Modular-Topology Optimization of Truss Structures Composed of Wang Tiles

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Objectives

- Multi-scale design with guaranteed compatibility of adjacent cells
- Manufacturable aperiodic arrangement of cells, in contrast to the (locally) periodic microstructures
- Development of the modular-topology optimization framework for the optimal design of (i) the topology of truss modules and (ii) their arrangement in the optimized design domain

Formalism of Vertex-Based Wang Tiles

- Each module is described as a Wang tile – square domain with fixed orientation and attributed vertex codes
- The framework enables aperiodic assembly plans
- 4 types of horizontal and of vertical edges ensure mutual compatibility of adjacent cells

Tile Ground Structure

- All modules/tiles are assigned the same ground structure
- Modularity enforces equal topology among identical tiles and edges

Modular-Topology Optimization

- Bilevel combinatorial-convex program seeking for the optimal module arrangement and the optimal topology of modules/tiles
  1. Topology optimization for a given assembly plan (bottom level)
  - Convex Second-Order Cone Programming formulation for topology optimization with a priori specified assembly plan
  - Modularity constraint decreases the number of design variables
  2. Optimal assembly plan (top level)
  - Simulated Annealing (SA), provisional

Example: Simply-Supported Beam

Conclusions & Future Work

- Modular structures can be of comparable quality with the non-modular ones
- Aperiodic assembly plans provide a significant improvement over periodic designs
- Future plans are to enhance the approach to continuous topology optimization and to make the solution process more efficient
- Additive manufacturing

References


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