POLYTECHNIQUE MONTRÉAL

LE GÉNIE EN PREMIÈRE CLASSE

Reproducibility on a Platter

Nikola Stikov
École Polytechnique/Montreal Heart Institute
University of Montreal

CONP
PCNO

Kuhn: Structure of Scientific Revolutions

Phase 1- Pre-paradigm phase

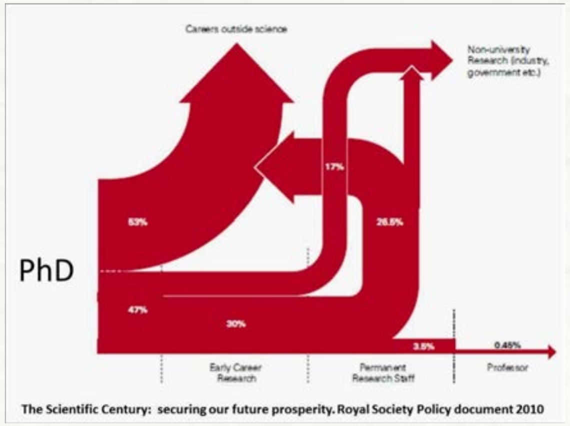
Phase 2- Normal science

Phase 3- Crisis

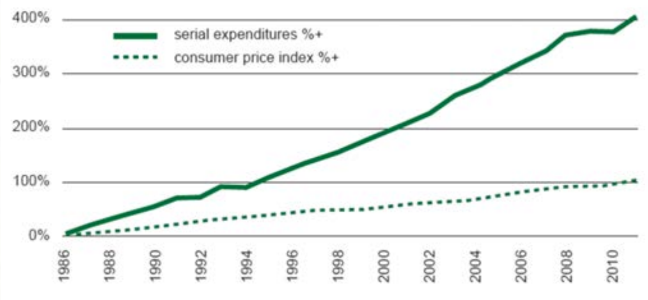
Phase 4- Paradigm shift

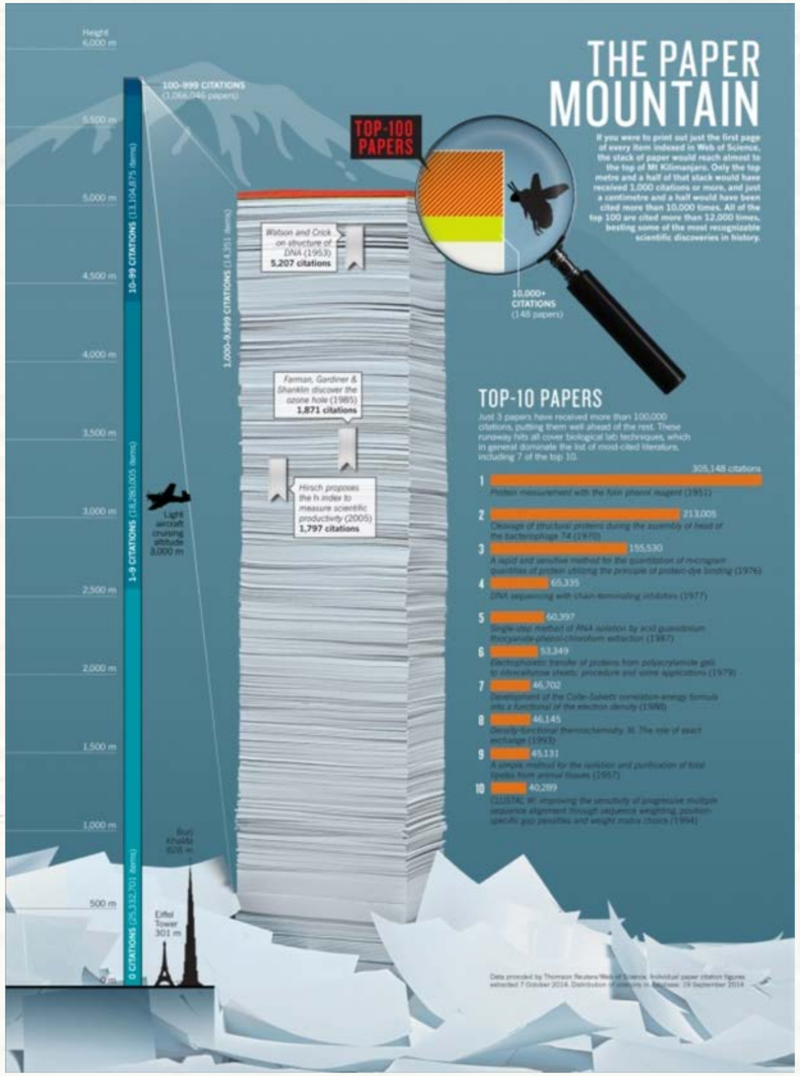
Phase 5- Post-Revolution

Phase 3 - The Crisis



The Scientific Century: securing our future prosperity. Royal Society Policy document 2010





Phase 4 – Paradigm shift

Scientific revolution is the phase in which the underlying assumptions of the field are reexamined and a new paradigm is established.

Open science

- Preprint archiving (arXiv, biorXiv)
- Open-access (PLoS, Frontiers, EU, NIH, CIHR)
- Open/paid peer review (Publons, eLife, Faculty of 1000, Veruscript, Collabra)
- Replication studies / negative results (OHBM Replication Award, Reproducibility Project, Journal of Negative Results in Biomedicine)
- Data/software sharing (Neurovault, DataDryad, Github, OpenfMRI, Flywheel, OpenNeuro)
- Publishing data and observations (ScienceMatters.io)
- Preregistration (Cortex, BMC Psychology)

Science Communication

www.humanbrainmapping.org/blog

MAGNETIC RESONANCE IN MEDICINE | ISMRM ONE COMMUNITY FOR CLINICIANS AND SCIENTISTS

Bridging the macro-micro gap: biophysical MR modeling of the central nervous system

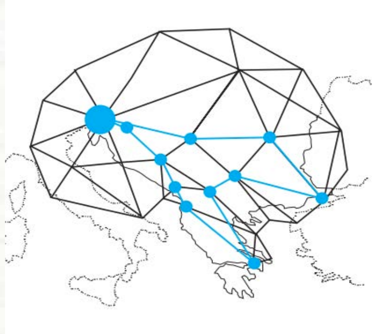
Christine Tardif, PhD
Douglas Mental Health Research Institute
McGill University

Nikola Stikov, PhD
École Polytechnique / Montreal Heart Institute
University of Montreal

www.ismrm.org/mrm

MR pulse

blog.ismrm.org



WWW.MRBALKAN.ORG

MR Imaging of Brain Microstructure

Guest Editors:

Prof. Bruce Pike [bruce.pike@ucalgary.ca]

Prof. Daniel C. Alexander [d.alexander@ucl.ac.uk]

Prof. Nikola Stikov [nikola.stikov@polymtl.ca]

$$SNR \propto \sqrt{Time}$$

My research timeline

ELSEVIER
NeuroImage
Volume 54, Issue 2, 15 January 2011, Pages 1112–1121

Bound pool fractions complement diffusion measures to describe white matter micro and macrostructure ☆

Nikola Stikov[a], Lee M. Perry[b], Aviv Mezer[b], Elena Rykhlevskaia[b], Brian A. Wandell[a, b], John M. Pauly[a], Robert F. Dougherty[b]

Contents lists available at ScienceDirect
ELSEVIER
NeuroImage
journal homepage: www.elsevier.com/locate/ynimg

In vivo histology of the myelin g-ratio with magnetic resonance imaging

CrossMark

Nikola Stikov [a,d,*,1], Jennifer S.W. Campbell [a,1], Thomas Stroh [a], Mariette Lavelée [a], Stephen Frey [a], Jennifer Novek [a], Stephen Nuara [a], Ming-Kai Ho [a], Barry J. Bedell [a], Robert F. Dougherty [b], Ilana R. Leppert [a], Mathieu Boudreau [a], Sridar Narayanan [a], Tanguy Duval [d], Julien Cohen-Adad [d], Paul-Alexandre Picard [e], Alicja Gasecka [f], Daniel Côté [f], G. Bruce Pike [a,c]

arXiv.org > physics > arXiv:1701.02760

Search or Art
(Help | Advanced

Physics > Medical Physics

Promise and pitfalls of g-ratio estimation with MRI

Jennifer S. W. Campbell, Ilana R. Leppert, Sridar Narayanan, Tanguy Duval, Julien Cohen-Adad, G. Bruce Pike, Nikola Stikov

(Submitted on 10 Jan 2017)

ELSEVIER
Data in Brief
Volume 4, September 2015, Pages 368–373
Open Access

36086||
Data Article

Quantitative analysis of the myelin *g*-ratio from electron microscopy images of the macaque corpus callosum

Nikola Stikov[a, d, 1], Jennifer S.W. Campbell[a, 1], Thomas Stroh[a], Mariette Lavelée[a], Stephen Frey[a], Jennifer Novek[a], Stephen Nuara[a], Ming-Kai Ho[a], Barry J. Bedell[a], Robert F. Dougherty[b], Ilana R. Leppert[a], Mathieu Boudreau[a], Sridar Narayanan[a], Tanguy Duval[d], Julien Cohen-Adad[d], Paul-Alexandre Picard[e], Alicja Gasecka[f], Daniel Côté[f], G. Bruce Pike[a, c]

Reproducibility vs. Replicability

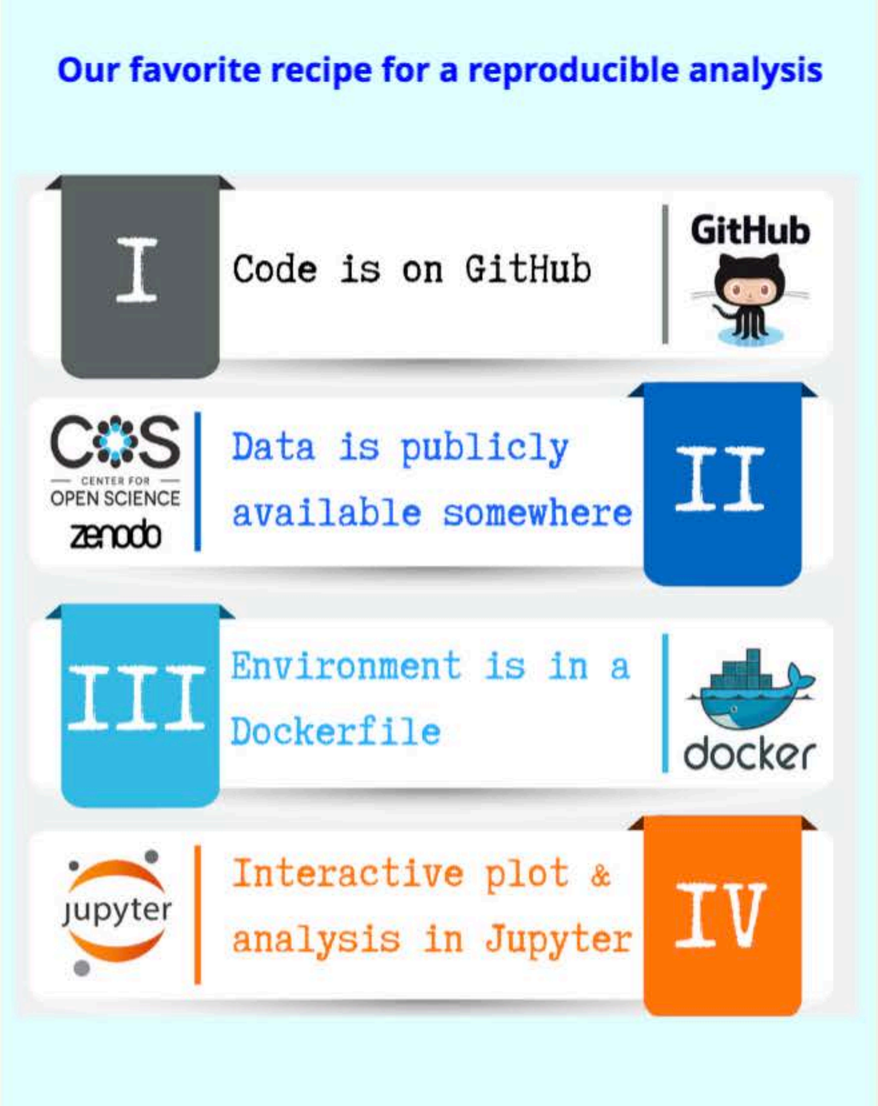
- Reproducibility: Can you recreate the same result using original data and code?

- Replicability: Can you recreate the same result using new data but same experimental design

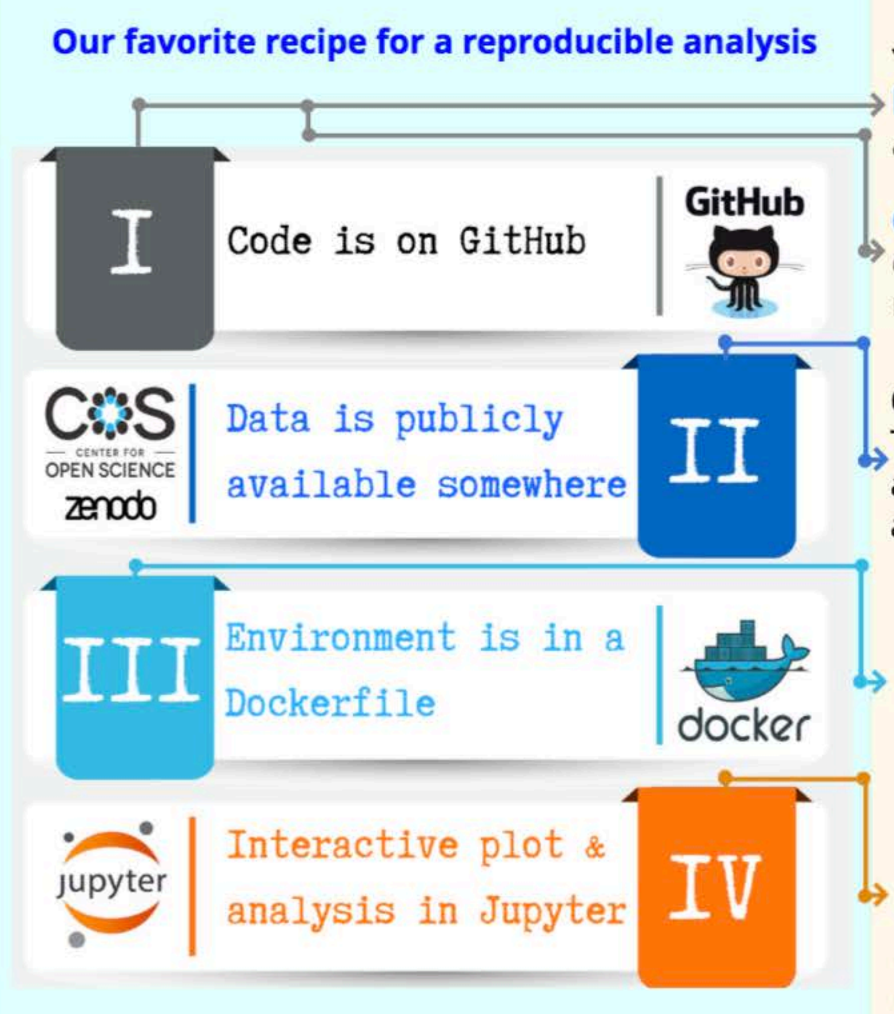
Reproducibility of neuroimaging analyses across operating systems

Tristan Glatard[1,2], Lindsay B. Lewis[1], Rafael Ferreira da Silva[3], Reza Adalat[1], Natacha Beck[1], Claude Lepage[1], Pierre Rioux[1], Marc-Etienne Rousseau[1], Tarek Sherif[1], Ewa Deelman[3], Najmeh Khalili-Mahani[1] and Alan C. Evans[1]*

Thanks to Chris Gorgolewski



http://qmrlab.org/jekyll/2018/09/24/tutorial-JN-win10.html



You can follow this beautiful lesson by software carpentry to learn about version controlling.

Create a GitHub account and discover millions of free repositories.

Open data for healthy science. There are platforms such as OSF and Zenodo, where you can find and share data at zero cost.

Docker is an amazing tool that enables you to create and share environments for your software.

You've already learned something about Jupyter in this tutorial.

Speaking of interactive plots, there are some really cool options. See the next slide.

http://qmrlab.org/jekyll/2018/09/24/tutorial-JN-win10.html

Working with JN on a local machine is fun.

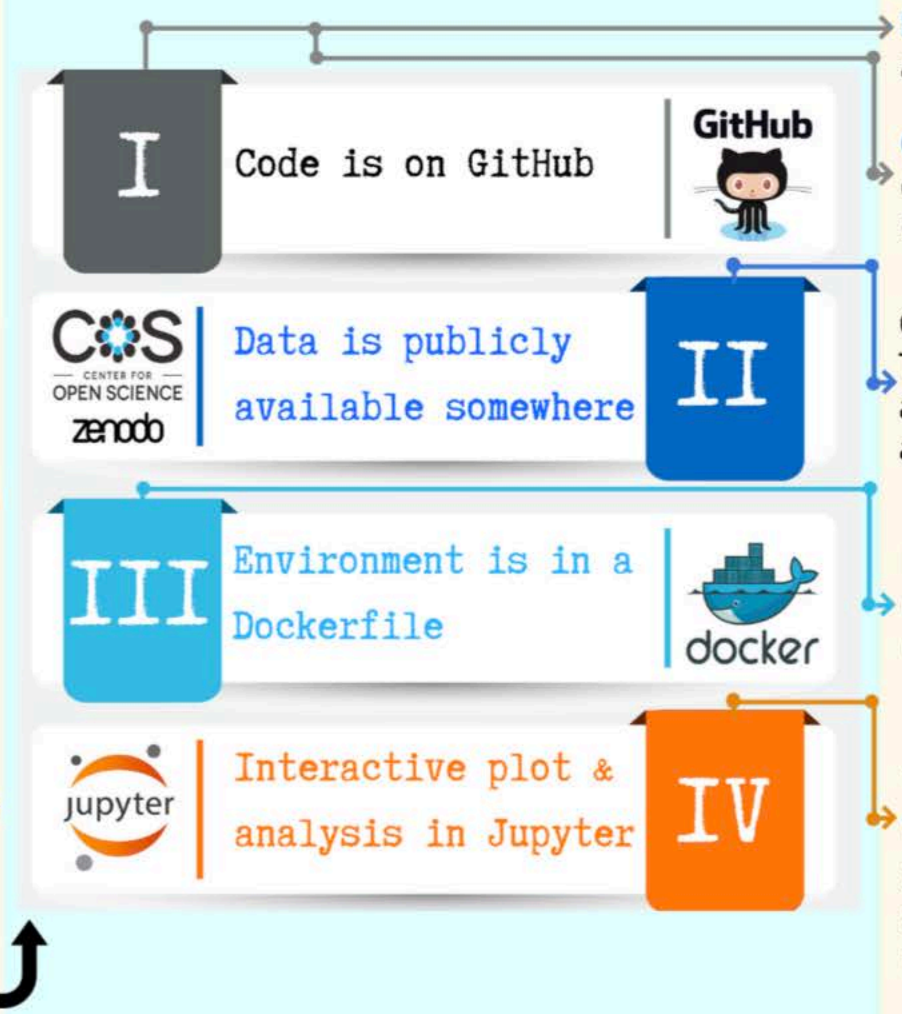
However, not enough to create a reproducible analysis.

Because other people may not have the exact same software versions you installed on your computer.

qMRLab provides you with the tools to create a reproducible qMRI analysis.

Stay tuned for our upcoming tutorials to follow this recipe!

Our favorite recipe for a reproducible analysis



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http://qmrlab.org/jekyll/2018/09/24/tutorial-JN-win10.html

Scientific director: Alan Evans

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incf International Neuroinformatics Coordinating Facility

Organization for Human Brain Mapping Advancing Understanding of the Human Brain


JB Poline


Pierre Bellec


Samir Das

Reproducibility

Aperture

jupyterhub

docker

jupyter

OPEN MATERIALS

binder

OPEN DATA

dat DATA

zenodo The place to share your research results

COS CENTER FOR OPEN SCIENCE

IPFS

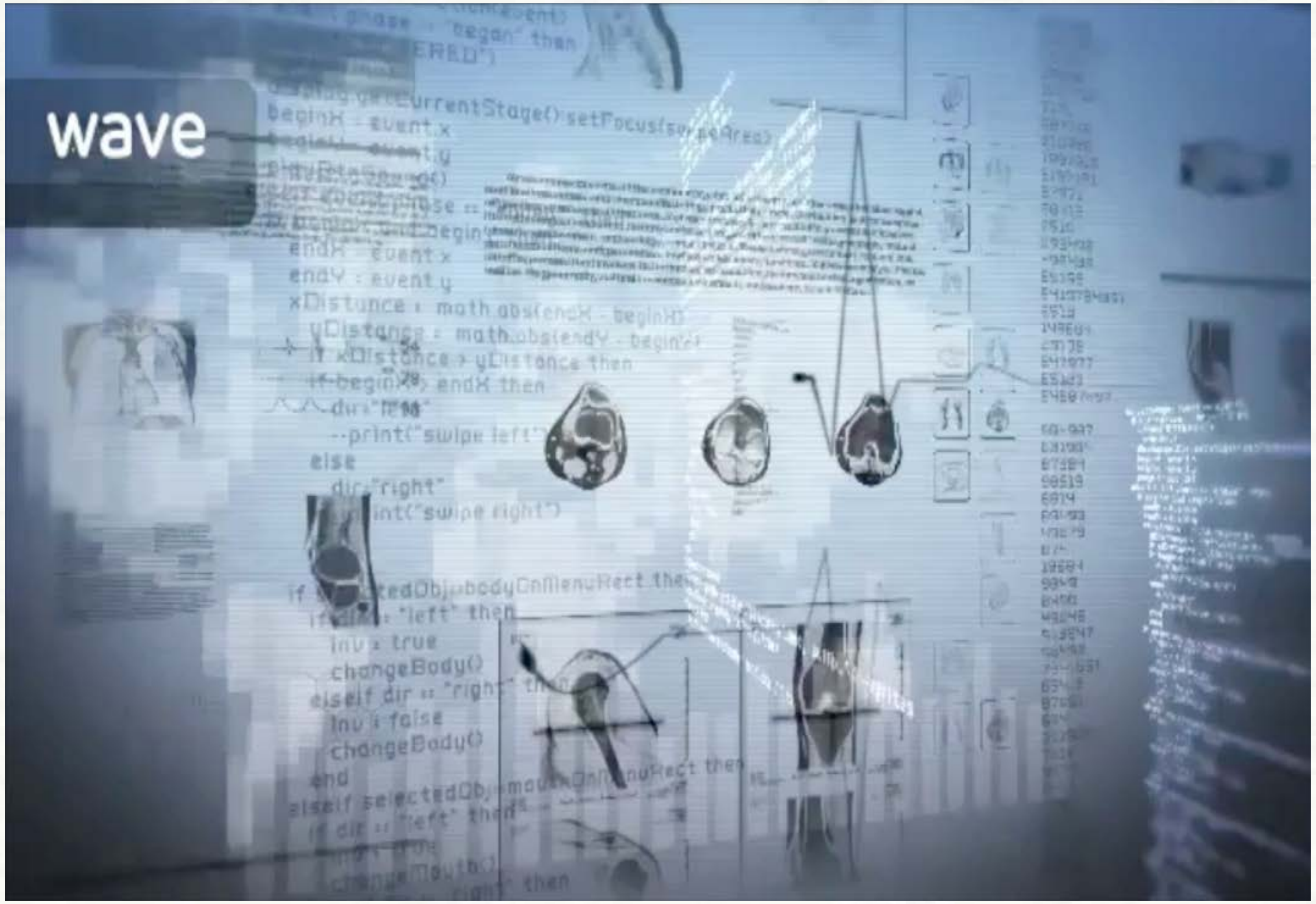
CONP PCNO

Reproducible notebooks


Pierre Bellec

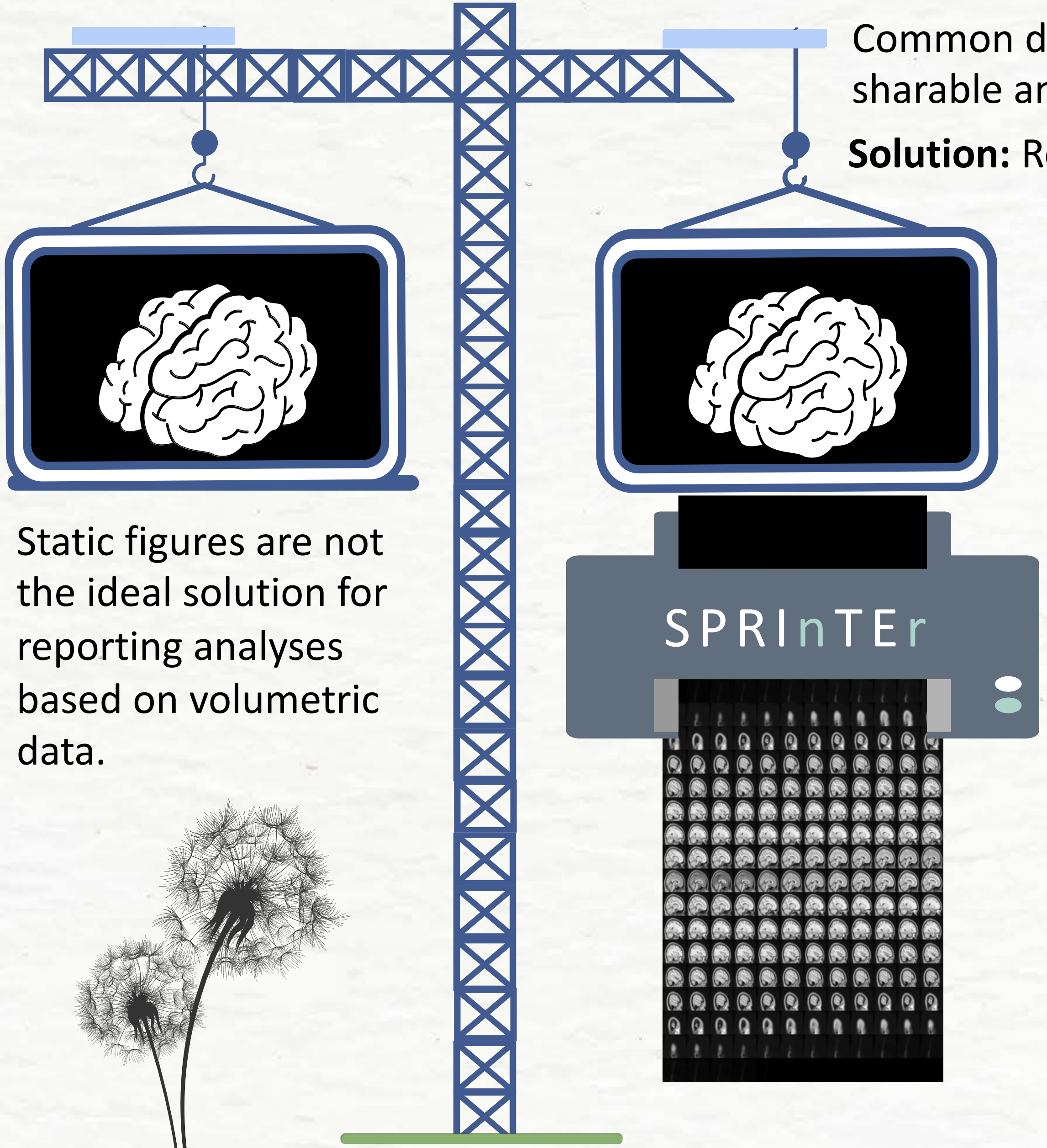

Samir Das


Agah Karakuzu



Common data formats used in research would require heavy lifting for sharable and interactive figures.

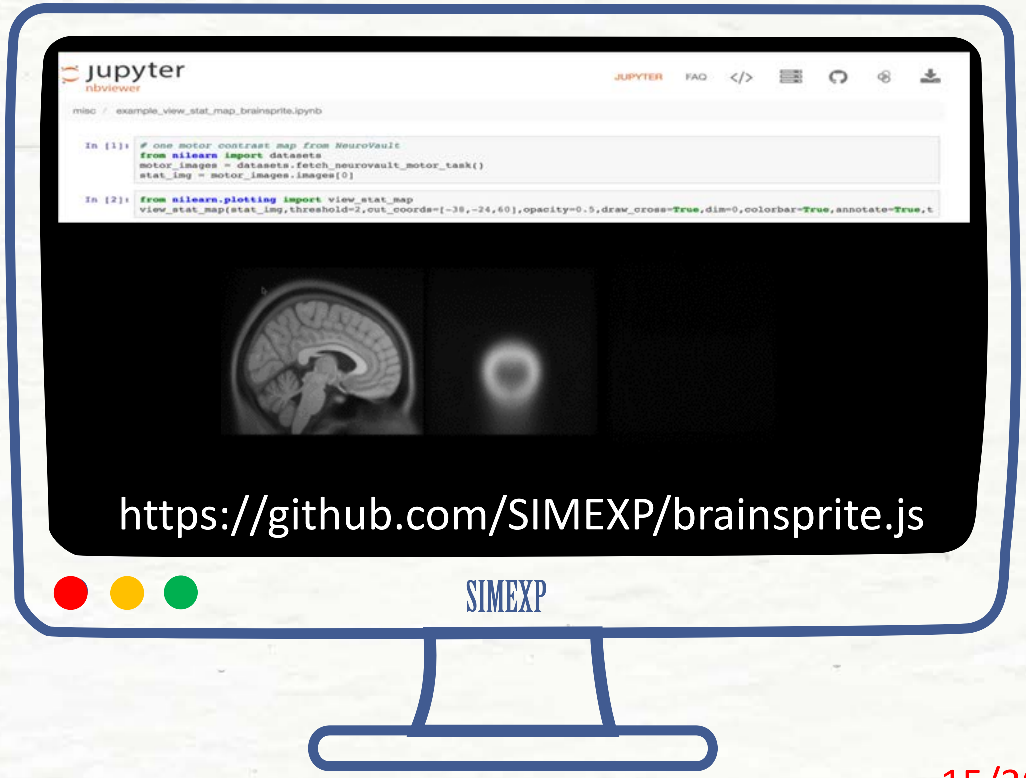
Solution: Reduce the load using sprites.



Static figures are not the ideal solution for reporting analyses based on volumetric data.

Brainsprite is an open source library to turn a sprite into an interactive, smooth and lightweight multi-planar slice navigator!

Python version will be soon available in nilearn.

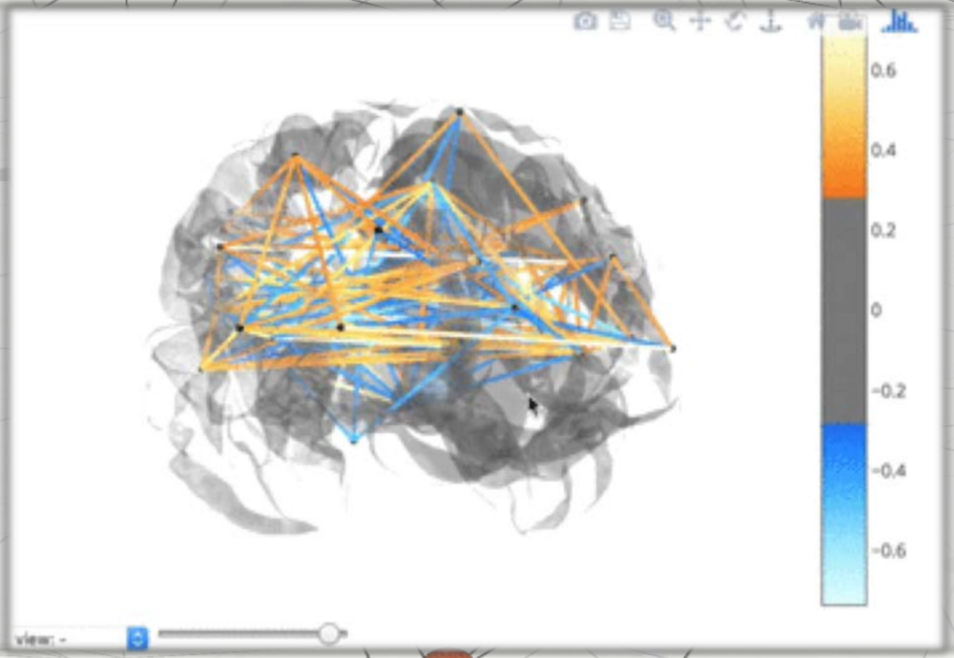


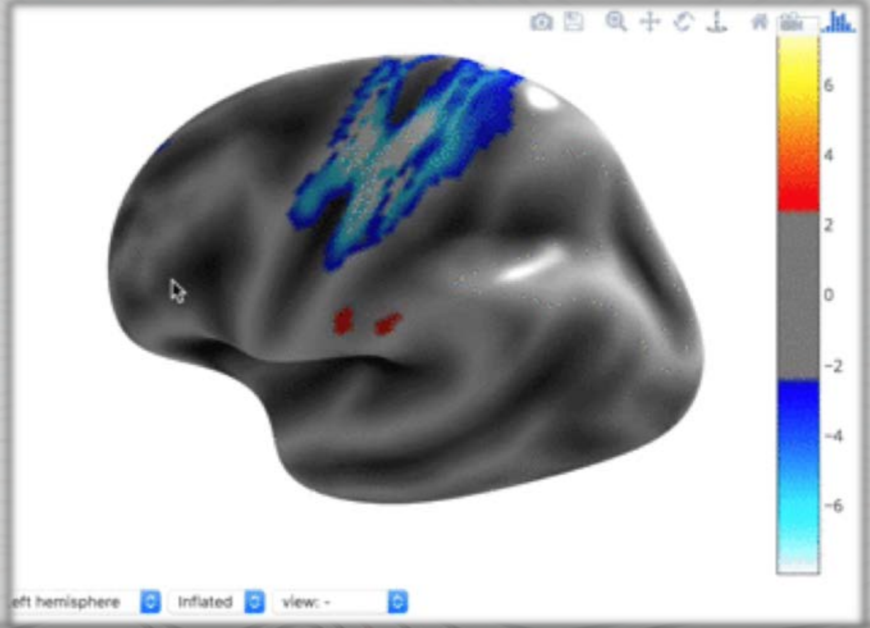
Slide by Agah Karakuzu

Nilearn is an open-source python for fast and easy statistical learning on neuroimaging data.

Now also enables seamless production of **plotly-powered interactive figures**!

http://nilearn.github.io





Slide by Agah Karakuzu

Preprint on Bioarxiv

Analysis on Binder

https://rebrand.ly/tam_2018

Data used in this study was privacy-sensitive, preventing authors from sharing it.

Yet, the core of the paper is reproduced in just a few minutes using simulated data!

A highly predictive signature of cognition and brain atrophy for progression to Alzheimer's dementia

Angela Tam, Christian Dansereau, Yasser Iturria-Medina, Sebastian Urchs, Pierre Orban, Hanad Sharmarke, John Breitner, Pierre Bellec, Alzheimer's Disease Neuroimaging Initiative

doi: https://doi.org/10.1101/352344

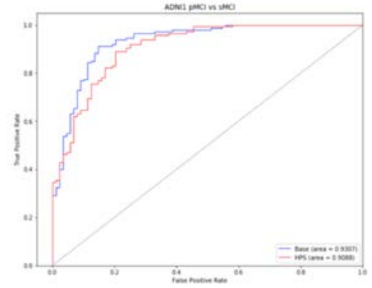
Discussion

We developed a highly precise and specific MRI and cognitive-based model to predict AD dementia. Our two-stage predictive model reached 93.2% specificity and 93.1% PPV (80.4% when adjusted for 33.6% prevalence of progressors) in ADNI1 when classifying progressor vs stable MCI patients (within 3 years follow-up). We replicated these results in ADNI2 where the model reached 96.7% specificity and 81.2% PPV (87.8% adjusted PPV).

ADNI1

Plot the two ROC curves

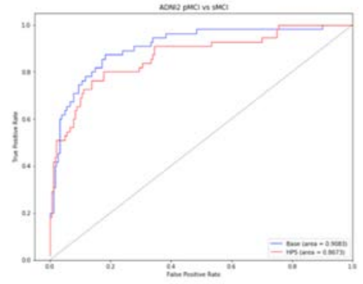
In [29]:
```
fig, ax = plt.subplots()
fig.set_size_inches(10, 8)
lw = 1
plt.plot(fpr_b, tpr_b, color='blue',
         lw=lw, label='Base (area = %0.
plt.plot(fpr_h, tpr_h, color='red',
         lw=lw, label='HPS (area = %0.4
plt.plot([0, 1], [0, 1], color='grey',
plt.xlim([-0.05, 1.00])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ADNI1 pMCI vs sMCI')
plt.legend(loc="lower right")
plt.show()
```



ADNI2

Plot the figure

In [45]:
```
fig, ax = plt.subplots()
fig.set_size_inches(10, 8)
lw = 1
plt.plot(fpr_b, tpr_b, color='blue',
         lw=lw, label='Base (area = %0.
plt.plot(fpr_h, tpr_h, color='red',
         lw=lw, label='HPS (area = %0.4
plt.plot([0, 1], [0, 1], color='grey',
plt.xlim([-0.05, 1.00])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ADNI2 pMCI vs sMCI')
plt.legend(loc="lower right")
plt.show()
```



Slide by Agah Karakuzu

Coko sprint

Aperture

JB Poline

Organization for Human Brain Mapping
Advancing Understanding of the Human Brain

CONP PCNO

Agah Karakuzu, Mathieu Boudreau, Tanguy Duval, Tommy Boshkovski, Julien Cohen-Adad, Ilana Leppert, Bruce Pike

Quantitative MRI. Under one umbrella.

https://github.com/neuropoly/qMRLab

I have a tool

And I have a Docker

Uh! Dockerized qMRLab

Thanks to Agah Karakuzu and Alex Leemans

qMR Lab

Ga s available tools
e -reviewed c
ular
en-source
Collaborative (10+ contri tors)

mcr

Octave Syntax

Shell Script + Python Syntax

Simulations

nd sensi ity an
batchi

boutiques

computecanada
Cloud

Diffusion MRI
Relaxometry

HPC

computecanada

cbrain

OpenNEURO

Codebase

Functionality

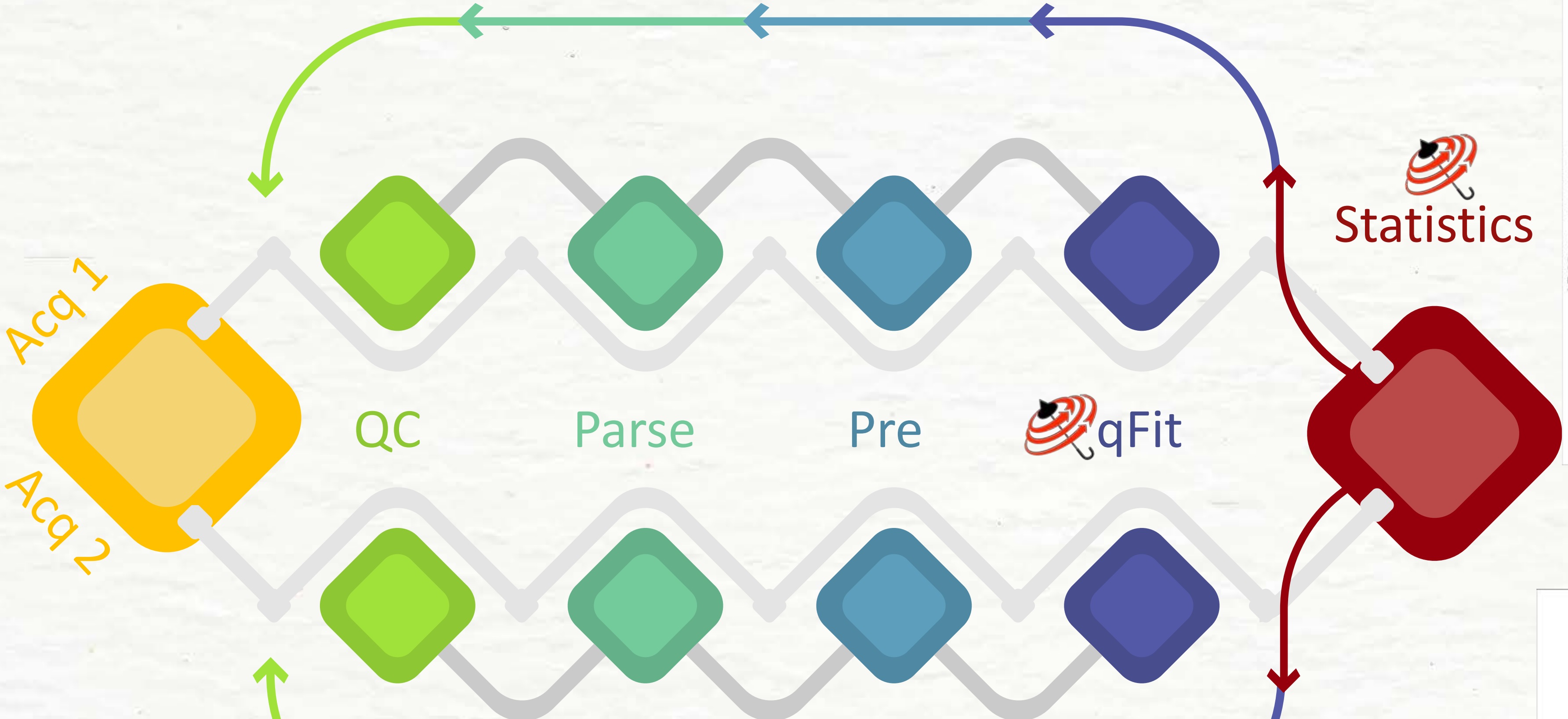
qMR methods

Deploy & Integrate

T_1 Mapping: Inversion Recovery

Widely considered the gold standard for T_1 mapping, the inversion recovery technique estimates T_1 values by fitting the signal recovery curve acquired at different delays after an inversion pulse (180°). In a typical inversion recovery experiment (Figure 1), magnetization at thermal equilibrium is inverted using a 180° RF pulse. After the longitudinal magnetization recovers through spin-lattice relaxation for predetermined delay ("inversion time", TI), a 90° excitation pulse is applied, followed by a readout imaging sequence (typically a spin-echo or gradient-echo readout) to create a snapshot of the longitudinal magnetization state at that TI. Inversion recovery was first developed for NMR in the 1940s (Hahn 1949; Drain 1949), and the first T_1 map was acquired using a saturation-recovery technique (90° as a preparation pulse instead of 180°) by (Pykett and Mansfield 1978). Some distinct advantages of inversion recovery is its large potential range of signal change (up to $2M_0$) and an insensitivity to pulse sequence parameter imperfections (Stikov et al. 2015). Despite its proven robustness at measuring T_1, inversion recovery is scarcely used in practice, because conventional implementations requires repetition times (TRs) on the order of 2 to 5 T_1 (Steen et al. 1994), making it challenging to acquire whole-organ T_1 maps in a clinically feasible time. Nonetheless, it is continuously used as a reference measurement during the development of new techniques, or when comparing different T_1 mapping techniques, and several variations of the inversion recovery technique have been developed, making it practical for some applications.

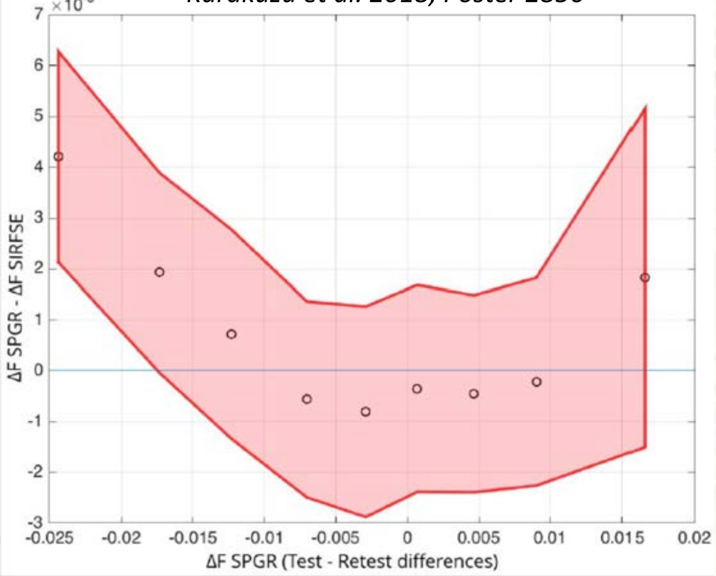
qMRI workflow



Provenance

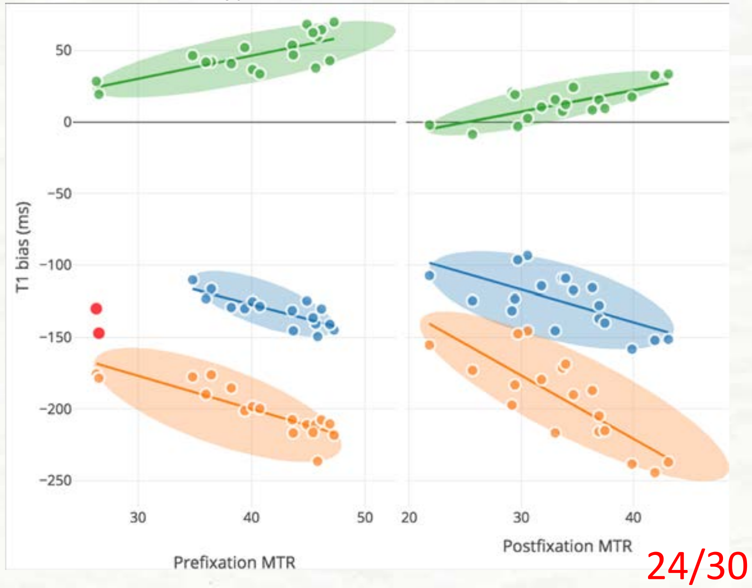
SPMRT

Karakuzu et al. 2018, Poster 2850



Robust Correlation

Hafyane & Karakuzu et al.



Slide by Agah Karakuzu

Engaging with industry

HEARTVISTA
Advancing MRI Technology

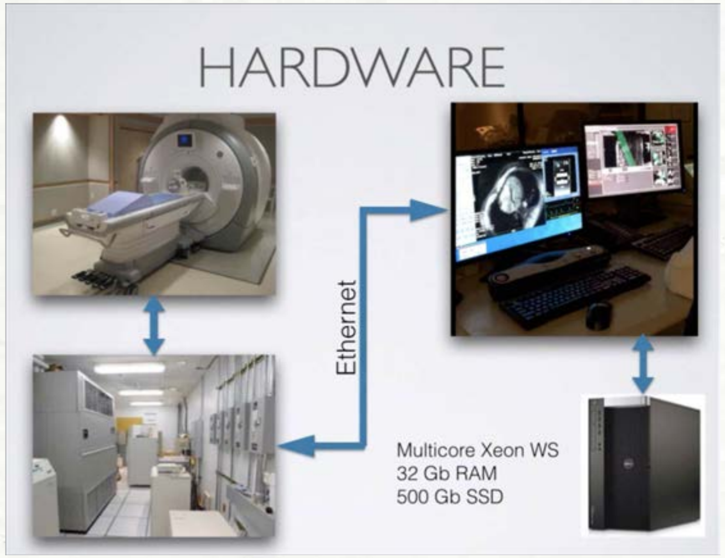
SIEMENS

qMR Lab

Fetch data from the scanner and generate qMR maps

Developing custom MRI apps with RTHawk

HEARTVISTA
Advancing MRI Technology



Plugin API

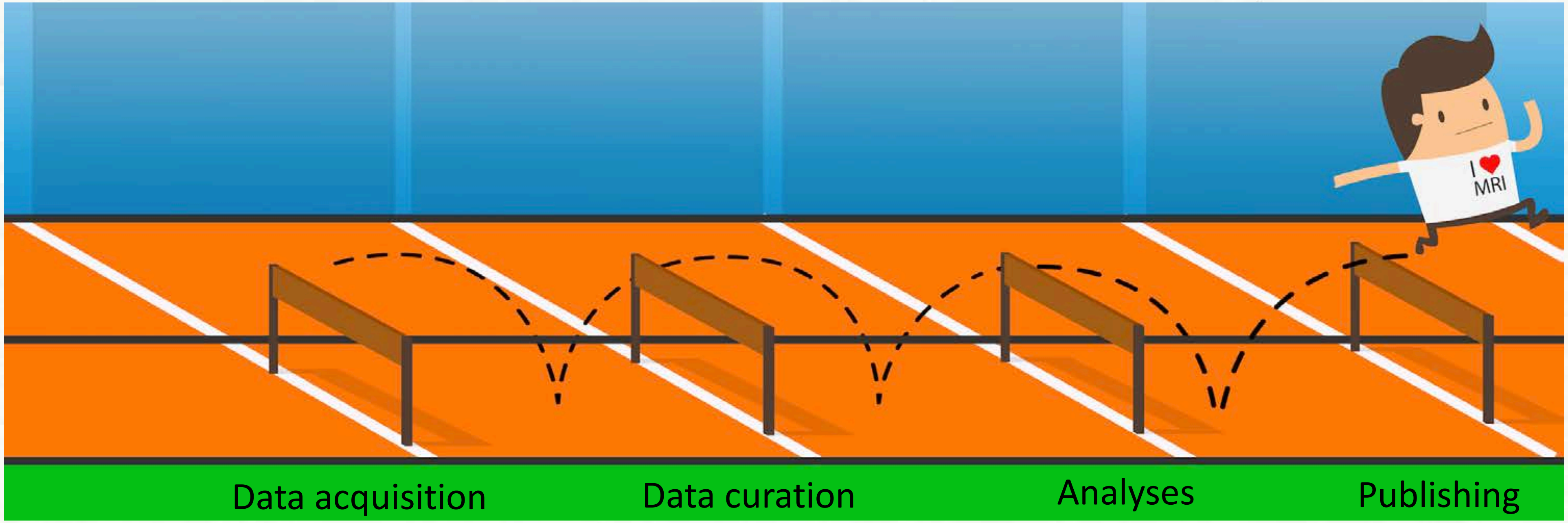
Opens the doors of the app to use & to be used by external software installed on workstation.

qMaps at Scanner Site

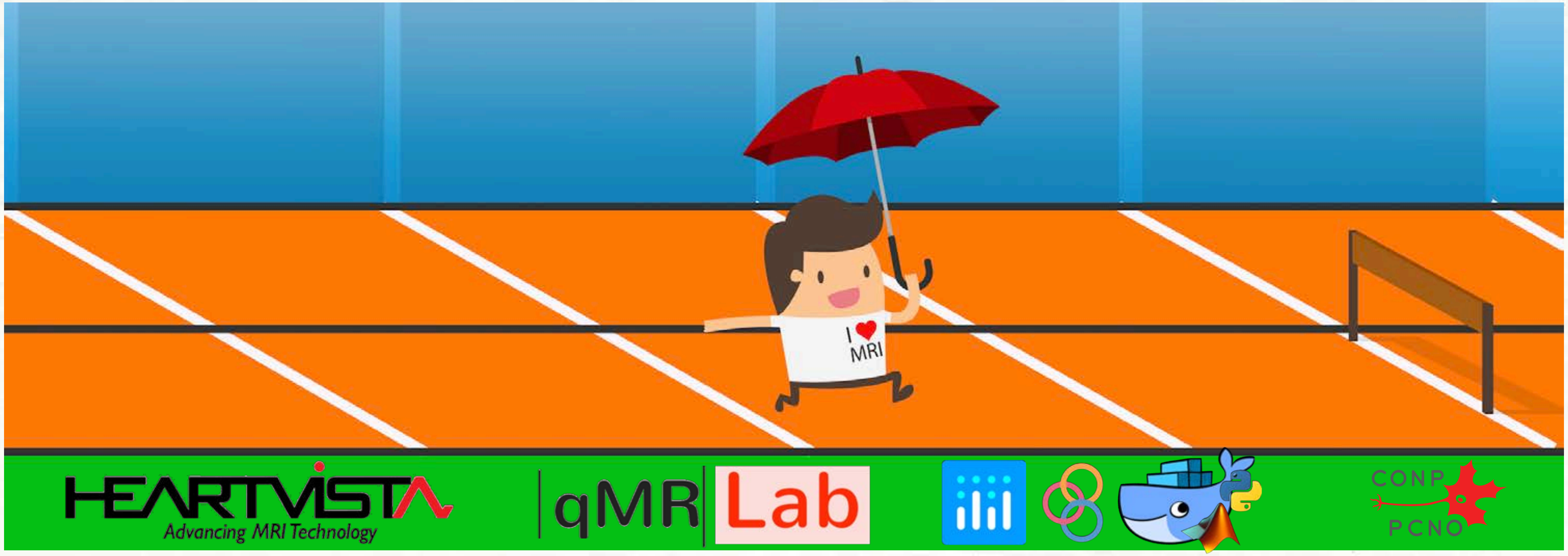
Trigger a qMRI workflow

Outcome

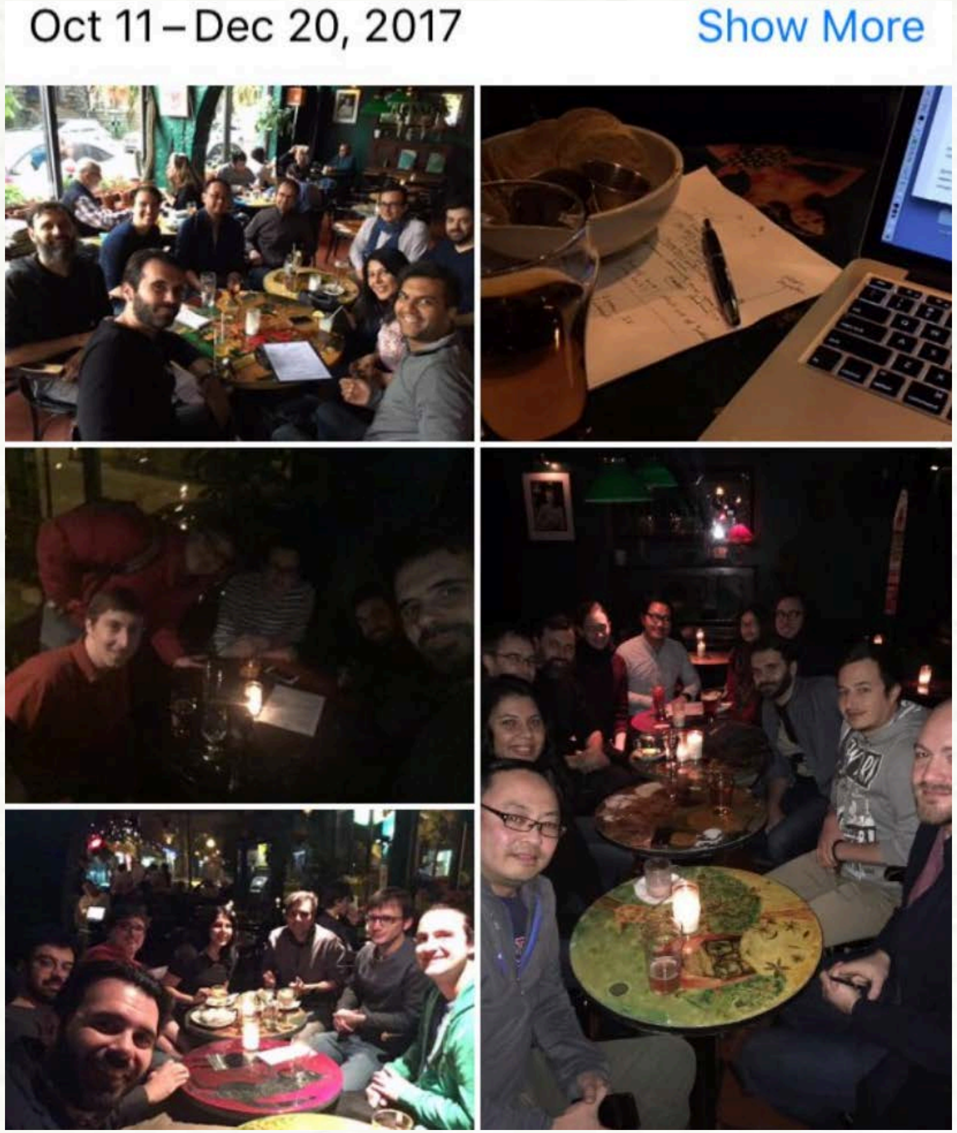
Traditional



Proposed



Community



Oct 11 – Dec 20, 2017
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Nikola Stikov @Stikov · Feb 7
Taking #openscience to the next level. The Montreal crew warming up for an eventful spring
2
33

One year of OSB: Wednesdays at Else's at 4:44pm

Else's, 156 Roy St

THANKS!

Agah Karakuzu
Tommy Boshkovski
Mathieu Boudreau
Julien Cohen-Adad
Jean-Francois Cabana
Tanguy Duval
Ilana Leppert
Bruce Pike
Jennifer Campbell
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