2018 PyLith Hackathon Report

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OVERVIEW

The PyLith developers have provided numerous online and in-person tutorials over the past ten years. These have fostered use of the code but have not led to users contributing to development of the PyLith code itself. Based on the increase in user-developers as a result of the ASPECT hackathons, the PyLith developers identified a hackathon as the best way to increase the number of people contributing to the development of PyLith.

The focus of the 2018 PyLith hackathon was to provide six users the opportunity to work closely with the three PyLith developers to add new features to the code. Based on the areas of interest specified in the hackathon applications, the PyLith developers identified three projects: implementing a poroelasticity, implementing an infinite boundary via a boundary integral formulation, and implementing an anisotropic material. The PyLith hackathon was held jointly with an ASPECT hackathon to leverage the experience of the ASPECT maintainers in running hackathons, facilitate discussions of how to implement CIG-software best practices, and build the CIG community.

The PyLith hackathon involved five intense days of work, starting at 9am each morning and running until around 9pm or 10pm in the evening. At the beginning of each day, during "morning rounds" each person summarized what they accomplished the previous day, highlighted obstacles or areas in which help was needed, and described what they planned to work on that day.

Schedule

Day	Scheduled Event
Mon, Jun 18	Arrival 8pm ASPECT+PyLith: Logistics, overview
Tue, Jun 19	9am ASPECT+PyLith: Introductions 9:30am ASPECT+PyLith: Git pull requests (Timo Heister, Wolfgang Bangerth) 10:30am PyLith: What are finite elements? (Matthew Knepley) 11:30am PyLith: Overview of code layout (Brad Aagaard)
Wed, Jun 20	9am ASPECT+PyLith: Morning rounds
Thu, Jun 21	9am PyLith: Morning rounds 1:30pm ASPECT+PyLith: Adjoint formulation (Jacky Austermann)
Fri, Jun 22	9am ASPECT+PyLith: Morning rounds
Sat, Jun 23	9am PyLith: Morning rounds 4pm PyLith: Wrap-up
Sun, Jun 24	Departure

Participants

Name and Affiliation	Goals and interest
Brad Aagaard, USGS	• Guide groups through the process of adding, testing, and documenting new features. • Work with Matt and Charles to resolve several issues in implementing new features. • Improve the developer documentation based on interactions with participants. • Learn how ASPECT maintainers follow the CIG software development best practices.
Matt Knepley, Univ. of New York, Buffalo	• Help groups overcome obstacles in implementing new features. • Work with Brad and Charles to resolve several issues in implementing new features. • Learn more about how features are implemented in ASPECT and what directions it is going.
Charles Williams, GNS Science	• Help groups overcome obstacles in implementing new features. • Make further progress reimplementing the material models using the new multiphysics formulation.
Maryam Alghannam, MIT	• Derive the formulations for quasi-static and fully dynamic poroelasticity. • Learn about how PyLith solves the contact or fault slip problem numerically. • Participate in coding the quasi-static poroelasticity implementation.
Josimar Alves da Silva, MIT	• Increase my understanding of the PyLith code structure and organization. • Learn how to compile the code and how to make changes to it.
Xiaoxi Zhao, USC	• Implement poroelasticity.
Luca Urpi, ETH	• Implement poroelasticity. • Setup a couple of example problems using poroelasticity.
Xia Ma, Univ. of Illinois, Urbana Champagne	• Implement the SBIE/FEM coupling method for a 2D infinite boundary. • Run validation exercises against SCEC benchmark TPV205.
Farrokh Shelbani	• Implement triclinic anisotropy bulk rheology.

PROJECTS

With only five days for the hackathon, the objective was for each project to make substantial progress towards implementing a new feature, such that the participants could complete the implementation after the hackathon with substantially less interaction with the developers. The projects were all setup so that once the implementations are complete, they can be integrated into the CIG PyLith repository using pull requests.

Poroelasticity

Participants: Maryam Alghannam, Josimar Alves da Silva, Luca Urpi, and Xiaoxi Zhao

The group worked on implementing poroelasticity for 2D plane strain. Brad, Charles, and Matt all interacted with the group at various times. They completed the formulation and its implementation. They started working on unit tests using a solution for hydrostatic fluid pressure and gravitational body forces. The unit tests exposed several bugs, which they squashed. The group continues to meet in weekly teleconferences to complete the unit test and resolve additional issues. Once they complete the plane strain version, they plan to implement wells (source density), a 3D version, and possibly coupling to external complex multi-phase flow simulators.

2D Infinite Boundary Condition

Participant: Xia Ma

The focus of this project was implementation of an infinite boundary condition in 2D using a spectral boundary integral approach. This permits use of a smaller finite-element domain, thereby allowing finer discretization for a given problem. Xia worked with Matt and Brad to setup the workflow for implementing the boundary condition as a coupling the finite-element and spectral boundary integral methods. Xia made substantial progress in implementing the boundary condition. He plans to continue to interact with the PyLith developers to complete the implementation and testing of the infinite boundary condition.

Anisotropy

Participant: Farrokh Shelbani

This project targets implementation of anisotropic based on the triclinic model presented in Mensch and Rasolofosaon, GJI, 1997. The triclinic model was chosen because it can represent orthotropic, horizontally transverse, and vertically transverse anisotropy and has closed-form analytic expressions for the elastic constants. Farrokh worked with Charles to derive the expressions for the elastic constants in terms of seismic velocities and orientation. Farrokh intends to complete the implementation of anisotropy and compare the results against analytic solutions.

FEEDBACK

All six participants and three PyLith developers described a very positive experience. The six participants learned quite a bit about the PyLith code layout, data structures, and development process. The PyLith developers came away with ideas on how to improve the experience for future hackathons and identified gaps in the developer documentation.

Things that went well

- Availability of PyLith developers for help and discussion.
- Setting the overall timeline and goals for each day.
- Instruction on PyLith formulation and structure of the code.
- Learning how to use GitHub in the context of the forking workflow, and editing and recompiling PyLith.
- Discussion of the software development process, which can be applied to other projects.
- Working together in a small group with other postdocs and graduate students on a project.

- Quiet, beautiful location.
- Mingling with ASPECT hackathon participants.

Suggestions for improvement

- Increase duration to 6-7 days to allow more time to accomplish tasks.
- Assign all participants to small groups to work on very specific tasks.
- Limit the size of the hackathon (grow slowly) to maintain the same productive environment.
- Improve installation/setup of PyLith and dependencies for user development.
- Expand developer documentation, e.g., GitHub workflow, code structure and layout.
- Participants and PyLith developers iterate on project scope and plan before hackathon begins to maximize productivity at hackathon.
- Hold hackathon in an academic environment to facilitate exposure to additional people.