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# Finite Element Solver Technology Optimization

The most expensive part of most Finite Element (FE) simulations is solving the linear equation system

$$\mathbf{K}\ \mathbf{a} = \mathbf{f} \tag{1}$$

where $\mathbf{K}$ is a so-called sparse matrix (i.e. most entries are zero and are typically not explicitly stored). For nonlinear or time dependent problems, we have to solve such equation systems many times. Finding optimal solvers is an important research area, and many different solver algorithms exists. It is therefore crucial to choose the correct solver for the particular problem at hand, which is the main purpose of this project.

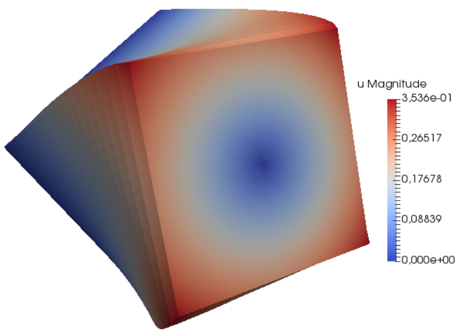


Figure 1: 3d FE solution for nonlinear hyperelasticity in Ferrite.jl

Specifically, the project consists of two main tasks, and a third more advanced task if the project is conducted as a master thesis (and optional in a specialization project)

- Theory and literature review for sparse linear solvers
- Numerical study of solver performance for different FE problems
- Optimization of solvers for nonlinear or time-dependent problems

While the theory and literature review should be quite broad, the numerical study should initially focus on single-CPU (but multithreaded) solvers. If time allows, distributed solvers (e.g. MPI) or matrix-free GPU solvers can be explored according to time, findings, and interest. The idea of optimizing solvers for nonlinear or time-dependent problems will start by looking at ways to reuse e.g. the LU-factorization, either in a Quasi Newton scheme, or as linear preconditioners.