Reaction-diffusion equation–based topology optimization: 3D fluid-structure system design using FreeFEM-PETSc-Mmg

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Abstract

We propose a parallel distributed and open-source framework for full-scale 3D fluid-structure system design based on topology optimization (TO). This can be achieved by properly combining parallel computing and mesh adaption techniques by adopting a reaction–diffusion equation (RDE) based level-set method. Mesh adaptivity which discretizes and optimizes an implicitly defined surface (level-set interface) can allow us to reach an optimal solution with high-resolution and clear boundaries. Our framework can be easily applied to the real world engineering product design which have complex geometries, and the generative design represented by the body-fitted tetrahedral mesh can be efficiently converted to the Spline CAD data. Furthermore, the proposed optimization algorithm can mitigate dependency to initial guess and mesh resolution to some extent. Our numerical implementation uses FreeFEM for finite element analysis (FEA), PETSc for distributed linear algebra, and Mmg for mesh adaption. Several numerical examples and 3D printed prototypes support these remarkable features.

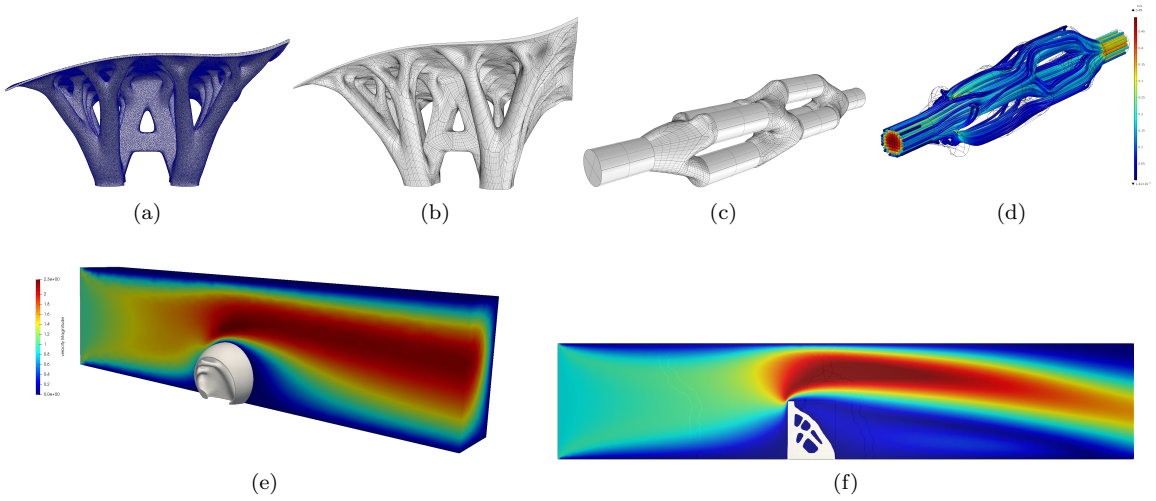

Figure 1: Optimal solutions. (a)–b): Roof support design; (c)–d): pipe connector design; (e)–f): FSI problem.

References

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