Fostering Dynamic Interdisciplinary Creation of Research Software—Case Study

Najmeh Khalili-Mahani, MEng, PhD
Natacha Beck, MSc
Holistic Approach to Health Science

We need data-driven, ‘holistic’ and participatory research ecosystems that allow for inter-disciplinary inquiries into possible causes of illness.
Research Software Requirements

- Integrative
- Reproducible
- Robust

Models

Data

Functions

Parameters

Computation

Storage
Our Objective

Make a niche functional neuroimaging software available to larger community of (clinical) researchers.
Aims

**fMRI => CBRAIN**

Functional Magnetic Resonance Imaging measures brain activation in response to stimuli or drugs. Canadian Brain Research and Imaging Network is a CANARIE-funded web-based data processing system for analyzing large-scale research data.
## Motion Artifacts

Physiological Signals
Cerebral Blood Flow + fMRI

### Sources of Heterogeneity

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Single dose, dose controlled, oral, intravenous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>3T, 1.5 T, <strong>RSfMRI</strong> (# frames, TE/TR), <strong>ASL</strong> (pulse/continuous)</td>
</tr>
<tr>
<td>Objectives</td>
<td>Localization, Dose-response, Validation, Calibration, Clinical</td>
</tr>
<tr>
<td>Analyses</td>
<td><strong>Preprocessing and noise removal</strong>, phenotypes (static/dynamic connectivity, hubness, BOLD response, etc.), Modeling</td>
</tr>
</tbody>
</table>

---


---

Tracy, Wise (2014)

---

Sherif et al (2014)
Typical fMRI dataset (Raw 0.2 GB -> Derivative 4.0 GB)

Subject \{1 \ldots N\}

Session \{1 \ldots M\}

- **Anatomical MRIs** => Pipeline A => Standardize to an Atlas
- **T2* Weighted fMRI** => Pipeline B + Pipeline A => Compute Metrics
- **Physiological Data** => Pipeline C + Pipeline B => Noise-Correct
- **Arterial Spin Labeling** => Pipeline D + Pipeline A => Compute Metrics
Challenge: Integration of Heterogenous Methods into Standardized & User-Friendly Software
In this presentation

- Approach
- Methodology
- Outcomes
Pragmatic Approach

Stretching the Penny
• Ensure that the additions support and fall in line with previous or ongoing work.

Identifying the Lowest Hanging Fruit
• Create intrinsic reward by energizing the team from succeeding in delivering MVPs.

Fitting In
• Respect existing standard operating procedures and software development culture.

Communication
• Translate between different disciplines and their practical cultures (e.g., neuroscientist, physicist, software engineer, designer.)
Participatory Approach

Identify scientific stakeholders

• Have they developed any computationally intensive software?
• Do they work with large-scale datasets?
• Do you have a history of collaboration?

Invite them to no-cost partnership

• Include their students in software integration efforts
• Pre-plan for co-publishing at the end of the project.
Methodology

Quasi-Agile Simulation-Assisted Pair Programming
Quasi-Agile: Constraints

**Existing Code**
- PhysIO
- OxfordASL
- fMRIPrep

**Existing Framework**
- NIFTI file format
- CBRAIN
- Boutique

**HQPs**
- Students who needed training
- Coders who needed time
- Scientists who had time & data

**Funding**
- No revenues can be expected
- Under-appreciation of software development costs
Quasi-Agile “Sprints” are not 2-weeks!

**fMRIPrep**
- Commonly demanded
- Incorporated by senior programmer
- Used as a show-case to recruit Partner 1

**OxfordASL**
- Partner 1 offered student A
- Similar tools were already implemented and used to train student A & B
- Student A & Senior developer implemented the tool

**PhysIO**
- New tool assigned to Student B and New developer C
- Implement in CBRAIN
Tool Preparation For Each Sprint

This task was done by students (Neuroscience and Brain Imaging) who were found through scientific research partners.

- Plan the data flow and parameter selection
- Write wrappers
- Examine UI & Modify wrapper to improve UX
- Create Boutiques Descriptors
Simulation-Supported Design via **Boutiques**

Boutiques is a tool to automatically publish, integrate, and execute applications across computational platforms. Boutiques applications are summarized in a simple yet rich JSON description, and enable the simulation, validation, evaluation, and application-specific monitoring of command-line tools.

BoutiquesDescriptorMaker

- Write a JSON Descriptor
- Upload to CBRAIN
- Test Out the UI
Pair Programming

Facilitated by **Boutiques**.

Allowed ongoing training and communication over UI/UX simulations.

Fostered innovations that will further simplify tool integrations procedures.
Core development team (N=3)

Deliverables (n = 3)

Trainees (n= 5, retained 2)

Innovations (n = 5)
Neuroimaging Software integration is a challenging process due to the complexity of the data and exploratory nature of it.

**A Pragmatic and Participatory Approach** helped us accomplish our aims to integrate specialized fMRI tools into CBRAIN.

**A Quasi Agile Methodology + Simulation frameworks** facilitated student training and software integration.

We were able to complete deliverables and improve tool integration process along the way.
Acknowledgement

Pierre Rioux
Sergiy Boroday
Darius Valevicius
Safa Sanami
Darcy Quesnel
Bryan Caron
Reza Adalat
Alan Evans