Commentary
Volume 14:1, 2023

Journal of Physical Mathematics

ISSN: 2090-0902

Open Access

Eliminate Contained Holes in Topology Optimization: A Novel Method Based on Spectral Graph Theory has been developed

Onur Schaub*

Department of Chemical Engineering, University of Southern California, Los Angeles, USA

Description

In structural design, topology optimization (TO) has emerged as an essential conceptual tool. The non-trivial task of distributing a limited amount of material in a design space in order to optimize a specific objective function while meeting constraints is greatly aided by this. However, it is true that conventional manufacturing processes can sometimes make it difficult to implement TO-based designs. Because AM technologies make it possible to manufacture extremely complex structures directly from a computer, they have received special attention in the last ten years, along with TO. However, even though these are cutting-edge methods for 3D printing, there are still a few obstacles to overcome. To avoid enclosed holes in topology optimized structures, particularly those of minimum compliance, our work focuses on the structural connectivity problem [1].

In two-dimensional topologies, it is common, and it is also well-known in three-dimensional topologies, for the void phase to be distributed in a manner that is not connected when compliance is minimized (or stiffness is increased). Even though enclosed voids are desirable from a stiffness standpoint, their production is extremely difficult or impossible, especially when AM is used. This has led to the development of constraint-based methods for topology optimization among others that assist in preventing the formation of enclosed holes in structures that have been optimized for topology. According to the authors' knowledge, connectivity constraints in topology optimization problems have only been referenced a few times in recent times. The virtual temperature method (VTM) was the first approach to this problem that was independently proposed by a number of authors [2].

The idea is to solve a linear auxiliary thermal problem by treating the solid as an insulator, the void as a conductive material, and some parts of the boundary as heat sinks. By restricting the maximum temperature in the void phase, void connectivity is imposed there. In the fluid analysis problem, similar strategies have been used to prevent enclosed (fluid-filled) pores that cause singularities. This method can also be used to take molding constraints into account when designing a structure and to make piezo-transducers with simply connected electrodes so that they don't need as much electrical wiring. By incorporating a nonlinear heat source term, it has recently been improved making the temperature in enclosed voids uniform across the entire structure regardless of void sizes, wall thickness, or locations [3].

Other authors have developed a method that is comparable to the VTM and is based on the well-known electrostatic theory. This method can handle casting constraints and stress constraints. The following are additional methods that have been developed over the past few years to eliminate enclosed voids: a bi-directional evolutionary structural optimization method a projection-based method a feature-driven method and a particle diffusion-based method. This final piece also draws inspiration from graphs, but not in the same way that this one does.

This work aims to propose a novel strategy for avoiding internal or encapsulated holes in topology optimized structures by combining the fields of topology optimization and graph theory. The reader need not have a deep understanding of graph theory to fully comprehend the concept we present here, so we will provide the necessary preliminaries. Our idea was originally designed to find and avoid enclosed voids in structures. However, it could be used to identify isolated characteristics of any materials in a design domain where two phases coexist. In particular, it would be very interesting to design photonic devices that can detect and control the number of "floating islands" and piezoelectric transducers with effectively connected two-phase electrodes (this is actually a work in progress).

The following is the layout of the paper: The second section examines the necessary concepts and provides a brief introduction to graph theory. A method that successfully detects the number of enclosed holes in a design domain with coexisting two phases-a material phase and a void phase-is presented in the context of a topology optimization problem, a brand-new formulation for structural design that incorporates the connectivity constraint over the void phase is made available. Additionally, the sensitivity analysis is included in some numerical examples for minimum compliance with and without connectivity constraints are provided in the final section concludes with some observations and conclusions [4].

The issue of preventing inner holes from forming in topology optimized structures has been approached in this work from a more mathematical perspective than has been previously utilized. The method consisted of treating the centroids of the finite elements in a mesh as nodes, which form a graph by connecting the mesh's elements. It is first developed a method that is successful in determining the number of non-connected void areas in a design domain where coexisting two phases. This method is based on known graph connectivity results from spectral graph theory. Despite the fact that they are frequently both material and void phases, they function independently of their physical meaning [5].

Conclusion

To prevent the formation of inner holes in minimum compliance structures, a TO-based formulation is also proposed as an extension of that concept. In 2d and 3d, a number of convincing examples have demonstrated this. The first non-zero eigenvalue of the Laplacian matrix, which is used to measure the overall graph connectivity, is better understood thanks to these two aforementioned contributions. To fully comprehend this eigenvalue, we believe that there are still some unresolved issues that fall outside the scope of this work. Because of this, we will soon continue to expand our understanding of this invariant. Additionally, we intend to apply these concepts to other relevant physical contexts.

Acknowledgement

None.

Conflict of Interest

None.

References

1. Liu, Jikai, Andrew T. Gaynor, Shikui Chen and Zhan Kang, et al. "Current and future trends in topology optimization for additive manufacturing." *Struct Multidiscip Optim* 57 (2018): 2457-2483.

***Address for Correspondence:** Onur Schaub, Department of Chemical Engineering, University of Southern California, Los Angeles, USA, E-mail: onurschaub@yahoo.com*

Received: 02 February 2023, Manuscript No. jpm-23-91411; **Editor assigned:** 04 February 2023, Pre QC No. P-91411; **Reviewed:** 16 February 2023, QC No. Q-91411; **Revised:** 21 February 2023, Manuscript No. R-91411; **Published:** 28 February 2023, DOI: 10.37421/2090-0902.2023.14.415

2. Gersborg, Allan Roulund and Casper Schousboe Andreasen. "An explicit parameterization for casting constraints in gradient driven topology optimization." *Struct Multidiscip Optim* 44 (2011): 875-881.
3. Sato, Yuki, Takayuki Yamada, Kazuhiro Izui and Shinji Nishiwaki. "Manufacturability evaluation for molded parts using fictitious physical models, and its application in topology optimization." *Int J Adv Manuf Technol* 92 (2017): 1391-1409.
4. Yoon, Gil Ho. "Structural topology optimization of layout and raster angle for additive manufacturing technology with the shadow density filter." *Comput Struct* 256 (2021): 106637.
5. Lee, Hak Yong, Mu Zhu and James K. Guest. "Topology optimization considering multi-axis machining constraints using projection methods." *Comput Methods Appl Mech Eng* 390 (2022): 114464.

How to cite this article: Schaub, Onur. “Eliminate Contained Holes in Topology Optimization: A Novel Method Based on Spectral Graph Theory has been developed.” *J Phys Math* 14 (2023): 415.