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# CUFESAP: A CUDA based finite element code for elastic structural analysis on GPUs

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Graphics processing unit (GPU) has obtained great success in scientific computations for its tremendous computational horsepower and very high memory bandwidth. In this paper, a multithreaded parallel finite element code for elastic structure analysis on NVIDIA GPUs using CUDA (CUFESAP) is developed to utilize the capacity of the GPU devices efficiently. The most time-consuming parts of finite element computation, stiffness evaluating, equations solving, and stress calculating, are all considered.

For assembly of stiffness matrix, the strategy of assembling by element is adopted as it's most similar to the serial one. In this assembling method, each thread is responsible for one element to compute and assemble the entries at a time and element coloring is used to avoid race conditions.

A common used CSR formant and newly proposed sliced block ELLPACK (SBELL) format are provided to represent the sparse stiffness matrix arising from finite element discretization of elasticity. The SBELL is a GPU-friendly variant of the storage format of ELLPACK and specially designed for the iterative solution of finite element equations of elasticity. With these formats, efficient CUDA SpMV kernels are implemented on NVIDIA GPUs and introduced into a polynomial preconditioned CG solver. Mixed precision technique is exploited to increase the performance of PCG kernel, which means low precision operations for inner preconditioning and high precision for outer CG iteration. After solution of nodal displacements, each thread concurrently performs stresses calculation at the points in one element assigned to it without communication and synchronization.

Extensive performance evaluations of this code have been carried for different examples. Numerical results show that satisfactory speedup to serial version can be got by using this code. With SBELL format and mixed precision algorithm, the GPU-based L-S preconditioned CG even can achieve a speedup of about 7-9 on a low-end NVIDIA Geforce GT430 GPU card.

## REFERENCES

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