

Zachary Knowlan
Computing at Scale
01/26/2025

Computing at Scale Term Project Proposal

My project for the Spring 2025 semester will focus on building a framework to use MFEM (<https://github.com/mfem/mfem>). As a library, MFEM relies largely on command line options for a single finite element solve. Within that single finite element solve, the user must define the mesh, boundary conditions, and other material or element data. While this helps in making MFEM lightweight and scalable, it requires a significant understanding of the MFEM framework to use (essential_dofs, coefficients, domain and boundary integrators to name a few). The goal of the additional framework is to make MFEM easier to use for many classes of problems such that people less familiar with the technical aspects can effectively use it.

This can be envisioned as an all encompassing “problem” class whos methods would be inherited into subclasses of problems such as “micromorphic problem”, “linear elastic problem”, “thermal problem” etc. Within each subclass of problem, the new framework would make boundary conditions, material properties, and other discretization information usable without manually creating instances of all the MFEM objects required to solve a problem.

The first class of problem to be implemented, as suggested from above, is the “micromorphic problem”, which requires significantly more knowledge of MFEM to work. This problem would require that the “problem” class as mentioned earlier be able to specify the mesh file, material properties, element orders, boundary conditions, micromorphic integrators, block structured assembly procedure, matrix regularization perturbation, use of static condensation, and files to output. This project will enable users to declare these in a separate file without explicitly knowing how to get all of these to work in MFEM.

In addition to the framework around MFEM, I believe that this class will provide me with additional background knowledge that will allow me to optimize the existing implementation of micromorphic linear elasticity. As a lesser part of my term project, I plan to use the new knowledge from this class to optimize the existing codebase and turn it into a precompiled library that can be used alongside MFEM. This new micro library will be linked using CMake such that it and will have sufficiently general inputs such that it doesn’t have to be rebuilt with each use case. This code will be documented at <https://github.com/LACES-LAB/micromorphic>. The “problem” class, however, will get it’s own git repository which has not yet been created.