Hyperbolic PDEs, Software, and GeoHazard Applications
Clifford Lectures, Tulane University
April 5–8, 2017
Lecture 3
Clawpack Software and Open Source Development

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Outline

1. Hyperbolic Equations and Riemann Solvers
   Linear / nonlinear, scalar / systems
   Acoustics, Burgers’ equation, Shallow water equations
   Jupyter notebooks

2. Finite Volume Methods and Adaptive Refinement
   High resolution Godunov-type methods
   Wetting and drying, well-balancing
   Adjoint error estimates for AMR

3. Clawpack Software and Open Source Development
   Design of software for broad applicability,
   Development on Github, Continuous integration

4. GeoHazard Modeling with GeoClaw
   Applications to tsunamis, storm surge, etc.
   Probabilistic hazard assessment, early warning
Clawpack: building an open source ecosystem for solving hyperbolic PDEs

Kyle T. Mandli¹, Aron J. Ahmadia², Marsha Berger³, Donna Calhoun⁴, David L. George⁵, Yiannis Hadjimichael⁶, David I. Ketcheson⁶, Grady I. Lemoine⁷, Randall J. LeVeque⁸

August 8, 2016

10.7717/peerj-cs.68
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- Hyperbolic problems not in conservation form,
- Balance laws (source terms)
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       My thesis on fractional-step / shock-capturing
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First releases:
1994–95: Sabbatical at NCAR/CU
1996: AMR in two dimensions
      Jan Olav Langseth: 3d algorithms
2002: Marsha & Donna Calhoun: 3d AMR
2002: Clawpack 4.3 used for examples in FVMHP book
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GeoClaw:
2003–05: Dave George — TsunamiClaw
2005–08: Kyle Mandli — storm surge
    Dave: dam break, debris flow
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Originally Matlab: Donna Calhoun — 3d
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PyClaw:
2008–: Kyle and David Ketcheson
  and Aron Ahmadia, others
Version control:

2007: started using Subversion, Trac
2013: Switched to Git and Github
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Greatly facilitates open source development!
   Large community of users, contributors, and developers
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BSD License: Allows re-use (with attribution) for any purpose
Version control does *not* mean....

Git — distributed version control system
Github — one cloud service for hosting repositories
**Git and Github**

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**Github** — one cloud service for hosting repositories

You can use Git without using Github, e.g.

- Single-user on your laptop
- Remote repository on your desktop, campus computer, etc.
- Other cloud services such as

  - [Software Carpentry](https://softwarecarpentry.org)
  - Git tutorials at SIAM CS&E 2017:  
      - Videos: [www.pathlms.com/siam/courses/4150](http://www.pathlms.com/siam/courses/4150)  
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  Slides:  
Current development paradigm

- **Use Git and GitHub**
  Fork and then clone. Lightweight branches. Issue “pull request” to merge back into master branch at:  [http://github.com/clawpack](http://github.com/clawpack)

- Multiple repositories under Clawpack “organization”, e.g. pyclaw, amrclaw, geoclaw, ...
- clawutil, riemann, visclaw, ...
- Most discussions on pull requests, issue tracker, claw-dev google group, etc.
- Still building up a suite of regression tests
  Continuous integration via Travis-CI
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clawpack.org Documentation created using Sphinx and Jupyter notebooks
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Source files in doc repository: http://github.com/clawpack/doc

Build and push html file to another repo for serving on web: http://github.com/clawpack/clawpack.github.com
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Archiving:

Releases archived on Zenodo with permanent DOIs, e.g. Clawpack 5.4.0: 10.5281/zenodo.262111

Facilitates reproducibility
Compare to Mathematics

Traditional research in Mathematics is reproducible...

A paper containing a new theorem cannot be published without the proof.
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It wasn’t always so...

*There is no . . . mathematician so expert in his science, as to place entire confidence in any truth immediately upon his discovery of it. . . . Every time he runs over his proofs, his confidence encreases; but still more by the approbation of his friends; and is raised to its utmost perfection by the universal assent and applauses of the learned world.*

— David Hume, 1739
Comparing to Mathematics

Many arguments against publishing code might be applied to proofs in an alternate universe...

“Top Ten Reasons To Not Share Your Code (and why you should anyway)”, SIAM News, April, 2013

• The proof is too ugly to show anyone else.
• I didn’t work out all the details.
• I didn’t actually prove the theorem—my student did.
• Giving the proof to my competitors would be unfair to me.
• The proof is valuable intellectual property.
• Etc.
Ten Simple Rules for the Care and Feeding of Scientific Data,

by Alyssa Goodman, Alberto Pepe, Alexander W. Blocker, Christine L. Borgman, Kyle Cranmer, Merce Crosas, Rosanne Di Stefano, Yolanda Gil, Paul Groth, Margaret Hedstrom, David W. Hogg, Vinay Kashyap, Ashish Mahabal, Aneta Siemiginowska, Aleksandra Slavkovic,

PLOS Computational Biology 10(2014), e1003542.
http://dx.doi.org/10.1371/journal.pcbi.1003542
Data Curation

Ten Simple Rules for the Care and Feeding of Scientific Data,

• Rule 2. Share Your Data Online, with a Permanent Identifier

• Rule 4. Publish Workflow as Context

• Rule 5. Link Your Data to Your Publications as Often as Possible

• Rule 6. Publish Your Code (Even the Small Bits)

• Rule 7. State How You Want to Get Credit

• Rule 8. Foster and Use Data Repositories

http://dx.doi.org/10.1371/journal.pcbi.1003542
DesignSafe: Enabling Research
Data Repositories

- **DesignSafe**: https://www.designsafe-ci.org/

  Ex: Data and code for journal article on GeoClaw validation, http://dx.doi.org/10.5281/zenodo.12185
Data Repositories

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- **Community Surface Dynamics Modeling System (CSDMS)**: [http://csdms.colorado.edu](http://csdms.colorado.edu)

  Data and model repositories,
  Web interface to some models
Data Repositories

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- **Zenodo**: [https://zenodo.org/](https://zenodo.org/)

  Ex: Data and code for journal article on GeoClaw validation,
  
  [http://dx.doi.org/10.5281/zenodo.12185](http://dx.doi.org/10.5281/zenodo.12185)
Some other links:

www.clawpack.org/community.html

www.geoclaw.org contains links to papers, codes