Reducing the entry barrier of Peridynamic simulations

Jan-Timo Hesse, Christian Willberg and Anna Pernatii

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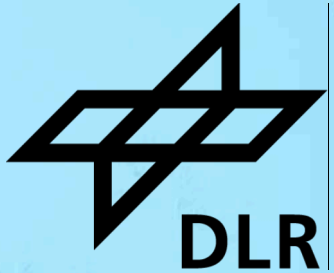

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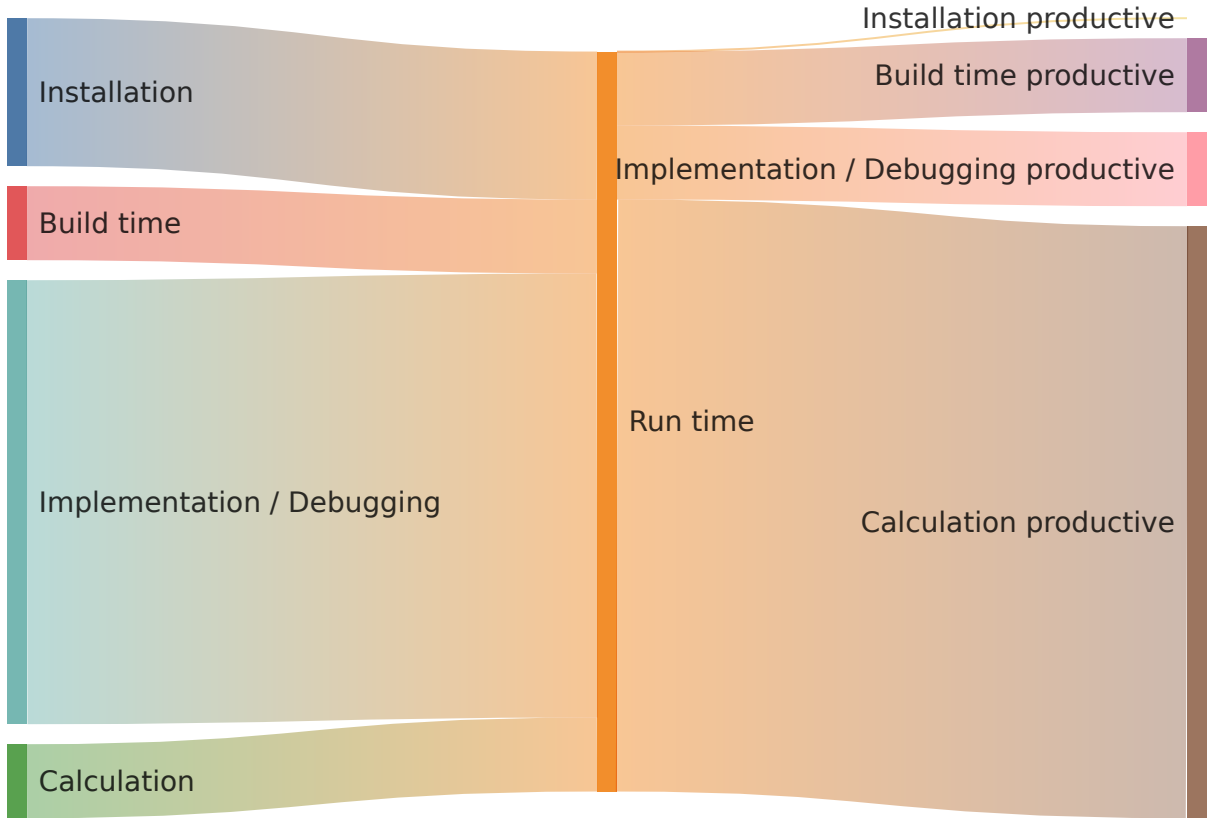
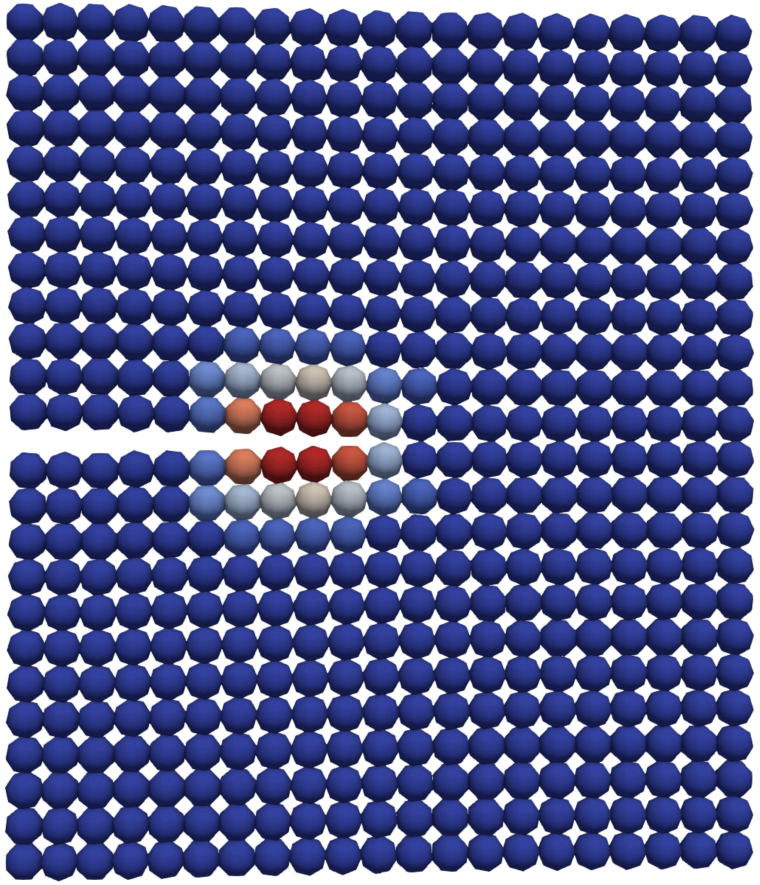
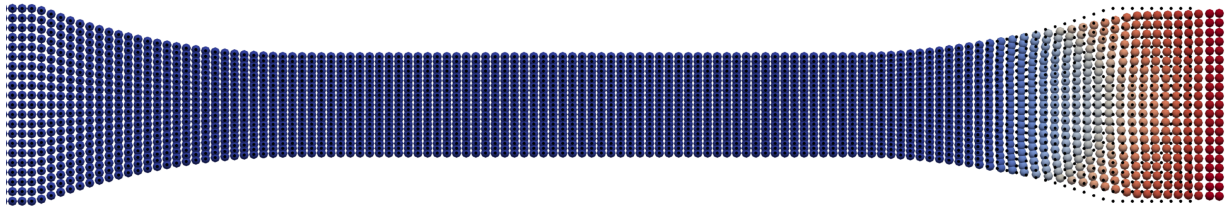
"Run time" or "time to reach a solution"?



Motivation Peridynamics (PD)

- alternative to classcical continuum mechanics $\mathrm{div}(\sigma) + \mathbf{b} = \rho\ddot{\mathbf{u}}$
- PD integral equation $\int_{\mathcal{H}}(\underline{\mathbf{T}}(\mathbf{x},t) - \underline{\mathbf{T}}(\mathbf{x}',t))dV_{\mathbf{x}} + \mathbf{b} =$
- focus material modeling and crack propagation no C^1 continuity for the displacement
- many applications and a lot of good research

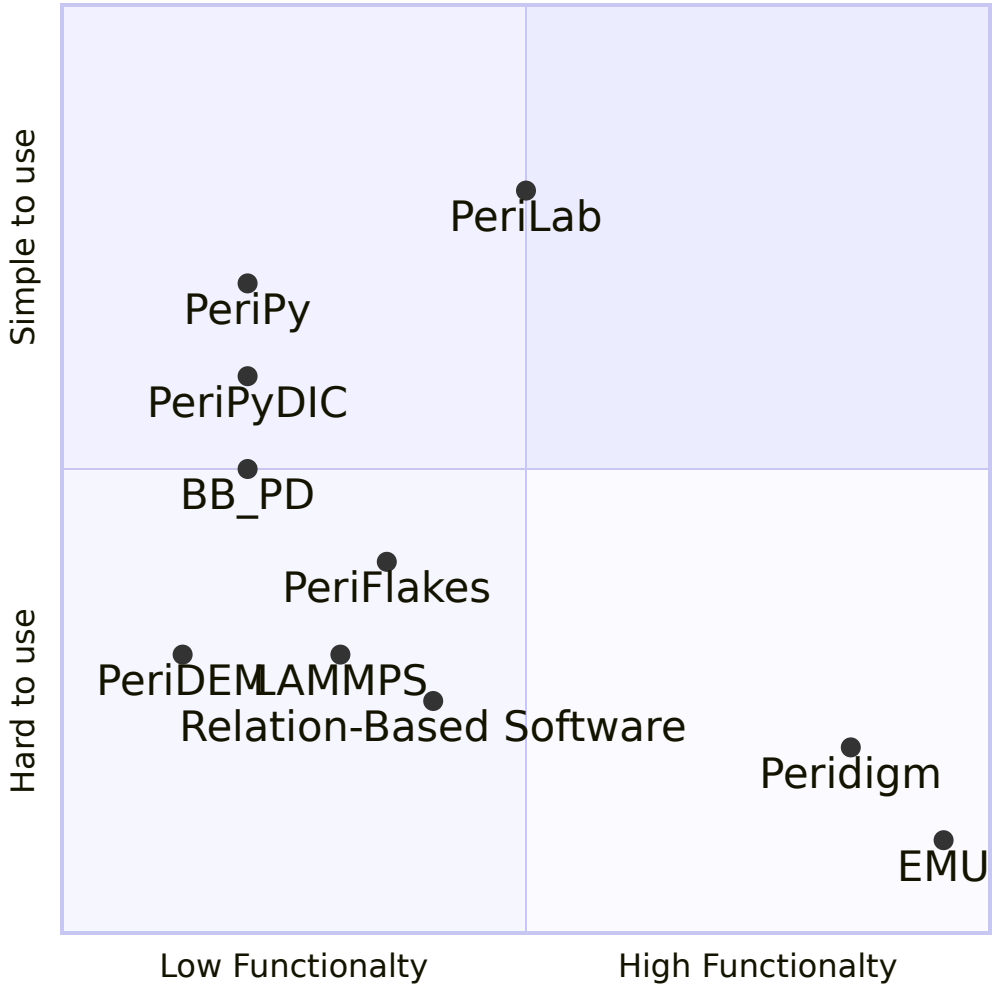




Solving process

- CM is typically solved using finite element method (FEM)
  - state of the art technology; many options
  - flexible
  - not able to model cracks in a consistent way
- PD is typically solved using material point method
  - simple implementation
  - low convergences
  - not many options

PD Software



Reference

Peridigm

PeriLab

EMU

PeriPy

PeriPyDIC

LAMMPS

PeriFlakes

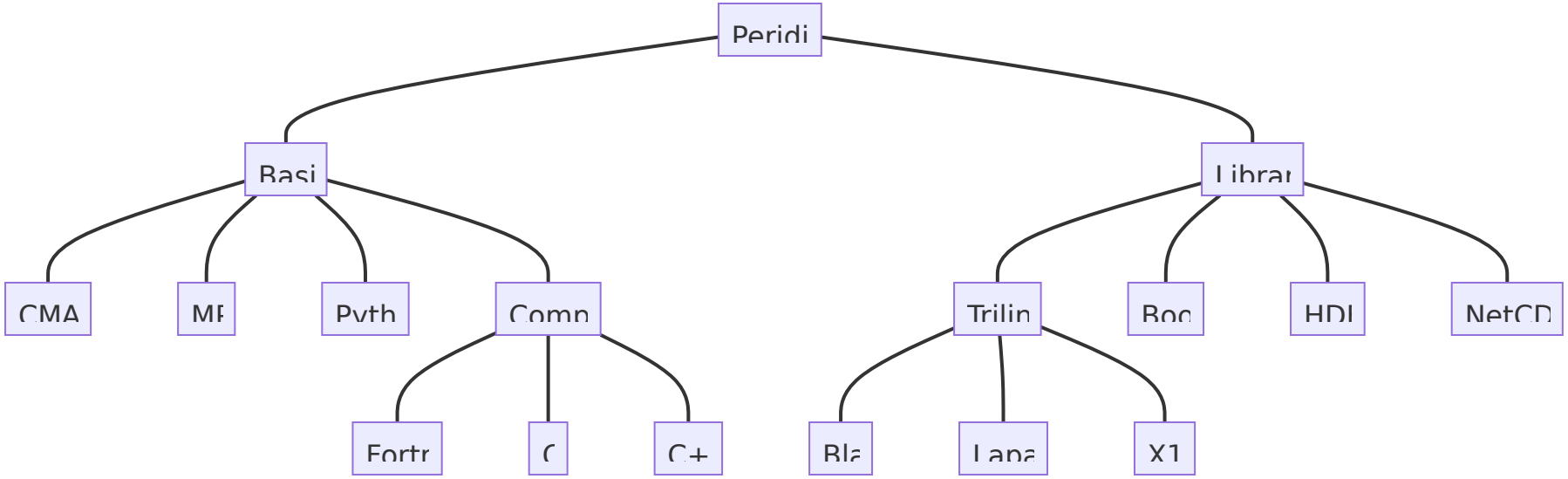
Relation-Based Software

BB_PD

PeriDEM

Problem description for example Peridigm

- many publications / algorithms, but not many codes
- Peridigm pain
- solution which does not run "requires" infinite time to solve a problem



Reducing entry barrier

Criteria	Peridigm	PeriLab
Distribution	Manual download	Package manager
Installation time	~1 day - 1 week	~1 day - 1 week
Build time	~10 minutes	< 5 minutes
New material	min. 5 files	min. 1 file
New Input parameter	Input deck / 6 files / compilation	In input deck
Libraries (inst.&upd.)	manual	automatic
Compiling process	deep knowledge	no knowledge

Package manager

- checks all dependencies
- allows the specification of the library version
- automatic installation
  - in terminal

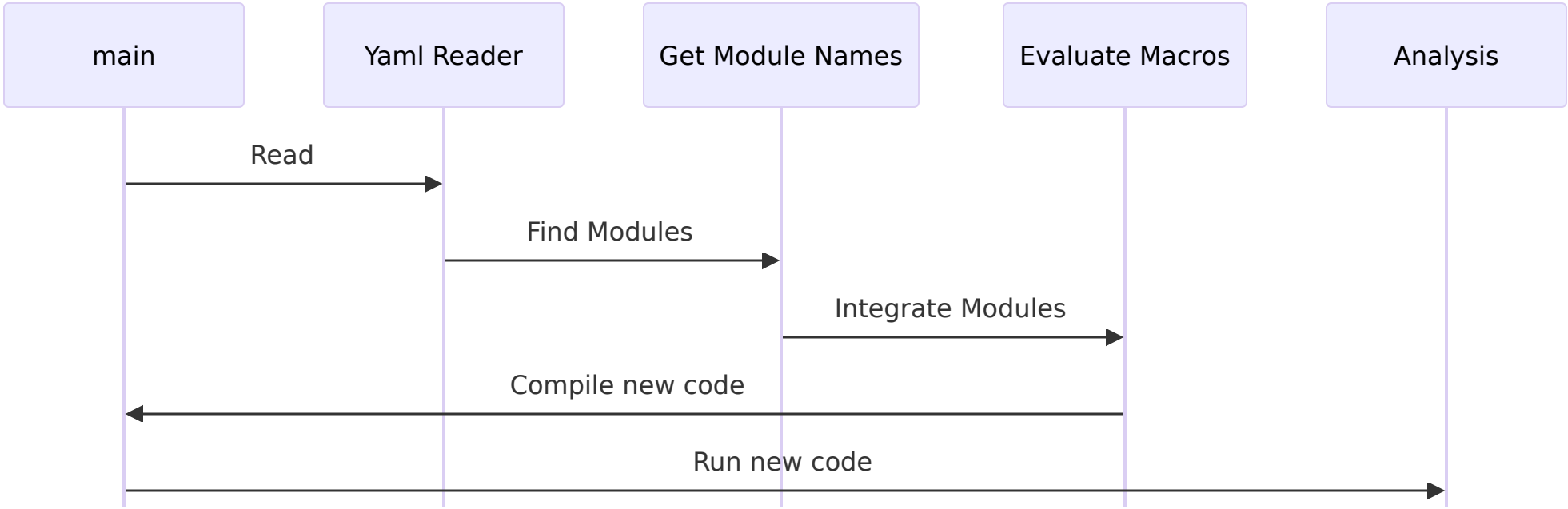
```
$ julia
julia> ]
pkg> activate .
pkg> up
```

- as a package, if no development takes place

```
$ julia
julia> ]
pkg> activate .
pkg> add PeriLab
```

Using Macros

```
        if eval(Meta.parse(parse_statement)) == name
            parse_statement = m["Module Name"] * "." * specifics["Call Function"]
            function_call = eval(Meta.parse(parse_statement))
            return function_call(values...)
        end
```



Adding external input (1/2)

- Peridigm steps
  - variable definition in code
  - specification of memory size for parallelization reasons
  - low flexibility
  - compiling, testing, etc.
- PeriLab process
  - define variable in mesh input
  - no extra compiling necessary

Adding external input (2/2)

Mesh and Nodesets Input

Mesh Input

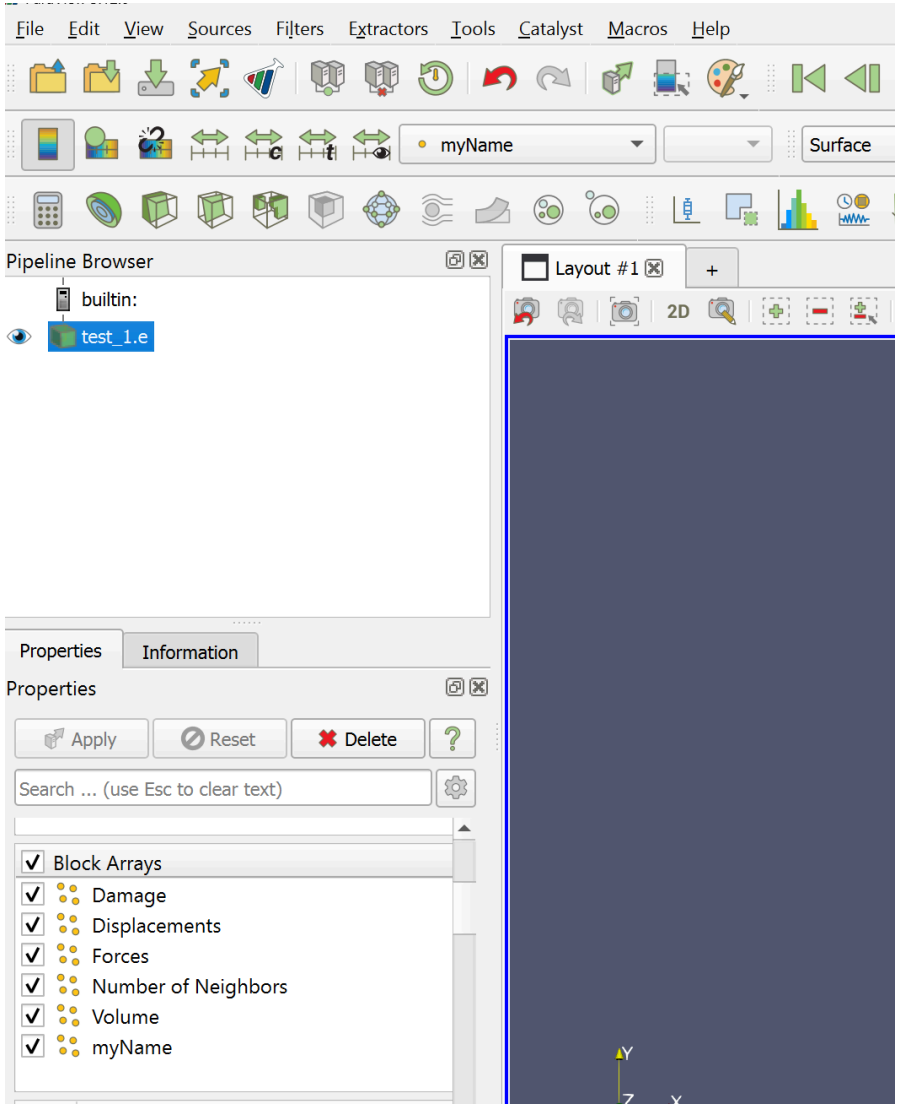
header: x y block_id volume myName

0.0 0.0 1 0.01 0.123

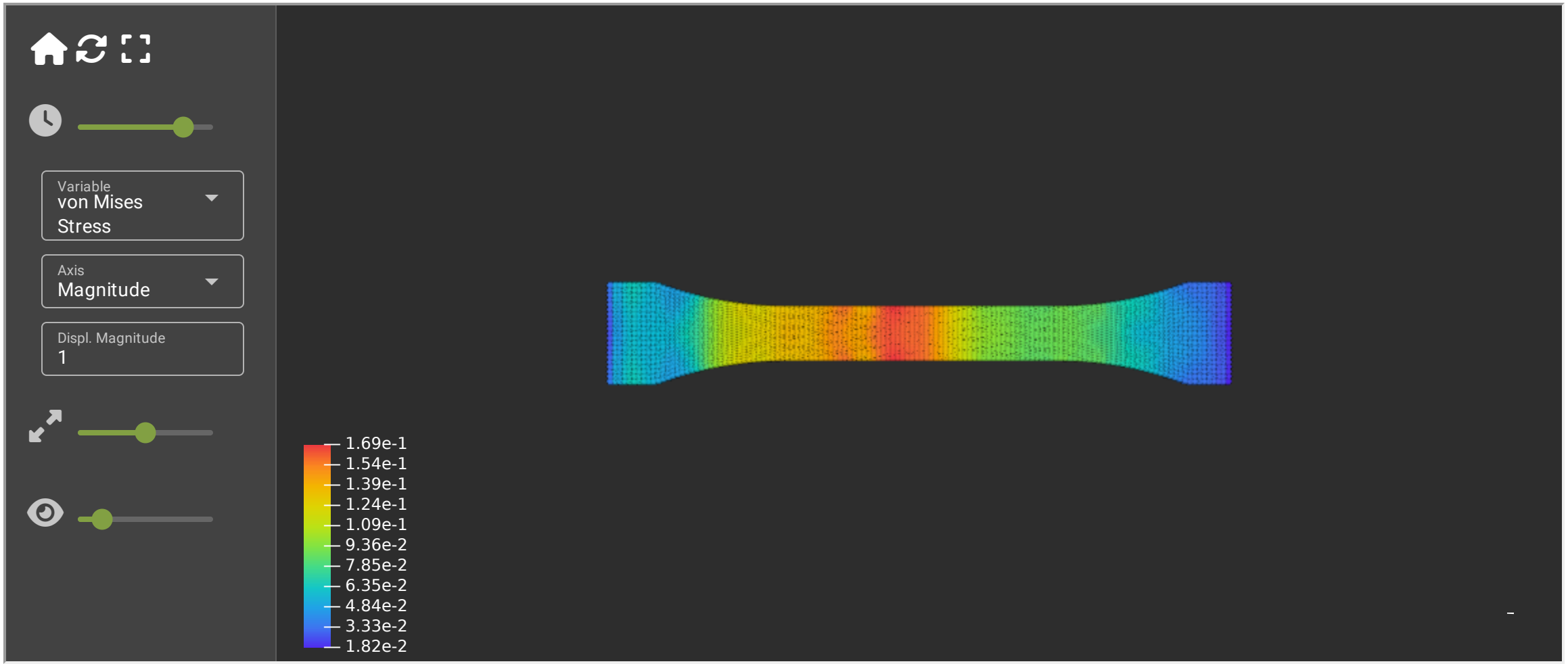
0.0 0.1 1 0.01 1.3

0.1 0.0 1 0.01 1.3

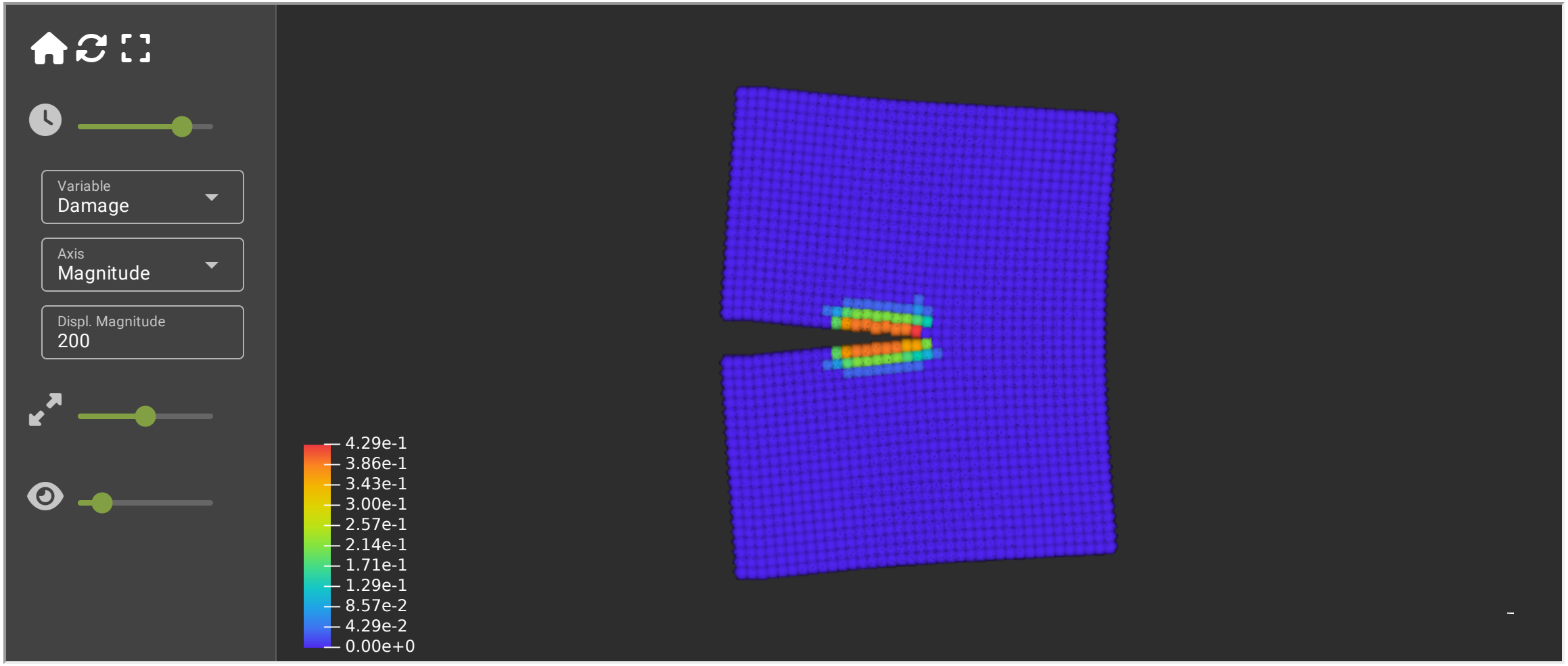
...



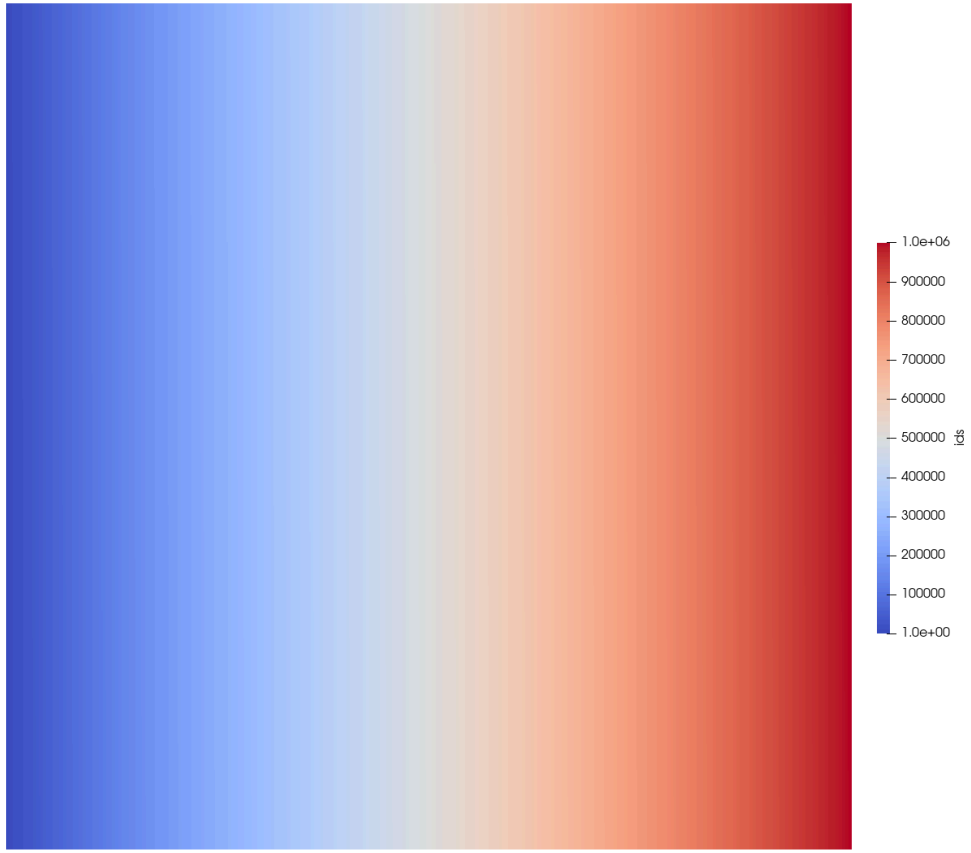
Examples (1/2)

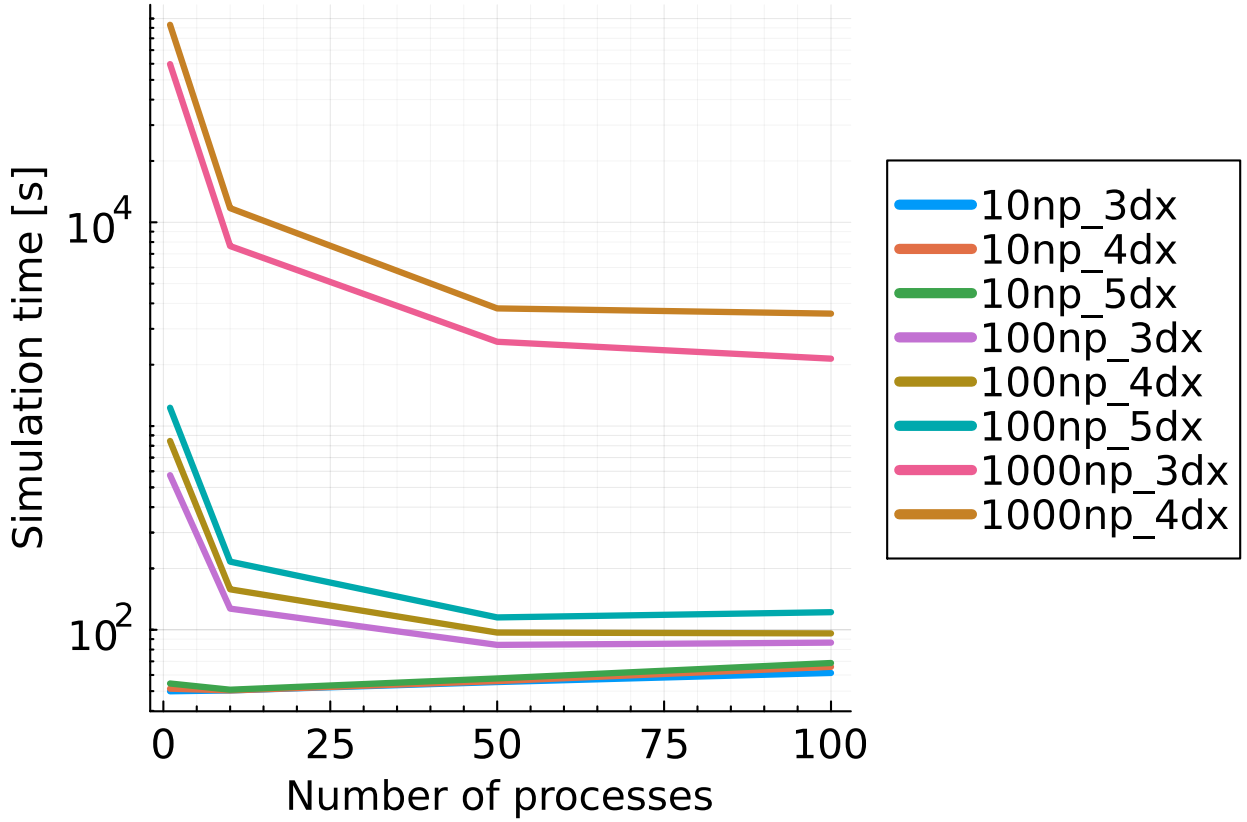

Variable
von Mises Stress
Axis
Magnitude
Displ. Magnitude
1
1.69e-1
1.54e-1
1.39e-1
1.24e-1
1.09e-1
9.36e-2
7.85e-2
6.35e-2
4.84e-2
3.33e-2
1.82e-2

Examples (2/2)


Variable
Damage
Axis
Magnitude
Displ. Magnitude
200
4.29e-1
3.86e-1
3.43e-1
3.00e-1
2.57e-1
2.14e-1
1.71e-1
1.29e-1
8.57e-2
4.29e-2
0.00e+0

Performance





Conclusion

- modern language should be preferred if new projects are started
- Julia is a great alternative to C++ and for PhD students easier to learn and to handle
- installation time was reduced to minutes from hours (if it even works)
- more user focussed developement

Thank you

Jan-Timo Hesse: German Aerospace Center; jan-timo.hesse@dlr.de
Christian Willberg: Magdeburg-Stendal University of Applied Sciences & German Aerospace Center; christian.willberg@h2.de
Anna Pernatii: OvGU Magdeburg
anna.pernatii@ovgu.de