Open-science for gravimetry:
Tools, challenges, and opportunities

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GFZ Helmholtz Centre Potsdam | 22 June 2021

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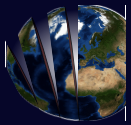
Fatiando a Terra

open-source tools for geophysics

This talk will be mostly about the Fatiando a Terra project. **Fun fact:** the name is Portuguese for **"Slicing the Earth"**

First, a bit of history

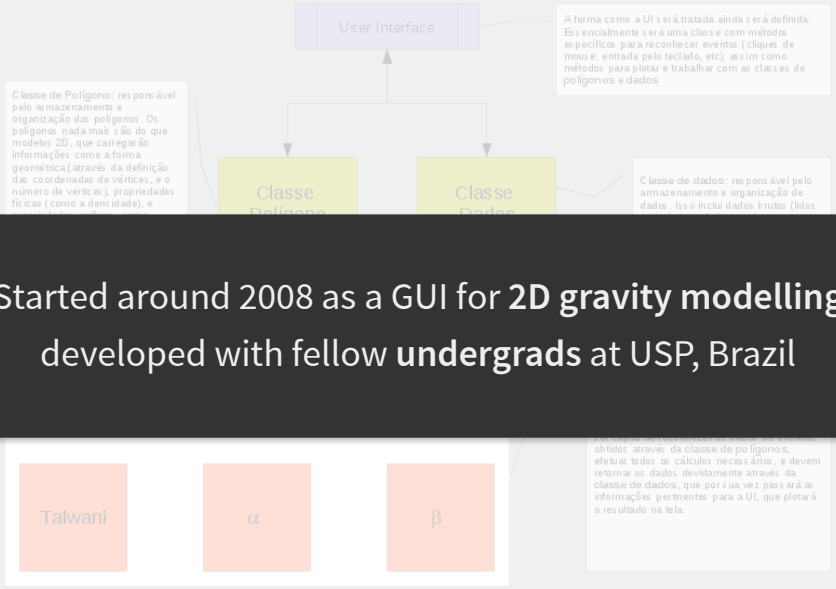


2010

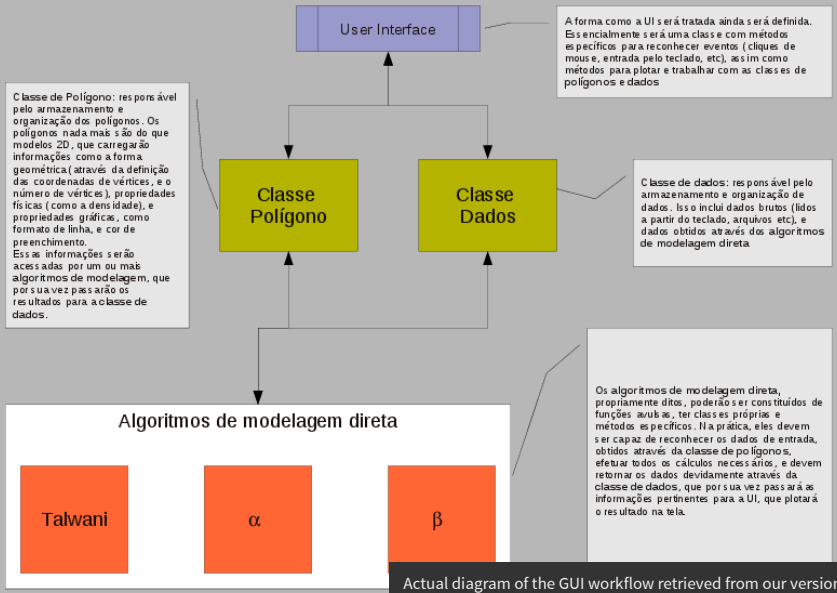
2014

2016

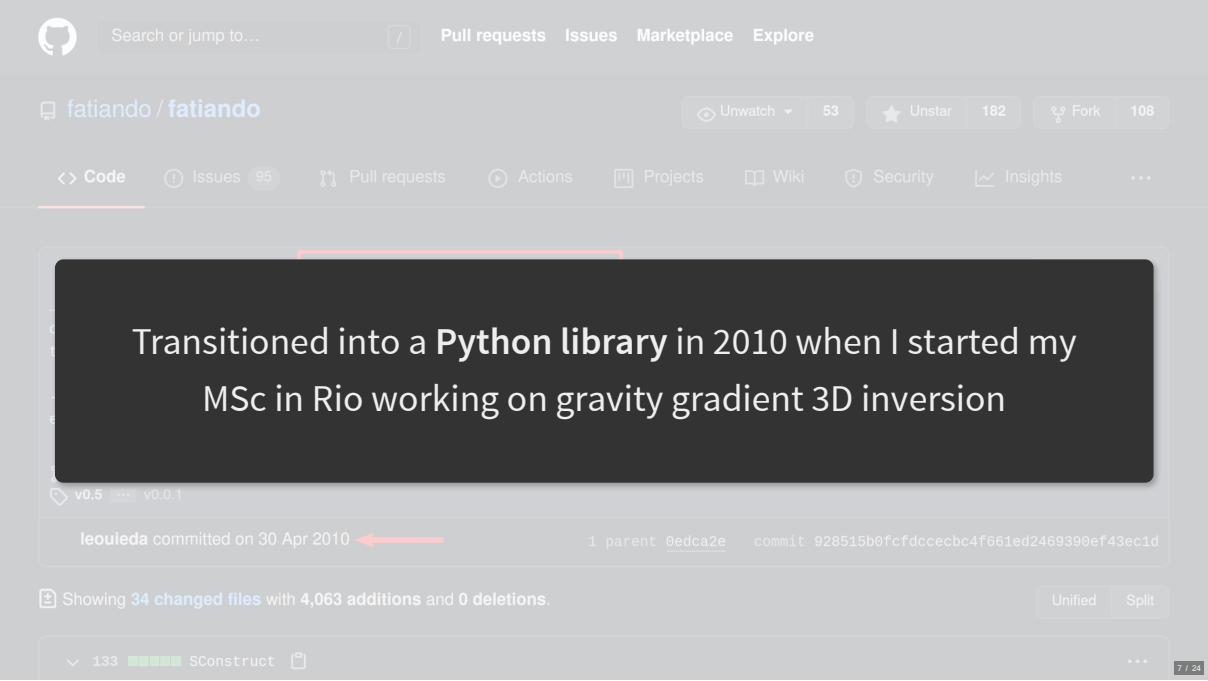
Our journey starts in Southeastern Brazil, specifically in São Paulo and Rio de Janeiro



Started around 2008 as a GUI for **2D gravity modelling** developed with fellow **undergrads** at USP, Brazil



Actual diagram of the GUI workflow retrieved from our version control system.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Issues 95
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Projects
Wiki
Security
Insights
Transitioned into a Python library in 2010 when I started my MSc in Rio working on gravity gradient 3D inversion
v0.5
v0.0.1
leouieda committed on 30 Apr 2010
1 parent 0edca2e
commit 928515b0fcfdccecbc4f661ed2469390ef43ec1d
Showing 34 changed files with 4,063 additions and 0 deletions.
Unified
Split
133
SConstruct

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Code Issues 95 Pull requests Actions Projects Wiki Security Insights ...

Restructured the repos. Made fatiando python package with directmods,...

Browse files

```
… math, utils and geoinv. Includes direct models for prism gravity, sclimate signal from heat well log, and simple
cartesian tomography. Geoinv has the inversion program for the single perturbation climate signal, and simple
tomography (including using an image as a model).

--HG--
extra : convert_revision : svn%3A2c9857fa-f4c4-11dd-ada4-5153b8187bf2/trunk%4037
```

master

v0.5 ··· v0.0.1

leouieda committed on 30 Apr 2010

1 parent 0edca2e commit 928515b0fcfdccecbc4f661ed2469390ef43ec1d

Showing **34 changed files** with **4,063 additions** and **0 deletions**.

Unified Split

133 SConstruct

The exact date and time when this happened is still registered in our git repository (commit: 928515b)

Search or jump to… /

Pull requests Issues Marketplace Explore

fatiando / **fatiando**

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Showing **34 changed files** with **4,063 additions** and **0 deletions**.

Learned a lot about software development: version control (went through 3), tests, packaging, documentation, and more.

133 ■■■■■ SConstruct

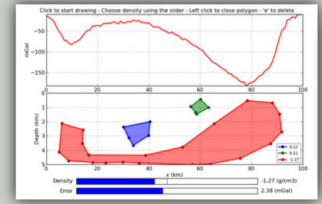
fatiando.org/gallery/index.html

Home Development Download Help Gallery Docs Blog Google+

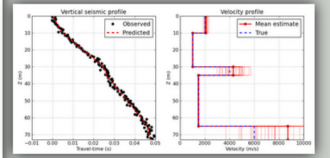
Example Gallery

Some of the functionality already implemented:

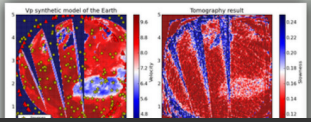
Moulder - 2D gravimetric direct modeling



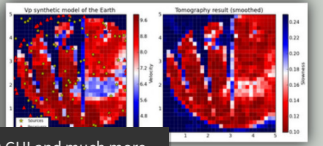
Inversion of synthetic vertical seismic profile data



Straight-ray travel-time tomography of large models using sparse linear algebra

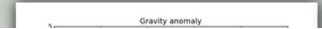


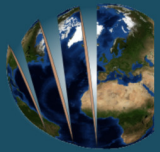
Straight-ray travel-time tomography



Around 2011 we built the first website and gallery. We ended up building a 2D GUI and much more, from seismic to potential fields and heat flow.

...zoidal basin





Next topic

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Enter search terms or a module, class or function name.

Fatiando a Terra: Geophysical modeling and inversion

An open source toolkit for geophysical modeling and inversion

Fatiando provides an easy and flexible way to perform common tasks like: generating synthetic data, forward modeling, inversion, 3D visualization, and more! All from inside the powerful Python language.

For more information visit the official site.

The **source code** of Fatiando is hosted on GitHub.

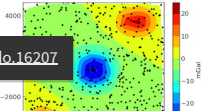
License: Fatiando is licensed under the **BSD license**. This means that it can be reused and remixed with few restrictions. See the *license text* for more information.

The best **place to start** learning about Fatiando is the *Cookbook*! There, you'll find many sample scripts with common tasks that can help you get started.

As an **example**, this is how easy it is to create synthetic noise-corrupted gravity data on random points from a 3D prism model:

```
>>> from fatiando.mesher import Prism
>>> from fatiando.vis import mpl
>>> from fatiando import gridder, utils, gravmag
>>> # Create the prism model
>>> prisms = [
...     Prism(-4000, -3000, -4000, -3000, 0, 2000, {'density':1000}),
...     Prism(-1000, 1000, -1000, 1000, 0, 2000, {'density':-1000}),
...     Prism(2000, 4000, 3000, 4000, 0, 2000, {'density':1000})]
>>> # Generate 500 random observation points at 100m height
>>> xp, yp, zp = gridder.scatter((-5000, 5000, -5000, 5000), 500, z=-100)
>>> # Calculate their gravitational effect and contaminate it with 0.1 mGal
>>> # gaussian noise
>>> gz = utils.contaminate(gravmag.prism.gz(xp, yp, zp, prisms), 0.1)
>>> # Plot the result
>>> mpl.contourf(xp, yp, gz, (100, 100), 12, interp=True)
>>> cb = mpl.colorbar()
>>> cb.set_label('mGal')
>>> mpl.plot(xp, yp, '.k')
>>> mpl.show()
```

which results in something like this:



First documentation built using sphinx for **v0.1** (2013). doi:10.5281/zenodo.16207

fatiando a terra

An open-source Python library for modeling and inversion in geophysics.

Our goal is provide a comprehensive and extensible framework for geophysical data analysis and the development of new methodologies.

Research

Make your research more **reproducible** by writing a Python script or Jupyter notebook instead of clicking through complicated menus.

Development

Don't start from scratch! Build upon the existing tools in Fatiando to develop new methods.

Teaching

Combine Fatiando with the Jupyter notebook to make rich, interactive documents. Great for teaching fundamental concepts of geophysics!

Overview

Santiago and other contributors joined and we made several releases until **v0.5** (2016). doi:10.5281/zenodo.157746

Modeling, inversion, and processing for potential field methods.

Simple modeling functions for seismics and seismology.

3D forward modeling with prisms, polygonal prisms, spheres, and tesseroids

Toy problems for: Cartesian straight-ray tomography, VSP, epicenter

The good parts

- State-of-the-art algorithms
- Used in several thesis & papers (>70 citations)
- 2-3 active contributors
- Enabled teaching through simulation

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The bad parts

- Too many toy problems and experimental code
- Not designed for testability
- Difficult to maintain
- Unstable foundations for growth

✨ New Fatiando ✨

Split into libraries

Better coding practices

Use modern tools

Supplement the ecosystem

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(used by other libraries)

fatiando/pooch

doi: 10.21105/joss.01943

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RockHound

Repository for our **sample data** (uses Pooch)

fatiando/rockhound

Early stages of design

Demo time!

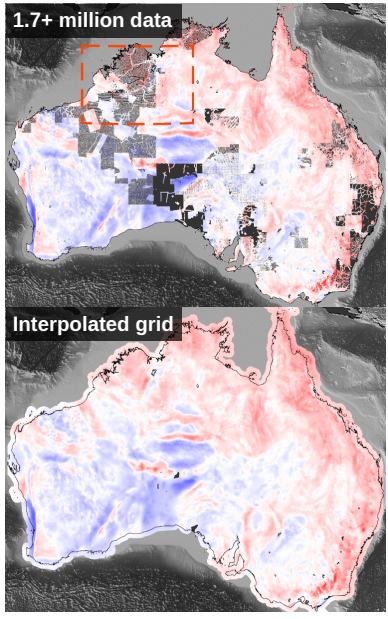
Ongoing developments

Equivalent sources

Using **gradient boosting** to scale to millions of data

Preprint on EarthArXiv (minor revision at GJI): Soler & Uieda (2021)

Code coming to Harmonica in the next few months



In development

- Frequency domain transformation (fatiando/harmonica#238)
- Tri-axial ellipsoids (fatiando/boule#76)
- Re-organization of the documentation (Pooch v1.4.0 was the first)
- Gather open-access data for tutorials (included in RockHound)
- Increase recruitment and diversity of our community

Come for the **code** </>

Stay for the **community**

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  - Software Carpentry has great open-access lessons

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- Documentation for each library (links at fatiando.org)

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Your help is always welcome!

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Video Calls: **Community Calls** (monthly) to socialize and plan, **Development Calls** (weekly) to discuss the details

About Fatiando: fatiando.org

Our research: compgeolab.org

Slides + demo: github.com/leouieda/2021-06-22-gfz

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