Research project offer

Location : ISAE SUPAERO, Toulouse, France **Department** : DAEP, in collaboration with CNES **Research group** : AEX **Supervisor** : Michaël BAUERHEIM and Sébastien LE MARTELOT **Email** : Michael.bauerheim@isae-supaero.fr and Sebastien.LeMartelot@cnes.fr	
OFFER DESCRIPTION	
Title : Deep Neural Networks to accelerate CFD towards a fast prediction of the performance of liquid pumps. **Proposed duration and period** : 6 months internship (with potentially a 6 months short-term contract after the internship)	
Context	The French Center for National Space Studies (CNES) is involved in the design of the next generation of rocket engines. In that context, a critical element is the turbopump, employed to pressurize the rocket propellant before its injection in the combustion chamber. The performance of the turbopump is of central interest, since the generated thrust of the rocket engine depends directly on the ergols pressure. Turbopumps are equipped with rotating radial compressors, for which the evaluation of the performance still requires complex and challenging 3D simulations. Accelerating these simulations is of prime importance to optimize the turbopump geometry at a pre-design stage. In particular, the Poisson solver used in the incompressible CFD solver is responsible for up to 80% of the computational cost. Thus, this internship intends to develop and validate an alternative solver based on artificial intelligence, by replacing the standard Poisson solver by a deep neural network. A preliminary work at ISAE-Supaero has shown a significant speedup of such AI-based solver, yet simulations do not account yet for rotation. Consequently, the objective of this internship is to introduce the rotation effect on the existing AI-based incompressible solver, and validate the proposed approach on simple rotating test cases.
Objectives and work	ISAE-SUPAERO is currently developing an innovative incompressible solver, where the standard Poisson solver is replaced by a deep neural network. This network is trained on a dataset to reproduce the pressure correction term, needed to enforce the mass conservation equation. Results have shown a significant speedup of the method compared with classical Poisson solvers, focusing on buoyancy-driven flows (plumes) and unsteady 2D aerodynamics (Von Karman street). This internship intends to evaluate the AI-based solver on rotating flows. To do so, the rotation effect will be introduced into the existing solver as an external volume force. The implementation will be validated on simple 2D rotating viscous and non-viscous flows with a classical iterative Poisson solver, at various rotational speeds. Then, the same cases will be evaluated using the AI-based solver, in order to assess both its precision and performance. Analysis of the flow physics and the network errors should allow the identification of potential improvements of the current method and learning strategy.

Possibility to continue with a PhD (Yes/No) : Yes, depending on fundings	
REQUIRED APPLICANT PROFILE AND SKILLS	
Study level	☐ Undergraduate students (3rd or 4th year) ☑ **Master students (1st or 2nd year)** ☐ PhD students
Required profile and skills	The student has a good knowledge on fluid dynamics and python/C++. Knowledge on rotating flows and artificial intelligence (in particular neural networks) would be a plus. French and/or English is mandatory. The candidate should be autonomous, with good soft skills for working in a team and presenting her/his results.