

# Open Source Development Best Practices in Ratel

Jeremy L Thompson

University of Colorado Boulder

*jeremy@jeremylt.org*

27 September 2022



**NNSA**  
National Nuclear Security Administration



University of Colorado  
Boulder





THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE




PSAAP III Fall Review, 26-27 September 2022; CU Boulder Multi-disciplinary Simulation Center (MSC)

# Overview



**ratel** 

Project ID: 29759477 

🔗 628 Commits 🌿 9 Branches 🏷 3 Tags 📦 235.4 MB Project Storage 📦 3 Releases

Topics: [solid mechanics](#) [elasticity](#) [matrix-free](#) + 3 more

Extensible, performance-portable solid mechanics with libCEED and PETSc

GitLab-CI [passed](#) License [BSD 2-Clause](#) Documentation [latest](#) coverage [97.40%](#)

Ratel is very young - 'move fast and break things'

Best practices from libCEED, PETSc break fewer things



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



PSAAP III Fall Review, 26-27 September 2022; CU Boulder Multi-disciplinary Simulation Center (MSC)

# Overview

- 1 CI Testing
- 2 CD Containers and Documentation
- 3 Issue Tracker
- 4 Community Contributions



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



PSAAP III Fall Review, 26-27 September 2022; CU Boulder Multi-disciplinary Simulation Center (MSC)

# CI for commits and MRs

CI is as essential part of MR acceptance

- Automated testing for every commit and merge request
- Testing multiple hardware and build configurations
- Automatic static code analysis and formatting

The screenshot displays four CI test stages, each with a green checkmark icon and a refresh icon:

- Test:stage-lint**: noether-lint
- Test:stage-cpu**: docker-cpu, docker-cpu-int64
- Test:stage-gpu**: noether-gpu
- Test:stage-ad**: noether-ad



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



# Unit testing

- Leverage upstream testing to lower test burden
- Linear model MMS to test solver setup
- Non-linear model regression tests
- Untested code is broken code; tested code is less broken code

# Code coverage

- GitLab has native support for code coverage reports
- Highlights vulnerable, untested code in MR diffs
- Untested code is broken code; tested code is less broken code

```

tests/t120-static-elasticity.c
+1 -1 Viewed
@@ -48,7 +48,7 @@ int main(int argc, char **argv) {
48 48 // Verify
49 49 PetscCall(RatelComputeMMSL2Error(ratel, U, &l2_error));
50 50
51 - if (fabs(l2_error) > 5e-8) printf("Error: L2 norm = %0.5e\n", l2_error);
+ if (fabs(l2_error) > 5e-8) printf("Error: L2 norm = %0.5e\n", l2_error);
52 52
53 53 // Cleanup
54 54 PetscCall(SNESDestroy(&snes));

```



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



# Static analysis

`clang-tidy` - Clang-based C++ “linter” tool

- Extensible framework for diagnosing typical errors - style violations, interface misuse, etc

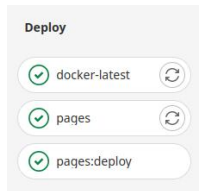
*ClangFormat* - formatting tools built on top of LibFormat

- Standalone tool with editor integrations
- Prevents format wars bikeshedding

# Automated deployment

Automatic deployment upon commit to main

- Docker images for dev environment and latest snapshot
- GitLab pages documentation and theory guide





# Docker containers

## Snapshot and dev environment images

- User quick start with general CPU only image
- Exact dependency commit hashes shipped with Dockerfiles

```
host$ docker run -it --rm -v $(pwd):/work registry.gitlab.com/  
micromorph/ratel  
container$ ratel-quasistatic -options_file config.yaml
```



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



# Documentation

## Latest documentation and theory guide

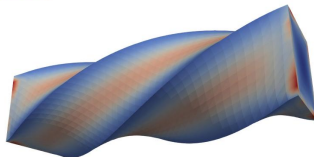
Ratel v0.1.2 documentation

### Ratel: Extensible, performance-portable solid mechanics

Ratel is a solid mechanics library and application based on [libCEED](#) and [PETSc](#) with support for efficient high-order elements and CUDA and ROCm GPUs.

Solid mechanics simulations provide vital information for many engineering applications, using a large amount of computational resources from workstation to supercomputing scales. The industry standard for implicit analysis uses assembled sparse matrices with low-order elements, typically  $Q_1$  hexahedral and  $P_2$  tetrahedral elements, with the linear systems solved using sparse direct solvers, algebraic multigrid, or multilevel domain decomposition. This approach has two fundamental inefficiencies: poor approximation accuracy per Degree of Freedom (DoF) and high computational and memory cost per DoF due to choice of data structures and algorithms. High-order finite elements implemented in a matrix-free fashion with appropriate preconditioning strategies can overcome these inefficiencies.

For further details on the benefits of high-order, matrix-free finite elements for solid mechanics, see [our preprint on arXiv](#).



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



PSAAP III Fall Review, 26-27 September 2022; CU Boulder Multi-disciplinary Simulation Center (MSC)

# Issue tracker

## • Transparent development roadmap

<b>Elastic anisotropy</b>			🔖 0
📅 #28 · created 4 months ago by Jed Brown	🕒 Fall 2022 review	methods to do	updated 3 months ago
<b>Enzyme for hyperelasticity</b>			CLOSED 🔖 1 🗨 3
📅 #27 · created 4 months ago by Jed Brown	🕒 Fall 2022 review	materials	closed 1 week ago
<b>Diagnostic force on surfaces</b>			CLOSED 🔖 1 🗨 2
📅 #21 · created 6 months ago by Jed Brown	🕒 Fall 2022 review	outer loop	closed 2 days ago
<b>Multiple materials</b>			CLOSED 🔖 1 🗨 0
📅 #12 · created 7 months ago by Jed Brown	🕒 Fall 2022 review	materials	closed 3 months ago

## • Bug tracker

<b>DMPLex Boundary Changes</b>			CLOSED 🔖 1 🗨 0
📅 #38 · created 3 months ago by Jeremy L Thompson	bug		closed 3 months ago
<b>Examples makefile does not obey PKG_CONFIG_PATH</b>			CLOSED 🔖 1 🗨 1
📅 #23 · created 6 months ago by Victor Eijkhout	bug		closed 6 months ago
<b>Fix Jacobian assembly numerical bug</b> 0 of 1 checklist item completed			CLOSED 🔖 2 🗨 3
📅 #19 · created 6 months ago by Jed Brown	bug internals		closed 6 months ago
<b>Order 1 broken in examples</b>			CLOSED 🔖 1 🗨 1
📅 #17 · created 7 months ago by Leila Ghaffari	bug internals		closed 6 months ago



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



# Upstream contributions

## Upstream improvements to libCEED and PETSc

### Fix /gpu/\*/gen backends for op with all CEED\_BASIS\_COLLOCATED #1006



jeremyt merged 1 commit into `main` from `jeremy/gen-all-collo-fix` on Jun 23



Conversation 0



Commits 1



Checks 19



Files changed 2



jeremyt commented on Jun 22

Member



Fixes a small bug discovered in Ratel

### Support MatSetValuesCOO() for AIJKOKKOS matrices

Edit

Code ▾



Junchao Zhang requested to merge `jc Zhang/feature-kokkos-coo` into `main` 7 months ago

All threads resolved ▾

Overview 41

Commits 8

Pipelines 8

Changes 17



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



# Questions?

- 1 CI Testing
- 2 CD Containers and Documentation
- 3 Issue Tracker
- 4 Community Contributions



University of Colorado  
Boulder



THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



PSAAP III Fall Review, 26-27 September 2022; CU Boulder Multi-disciplinary Simulation Center (MSC)