Topology Optimization using Neural Networks

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Neural networks (NN) and, more broadly, machine learning techniques have been exploited to accelerate topology optimization (TO) through data-driven training and image processing. This talk will discuss a new framework where one can directly formulate and solve TO problems using NN. The primary concept is to use the NN's activation functions to represent the popular pseudo-density field. In other words, the density function is parameterized by the weights and biases associated with the NN and spanned by the NN's activation functions. The density representation is thus independent of the underlying finite element mesh. Then, by relying on built-in backpropagation and a conventional finite element solver, the density field is optimized. Methods to impose various design and manufacturing constraints are described and illustrated. The proposed framework is simple to implement and is illustrated through several examples. Some of the unresolved challenges are also summarized.

Bio-Sketch

Krishnan Suresh is the Mead Witter Foundation Professor of Mechanical Engineering at the University of Wisconsin-Madison. He received an M.S. in Manufacturing Engineering from UCLA in 1992 and a Ph.D. in Mechanical Engineering from Cornell in 1998. He then served as an Engineering Manager at Kulicke and Soffa, Philadelphia, until 2002 before joining the University of Wisconsin-Madison as a faculty.

He has received numerous peer-reviewed grants, including the prestigious NSF Career Award. His research interests include topology optimization, additive manufacturing, advanced finite element analysis, high-performance computing, and quantum computing. He has co-authored over 100 peer-reviewed papers, two of which have received ASME best paper awards. He has also authored two textbooks on applied optimization. In 2024, he received the ASME CIE Excellence in Research Award.

He co-founded SciArt (www.sciartsoft.com), a UW-Madison spinoff that creates and supports high-performance topology optimization software solutions.