Weak Form & LiveLink™ for MATLAB® Based Modified Uzawa Method for Solving Steady Navier-Stokes Equation

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Abstract

We all know COMSOL Multiphysics® software can solve nonlinear PDE easily by built-in Newton method, and one typical example is Navier-Stokes equation. But sometimes we can't figure out a good initial guess for Newton method, or maybe we have some other good algorithms. In these cases, The Laminar Flow interface may not be so suitable.
So I want to demonstrate a simple example about how to design my own algorithm for steady N-S equation by weak form PDE (Figure 1) and LiveLink™ for MATLAB® (Figure 2).
First, I add geometry, each step (weak form equation) of my algorithm, mesh to COMSOL. Then I assign loop variables by adding a simple coefficient equation (u_k = u). Last, load the .mph model to MATLAB®, and let MATLAB® execute the loop, draw the answer and analyze the data.
After the computation, We get the same solution as other FEM packages (FreeFEM++ & FeniCs) at each iterative step (Figure 3), and we can see the N-S equation's solution and errors between each step (Figure 4).
With other physics models or equations, the mathematics branch and LiveLink™ for MATLAB® can also do the numerical experiment easily.

Reference

Puyin Chen, Jianguo Huang, Huashan Sheng, Some Uzawa methods for steady incompressible Navier–Stokes equations discretized by mixed element methods , Journal of Computational and Applied Mathematics 273 (2015) 313–325.

Figures used in the abstract

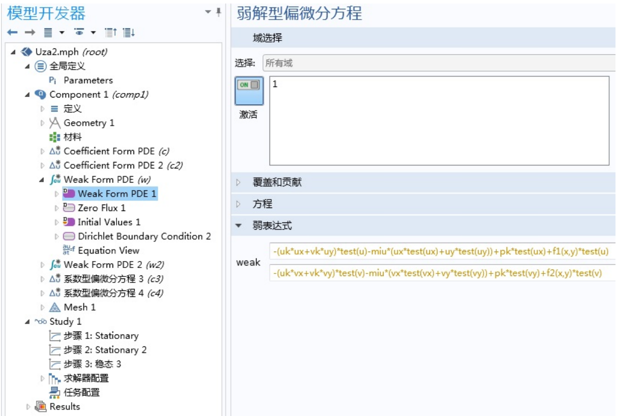

Figure 1: Weak Form PDE of Steady N-S Equation.

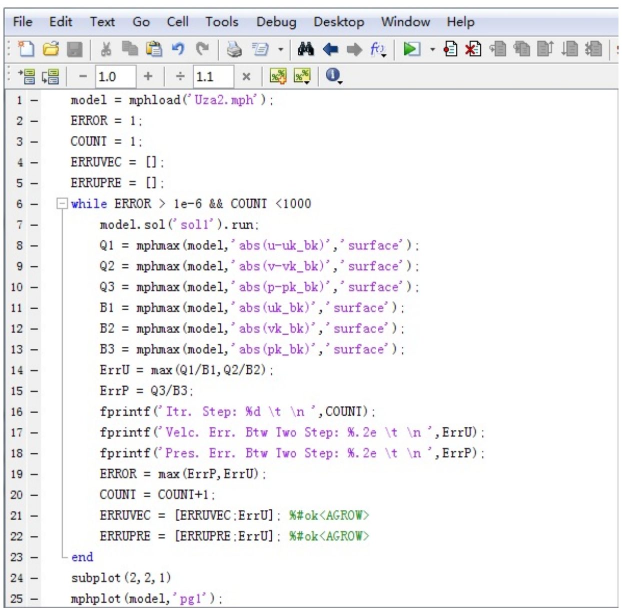

Figure 2: MATLAB Code for Looping.

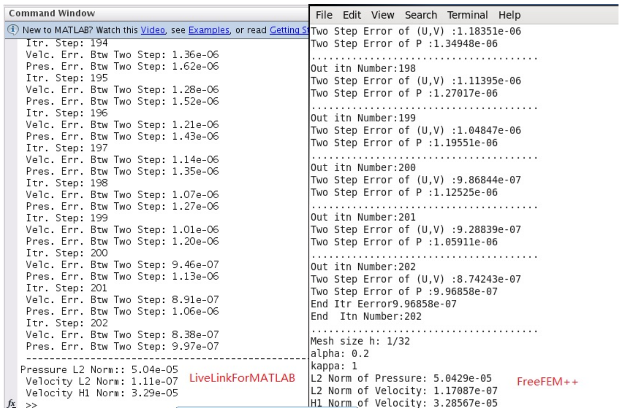

Figure 3: Solving Process Compared with FreeFEM++.

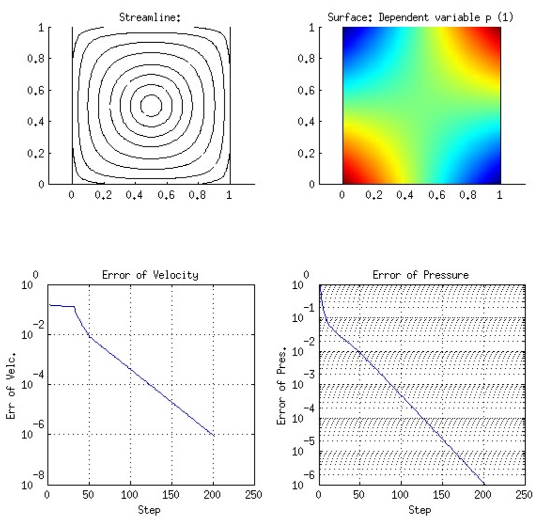

Figure 4: Solution and Iterative Errors of the Numerical Example.