Abstract of the Master Thesis

Ashish Shankar Darekar (03709039)
Master Student, CSE, Technical University Munich

February 4, 2021

Development of a general OpenFOAM-Coupling-Adapter for the Kratos-CoSimulation Multiphysics solver

KRATOS Multiphysics ("Kratos") is a Open Source framework for building parallel, multi-disciplinary simulation software, aiming at modularity, extensibility, and high performance. Its main applications are Structural Mechanics, Fluid Dynamics (CFD), **Fluid-Structure Interaction (FSI)**, etc. The developers are always enthusiastic to solve the real world problems such as FSI of Olympic stadium roof of Munich.

FSI problems and multiphysics problems in general are often too complex to solve analytically and so they have to be analyzed by means of experiments or numerical simulation. The FSI problem is an interface multi-physics coupling problem, where a boundary is shared between structural domain and fluid domain. To solve this numerically there are two approaches namely monolithic approach and **partitioned approach**. Development of stable and accurate coupling algorithm is required in partitioned simulations. In order for the simulation to make sense and to be numerically stable, the values of the physical fields defined or computed on both sides of the interface need to be in agreement. And this is the major job of any **Coupling Software/Adapter**.

OpenFOAM is the one of the best Open Source softwares available in the market for fluid simulation. When we consider to solve any multiphysics application (eg. FSI mentioned above) where, OpenFOAM used as a Fluid solver and Kratos as a Structural solver. Then, they should have a coupling environment to transfer the data from OpenFOAM to Kratos and vice versa. Currently, the team has an application called **CoSimulationApplication**, which contains the core developments in coupling the black-box solvers with and within Kratos Multiphysics. Hence, they can couple Kratos (as a Fluid solver) with Kratos (as a Structural solver) for FSI application. But, when it comes to couple the Kratos with OpenFOAM they currently don't have any provision. So my thesis will focus on the **"Development of general OpenFOAM-Coupling-Adapter for Kratos using the capabilities of Kratos-CoSimulation"**. Currently, the team has a standalone tool developed in C++ called **CoSimIO** which is responsible for exchanging data when works in the combination with **CoSimulationApplicaiton**. CoSimIO can integrate easily with any solver/software tool using C/C++/Python interface. There is one more standalone application in Kratos called **MappingApplication** which can be used to map field data from one mesh to another while solving a coupling problem.

Major tasks in the developement of an adapter involves thorough knowledge of the **source code of OpenFOAM and Kratos-CoSimulation**, to use the methods available in the OpenFOAM to extract the required information of the parameters, to use the methods in the CoSimIO to communicate with the CoSimulationApplication and MappingApplication and to write some problem-specific functions (FSI here) required to get the information for a coupling. After successful development of this adapter, it is planned to be used for **solving the Fluid-Structure-Interaction problem on Olympic Stadium Roof of Munich.**

Requirements:

- Sound knowledge in the field of CFD, Software Engineering, HPC and FSI.
- Good programming skills in C++, MPI, Python.
- Knowledge and Hands-on experience on Open Source CFD solvers: OpenFOAM and KratosMultiphysics (KRATOS: https://github.com/KratosMultiphysics/)

Related Literature:

1 Dadvand, P., Rossi, R. Oñate, E. An Object-oriented Environment for Developing Finite Element Codes for Multi-disciplinary Applications.Arch Computat Methods Eng 17,(2010). (https://doi.org/10.1007/s11831-010-9045-2)

2 Gerasimos Chourdakis. A general OpenFOAM adapter for the coupling library preCICE. Master's thesis, Department of Informatics, Technical University of Munich, 2017.

3 Mataix Ferrándiz, V., Bucher, P., Rossi, R., Cotela, J., Carbonell, J. M., Zorrilla, R., ... Tosi, R. (2020, November 27). KratosMultiphysics (Version 8.1). Zenodo. (https://doi.org/10.5281/zenodo.3234644)

Supervision:

Philipp Bucher and Prof. Dr. -Ing. Kai-Uwe Bletzinger, Chair of Structural Analysis, TUM Department of Civil, Geo and Environmental Engineering