervised by the French ministries for research and industry, Inria’s missions are to produce outstanding research in the computing and mathematical fields of digital sciences and to ensure the impact of this research on the economy and society in particular. Inria covers the entire spectrum of research at the heart of these activity fields and works on digitally-related issues raised by other sciences and by actors in the economy and society at large. Beyond its structures, Inria’s identity and strength are forged by its ability to develop a culture of scientific innovation, to stimulate creativity in digital research. Throughout its 8 research centres and its 180 project teams, Inria has a workforce of 3 400 scientists with an annual budget of 265 million euros, 29% of which coming from its own resources.
3 Type of contract

The successful applicant will be offered a six (6) months internship followed by three year full-time funded contract by CEA. Duration: 36 months. Work location: mainly CEA-Saclay, and also CMAP (Ecole Polytechnique).

Potential Starting date: October/November 2022. Note that an M2 internship on the topic is possible between March and September 2022.

4 Requirements and Application Procedure

Candidates are required to have a Master’s degree in engineering, applied mathematics or a related discipline, and a specialization in computational fluid dynamics. Preferable qualifications for candidates include proven research talent, an excellent command of English, and good academic writing and presentation skills.

Applicants should submit a Curriculum Vitae, a covering letter as a single document detailing the knowledge, skills and experience you think make you the right candidate for the thesis, two letters of reference, a list of your MSc courses and grades, copy of your Master’s thesis and preferably a list of publications.

For further details and applications, please contact Maria Giovanna Rodio or Pietro Congedo (mariagiovanna.rodio@cea.fr, pietro.congedo@inria.fr). All applications should be emailed to mariagiovanna.rodio@cea.fr by 30 April 2022.

References


