A proposal on Solving the Incompressible Navier Stokes Equation using the DEAL.II Finite Element programming software

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01/27/2025

Introduction:

Deal.II is an open-source finite element (FE) library implemented in C++ that provides tools for developing sophisticated numerical solvers for scientific computation and has made significant contributions in computational fluid dynamics research. Its framework offers extensive capabilities for mesh handling and robust linear algebra operations. This software was particularly chosen for its parallel computing capabilities, extensive documentation and tutorials availability and its integration with OpenIFEM's codebase.

Implementation of the stabilized incompressible Navier-Stokes solver using Deal.II will be based on previously developed FEniCSx implementation of the same problem for FEM course project. The implementation will transfer the numerical approach to Deal.II while incorporating key components like mixed finite element formulation for velocity-pressure coupling, generalized-α method of time integration and SUPG, PSPG and LSIC stabilization techniques.

Methodology:

- Study the Deal.II tutorial steps 22 (delves on incompressibility) and 35 (discusses Advance NS implementation strategies) along with other required steps within them.
- Modify the existing implementation to include the stabilized generalized-α formulation of the incompressible NS equations
- Create test cases to validate the results against benchmark data (preferably, a 2D cylinder flow problem) with potential automation of the testing process
- Proper documentation of the implementation details

Objective:

The primary aim of the project is to implement a previously developed comprehensive approach to solving the incompressible Navier-Stokes equations in Deal.II. By developing a robust solver to help extend its capabilities, this implementation will be aimed to serve as a contribution to Deal.II's open-source ecosystem.

The proposal has been submitted considering this complex problem such that it will give me more hands-on experience with the process of developing CFD solver using the C++ programming language.