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Non-parametric Shape Optimization of 3-D Frame Structures for Maximizing a Natural Frequency

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This paper presents a non-parametric, or a node-based, shape optimization method for designing the optimal geometry of a 3-D frame structure composed of arbitrarily curved linear elastic beams. A design problem dealt with maximizing the natural frequency for a specified mode is formulated as a distributed-parameter shape optimization problem. Under the assumption of that each beam varies in the normal direction to its centroidal axis, the shape gradient function and the optimality conditions are theoretically derived by the Lagrange multiplier method and the material derivative method. The optimal free-form geometry is determined by applying the derived shape gradient function as the pseudo external forces upon the beams to maximize the objective functional, which is called the H^1 gradient method for frame structures, a gradient method in a Hilbert space, proposed by one of the authors. The effectiveness and validity of the proposed method is verified through several design problems.

Keywords: Shape optimization, Parameter-free, Free-form, Frame structure, Space frame