CDD Ingénieur de Recherche, LIMSI Laboratory

DIGITEO project: MUSE
(MUltiscale Spray combustion fully Eulerian solver in 3D)

Position: Research Engineer fixed term position: Visualization and analysis of flow dynamics.

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Context and objective: Current methods for the analysis of flows struggle to access the full space-time character of the flow, being generally restricted to the first and second order statistical moments of the unsteady field. A major challenge today is therefore to be able to measure, predict and understand the instantaneous structure of a turbulent flow and its temporal evolution. Moreover, humans are capable of comprehending much more information when it is presented visually, rather than numerically. Therefore, main objectives of this research are to develop efficient methodologies to analyze, compare and visualize large data-sets coming from both numerical simulations or experimental records.

The essential objective of this part is thus to significantly advance our analysis and visualization capabilities where the space-time structure of complex flows mainly devoted to combustion are concerned. A particular attention will be paid to the mechanisms by which these flows

generate unsteadiness. Our goal is to generate a greater understanding of the flow problem in combustion but also to achieve a real synergy between the laboratory partners for the conception of perspicacious analysis and visualization tools.

On the one hand, the candidate would have to focus on the development of multi-disciplinary analysis methodologies to provide means for understanding the pertinent physical mechanisms responsible for unsteadiness. Therefore, he will implement methods derived from recent developments in the domain of signal and image processing to allow processing of the extremely large numerical and experimental databases generated during this project.

On the other hand, the candidate would have to develop flow visualization techniques for both *(i)* the analysis of results coming from either experiments or CFD to enhance the fluid flow dynamics and *(ii)* the comparisons between numerical simulations and experimental results following specific criteria check in this project. In both cases, one of questions which arises is how to manage extremely large data-sets. The first task will consist in choosing a tractable file format for storing and managing the extremely large data. We plan to use data models like HDF5 or NetCDF for instance, libraries and file formats due to their portability, flexibility and efficiency for high volume of complex data. Moreover, as our applications need to read complex data (complex level of objects instead of data arrays), we will write the required conventions in XML or XDMF files that can be used to tell an application how to read and reassemble HDF5 array data into higher level constructs. In order to quickly build basic visualizations to analyze our data, we can use open source softwares (ParaView, Mayavi or Visit, for instance) developed to represent extremely large data sets using distributed memory computing resources. As numerical results are obtained by a multiresolution algorithm (grid adaptivity), each snapshot of the solution is known on a non conformal mesh that evolves in time. As recent features mainly developed using VTK library are not optimized for such a data structure, specific visualization scripts or reader plugins will be developed to go further in the visualization process and to optimize the time devoted to the calculation of isosurfaces and the rendering in order to interactively visualize all the details contained in our complex data. These scripts or plugins will be written in Python or C++ and they will use the Visualization ToolKit (VTK) library.

Qualification and application procedure: The candidate must have a good background in signal and image processing. He should also have an adequate skill programming in C++ and Python. Good knowledge in computational fluid dynamics, modal decomposition and/or dynamical system are welcomed but not mandatory. This one-year position will be funded by the RTRA DIGITEO. Applicants must send their detailed Curriculum Vitae, including a list of publications.