M. Sc. Project

Constructal theory - driven Topology Optimization

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Ever wondered why trees look the way they look? Nature impresses us with a multitude of tree-shaped flow structures: lungs, vascularized tissues, river basins and deltas, lightning,

botanical trees (canopies, roots, leaves), dendritic crystals, nervous systems, street patterns and urban growth, bacterial colonies, transportation, *etc*. Each tree connects an infinity of points (area, volume) with a single point (source or sink). The geometric forms spring out of the struggle for better global performance subject to global and local constraints. Adrian Bejan* constructs similar architectures in engineered systems that require similar volume-point connections. This approach, referred as *constructal theory*, is a fully deterministic principle that allows us to anticipate shapes and structures that occur naturally. It represents the law that governs naturally organized flow systems.

We seek to use this approach to gain a speedup in topology optimization (TO). One of the key factors that guides the convergence of TO is the extent of convexity of the optimization problem. For some problems *e.g.* solar cell front electrode design problem, the process is extremely sensitive to the initial guess and for even small differences in the initial designs, the optima might be different. Thus, for such problems, choosing an initial guess is an important step. The capability of constructal theory to design well-performing structures is proven in the recent literature and this approach could possibly be a good step in the direction of choosing an initial guess for TO.

Aim of the project:

The student is expected to achieve the following milestones:

1. Understand the concepts of constructal theory and topology optimization based on existing literature.
2. Study systematically the influence of initial designs in topology optimization.
3. Generate initial guesses for simple thermal/electric conduction problems and optimize using topology optimization.
4. Use constructal theory to generate initial guesses for more complex optimization problems *e.g.* solar cell front electrode problem.

Requirements:

We are seeking an enthusiastic individual with an interest to work on topology optimization. Experience with MATLAB or Python is required.

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*Adrian Bejan (2000) Shape and Structure, From Engineering to Nature, *Cambridge University press.*