Fluid Interface Detection with PETSc and DONLP2

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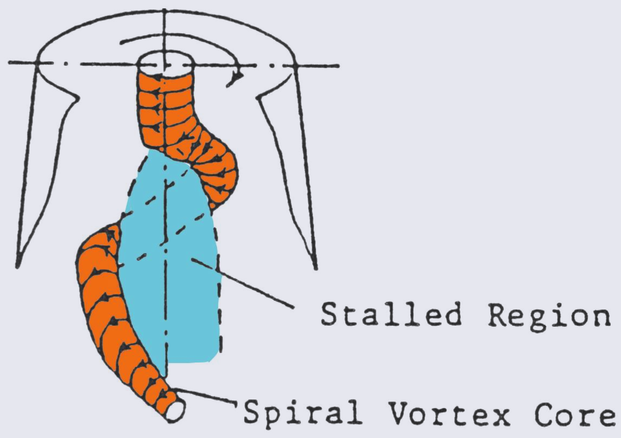
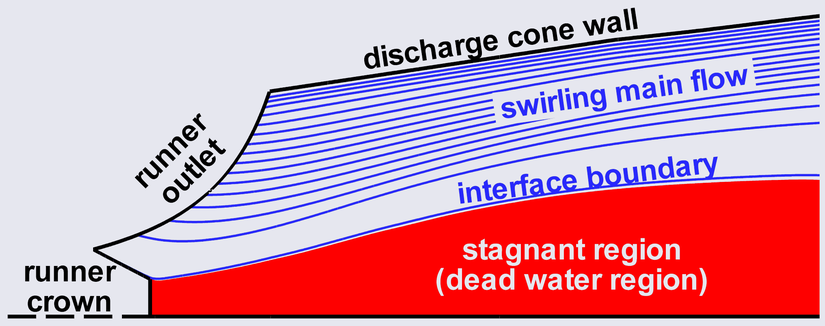
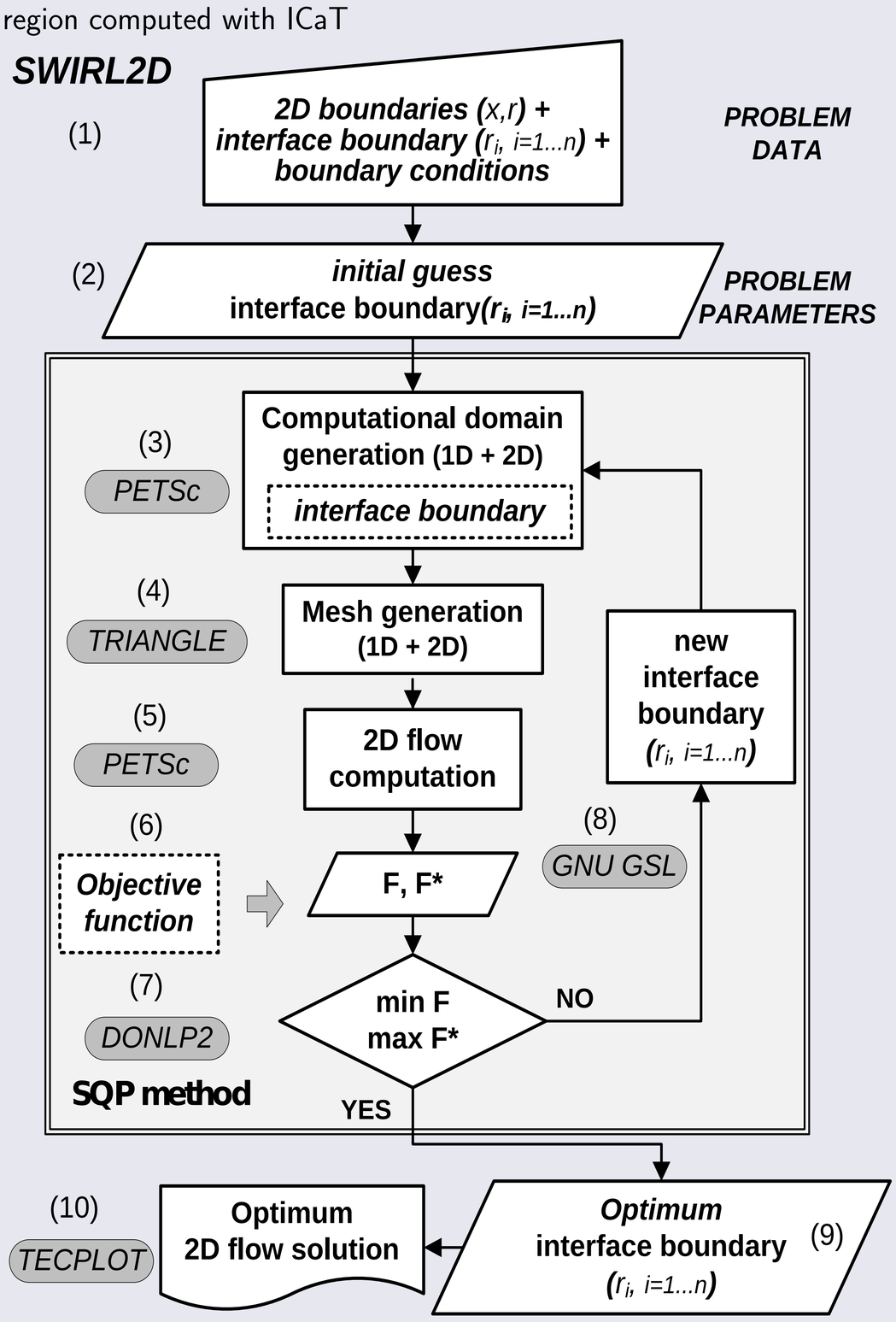
Introduction



- Vortex rope (self-induced instability) taking place in swirling flows
  - the stalled region is filled with stagnant water
  - 3D unsteady flow is modeled considering a 2D axisymmetric steady flow
  - the flowing-stalled fluid interface can be determined using interface capturing techniques (ICaT) and interface tracking techniques (ITrT)



- Two-dimensional axisymmetric flow numerical simulation with stagnant region computed with ICaT



- The SWIRL2D tool's algorithm for tracking the flowing-stalled boundary using ITrT
  - the ITrT uses the SQP optimization method from DONLP2 in order to minimize the F function

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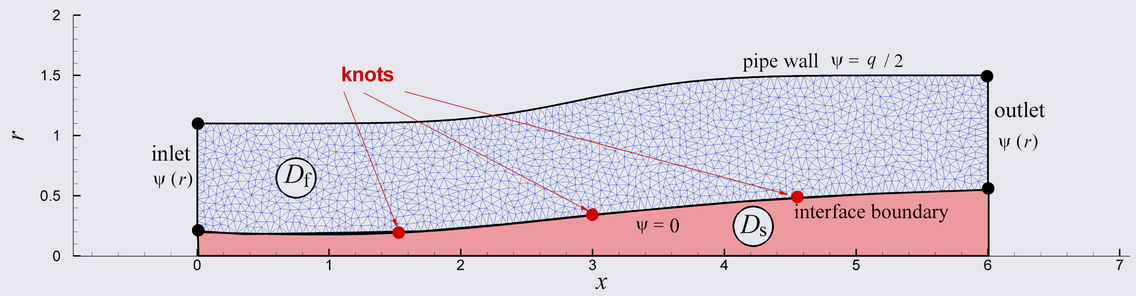
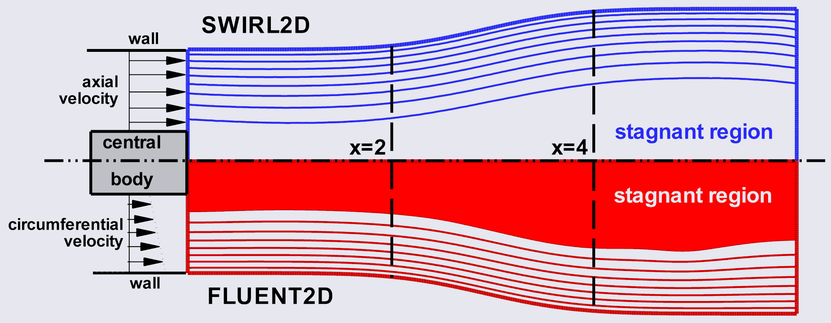
- an extended paper has been submitted to the Proceedings of the Romanian Academy

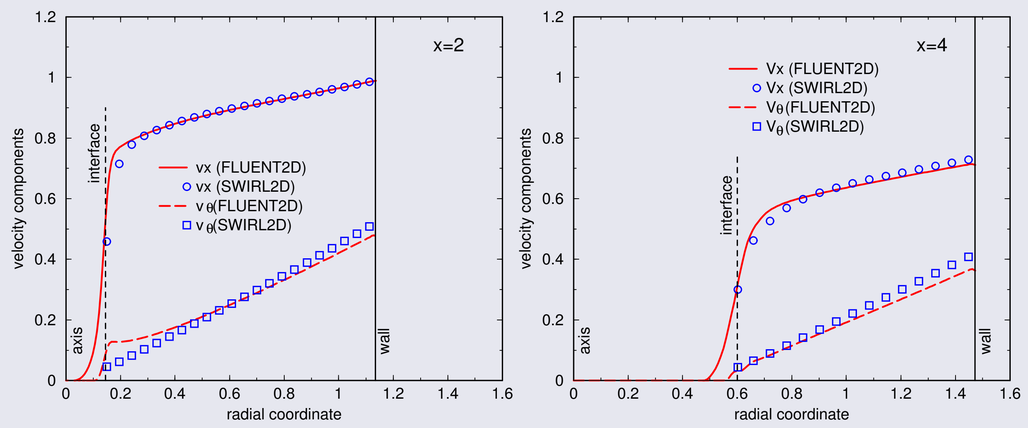
Interface detection using moving knots



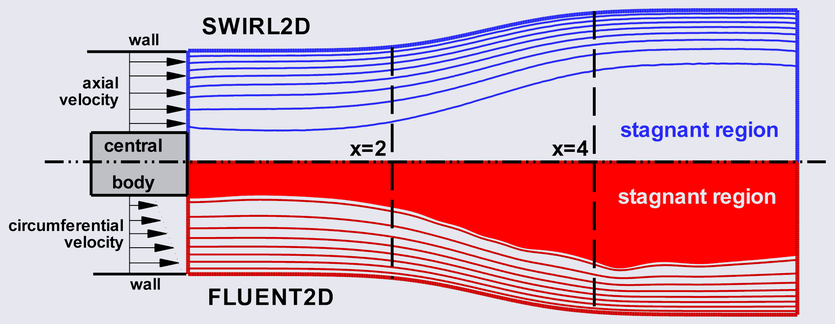
- the moving knots are used for SQP interface optimization
  - the interface is obtained through interpolation using cubic splines
  - a new mesh is generated using TRIANGLE and the 2D section axisymmetric flow is solved using the finite element method (FEM)

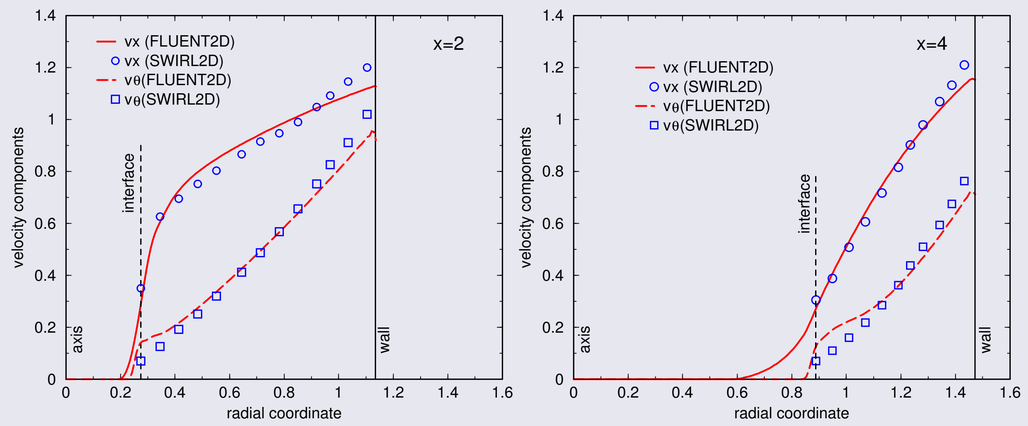
Results: SWIRL2D (ITrT) and FLUENT2D (ICaT)





- Streamlines for swirling flow with stagnant region for swirl intensity of $\xi = 1$
  - SWIRL2D solution (upper meridian half-plane) and FLUENT2D axisymmetric inviscid solution (lower meridian half-plane)





- Streamlines for swirling flow with stagnant region for swirl intensity of $\xi = 2$
  - SWIRL2D solution (upper meridian half-plane) and FLUENT2D axisymmetric inviscid solution (lower meridian half-plane)

Conclusions

- The numerical solutions computed with the ITrT SWIRL2D tool are in good agreement with the ICaT FLUENT2D solutions
- The SWIRL2D tool can accurately assess the swirling flow with less computational resources and much faster than ICaT

References

- SUSAN-RESIGA, R.F., MUNTEAN, S., ANTON, A., Swirling flows with stagnant region and vortex sheet: a novel variational approach, International Workshop on Cavitation and Dynamic Problems in Hydraulic Machinery, Sep. 8-11, 2013, Lausanne, Switzerland.
- SUSAN-RESIGA, R.F., MUNTEAN, S., STEIN, P., and AVELLAN, F., Axisymmetric swirling flow simulation of the draft tube vortex in Francis turbines at partial discharge, Int. J. Fluid Mach. Sys., 2(4), pp.295-302, 2009.