INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	SHASHI KANT RATNAKAR
Roll Number	:	146103004
Programme of Study	:	Ph.D.

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Name of Thesis Supervisor(s)	:	Dr. Deepak Sharma
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SHORT ABSTRACT

Topology optimization is a complex and time-consuming process used to develop the early conceptual design of industrial products. With the advancement of cost-effective many-core high performance computing architectures such as GPU, the challenge of high computational cost has been addressed. However, the development of efficient GPU computing strategies for the topology optimization of large-scale 3D continuum structures remains a challenge. This thesis aims to address some of the major challenges in GPU-based acceleration of structural topology optimization discretized by 3D unstructured meshes. In the first part of this thesis, a GPU-based finite element analysis (FEA) solver is developed. The proposed preconditioned conjugate gradient (PCG) FEA solver is equipped to handle large-scale 3D unstructured meshes efficiently. It employs a matrix-free or assembly-free strategy in which GPU threads solve the system of linear equations at the elemental or nodal level. The second part of the thesis focuses on enhancing the computational performance of the proposed GPU-based FEA solver by developing efficient GPU thread allocation strategies. The analysis of the results demonstrates a significant improvement in the computational performance as compared to the conventional GPU-based strategy from the literature. The proposed GPU-based FEA solver is further improved by reducing the amount of CPU-GPU data transfer and developing novel data storage and data access patterns on the GPU, which reduces the amount of GPU memory required by the FEA solver. The efficient GPU computing strategies proposed in this thesis accelerate the major computational bottlenecks of the GPU-based matrix-free FEA solver, resulting in a topology optimization framework with much less execution time and reduced memory consumption.