POST DOC position at ISAE SUPAERO on

Surrogate models based on deep learning networks and CFD data for multi-injectors combustion chambers.

Subject

Liquid rocket engines (LRE) are complex systems. Several dependent sub-systems, that have to be designed conjointly, intervein in the design of the whole system. In particular, the fluid flows description in the combustion chamber, in the cooling system and in the feed system play a fundamental role at this level. The preliminary sizing of the engine is based on semi-empirical correlations to describe the sub-systems, calibrated on existing engines. These low fidelity models induce high uncertainties in the subsystems designs that propagate and affect the global engine sizing. As a consequence, the engine development strongly relies on experimental studies, that go up to hot-tests of the engine, making use of very expensive experimental facilities. Therefore, increasing the numerical modeling reliability is a strategic matter that need to be addressed in order to reduce the development cost of innovative LRE for future launchers, and thus ensuring access to space.

High fidelity numerical simulation, and specifically **large eddy simulation (LES)**, has demonstrated its capacity to finely describe complex physical phenomena in LRE combustion chambers [1, 2, 3]. Nevertheless, LES is still a highly computational cost methodology, with long restitution times, which can limit its utilization in the context of concrete applications. What is the best way to exploit this tool for design [4] is an interesting question which is under investigation today. In order to answer this question, an original and innovative strategy has been developed in the Space Concepts team, hosted in the Department of Control and Design of Aerospace Vehicles (DCAS) of ISAE SUPAERO in collaboration with CERFACS. The main idea is the development of a proper methodology that combines numerical simulations of reacting flows in injector elements and deep learning algorithms in order to generate surrogate models for injectors and combustion chamber of liquid rocket engines [5,6,7]. These models have inference times of the order of the ms and are thus suitable to be used for system optimization. The long-term goal could be to increase the reliability of the low order models used in the preliminary design phase, thus accelerating all the process while reducing the number of experimental tests. The methodology is at an early phase of maturation: it is the subject of an ongoing PhD and recent results have been published [8,9,10]. The postdoc will continue these activities focusing on two principal research questions that need to be addressed as discussed in the research plan.

Research plan

1) The first question we want to address is how to reduce the size of the Design of Experiments (DOE) and thus the computational cost associated with the generation of the numerical data. Different approaches will be explored and compared (intelligent DOE generation, and transfer learning techniques,).
2) The second question is associated with the behavior of multi-injector chambers. In particular, one objective will be to investigate the possibility to use single injector surrogate models to reproduce a multi-injector combustion chamber, and to emphasize the limitation of the methodology.

Work environement

ISAE SUPAERO is Europe's leading institution of graduate education and research in aeronautics, space and embedded systems. Its missions are to provide the finest quality higher education in science and engineering, to train highly qualified, multidisciplinary engineers in aeronautics and space and in related fields, to engage in scientific research and technological development and to provide innovative solutions to tomorrow's challenges. ISAE SUPAERO provides high-level graduate programs in engineering, Masters, Advanced Masters and PhD degrees, opening a wide range of career opportunities. The ISAE SUPAERO campus located in Toulouse holds 1600 students and 420 permanent staff, 145 of whom are professors and engineers. It is connected to local, national and international academic partners via its Master programs and research activities.

The post-doc will work in the Space Concepts research group (hosted in the Department of Design and Control of Aerospace vehicles), that develops its research activities in the context of space access and exploration. One strong axis of investigation of the group is devoted to the use of deep learning algorithms, trained on numerical simulations data, as surrogate models for rocket engines injectors and chambers.

Duration: 24 months

Profile:
Candidate should have a PhD in numerical fluids mechanics in relation with reactive flows.
Experience in machine learning and basic knowledge in liquid rocket engines would be highly appreciated.

Applications:
curriculum vitae + motivation letter at annafederica.urbano@isae-supaero.fr

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