

*The Anatomy Lesson of Dr. Nicolaes Tulp*

# Using CoFI to experiment with geophysical inversion

A **Common Framework for Inference**



**AuScope**

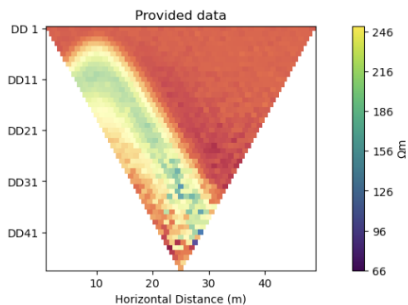


Australian  
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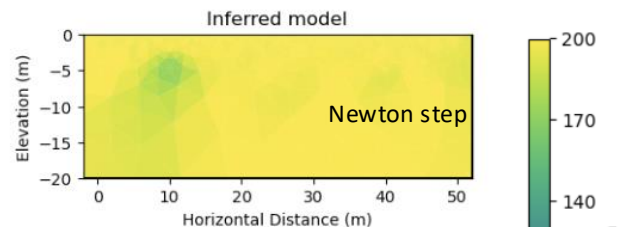
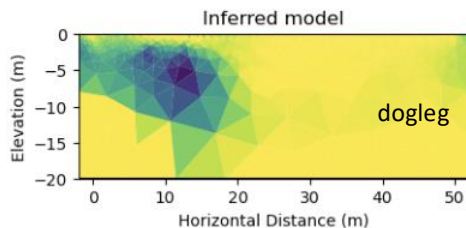


**InLab**

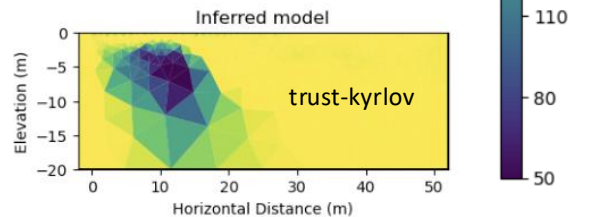
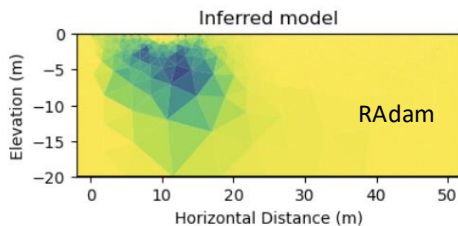
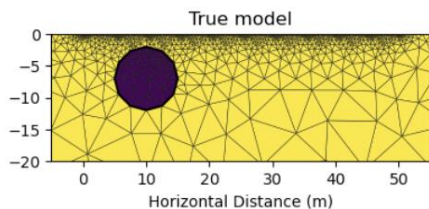
# Mineral exploration is about possibilities



## CoFI - Common Framework for Inference



## Electrical resistivity tomography



and so is finding an inference method using CoFI...

# Momentum based optimizers



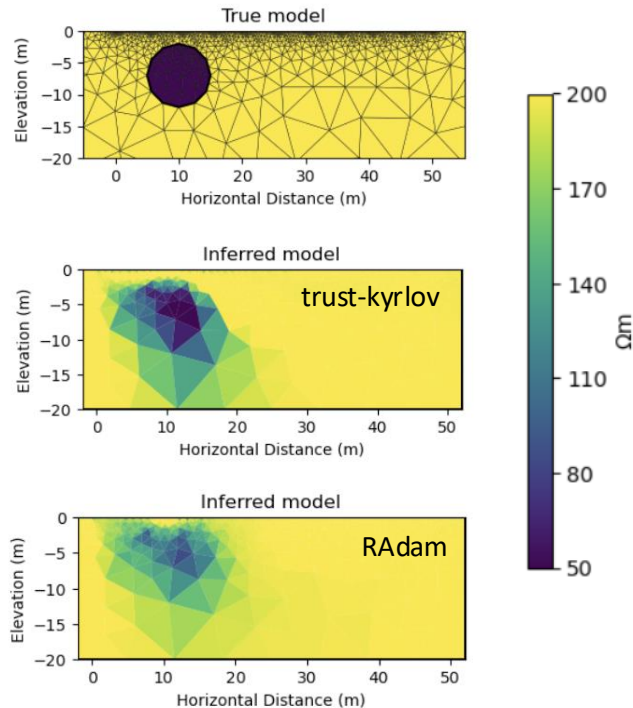
Vanilla iterative non-linear optimizers only consider the objective function at the current location

Machine learning methods are frequently applied to noisy data

Build inertia into the search direction to overcome local minima

```
CLASS torch.optim.RAdam(params, lr=0.001, betas=(0.9, 0.999), eps=1e-08, weight_decay=0, decoupled_weight_decay=False, *, foreach=None, differentiable=False) [SOURCE]
```

<https://pytorch.org/docs/stable/generated/torch.optim.RAdam.html>



# On the menu

Time	Topic
0830-0840	Welcome and setup
0840-0910	Introduction to CoFO
0910-1000	Interactive session: Linear regression
1000-1030	Morning Refreshments and Trade Exhibition
1030-1130	Inverting for a thin plate target
1130-1200	Questions and Answers

# Take home messages...

What we hope you will take home today:

An understanding what CoFI can do and can't do.

Some familiarity with the design and philosophy of CoFI

Cognizance of the avenues to engage with CoFI and InLab

What we hope to take away today:

Priorities: Expanding the methods; the examples, building a community, other?

Wish lists: scalability; real data problems; automatic differentiation...



# CoFI – A Common Framework for Inference

The application domain expert says:

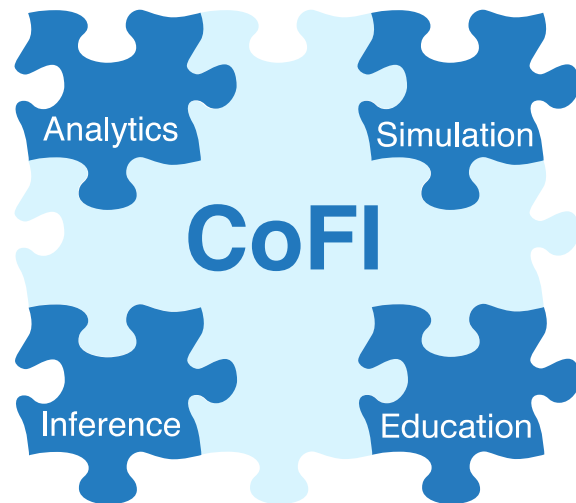
- What inference methods are suited to my data?
- Where can I get access to them? What is required to make them talk to my forward problem/data?
- How much work is that for me?

The research manager says:

- How can my staff learn about state-of-the-art inference methods
- How do we access the expertise?
- Can we keep our design options open?
- How long will it take?

The inference specialist says:

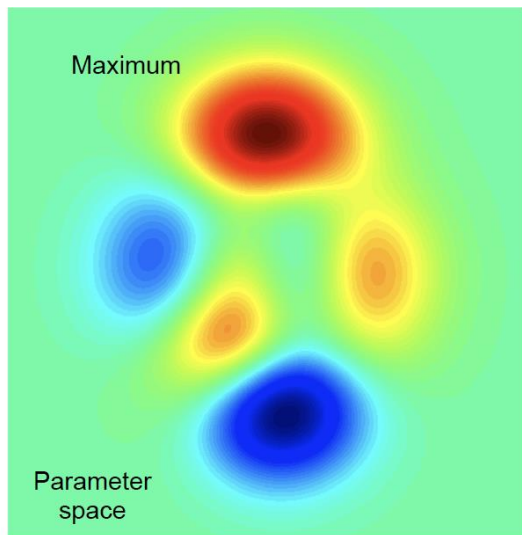
- What other problems can my inference method solve?
- Where can I get access to them?
- How much work is that for me?



[www.inlab.au](http://www.inlab.au)

# Two approaches to inversion

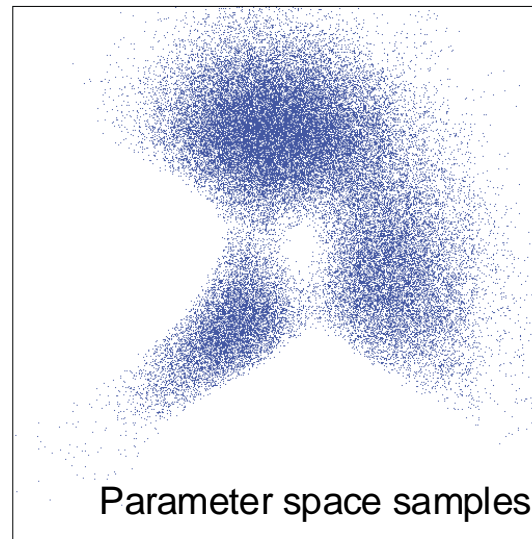
Parameter estimation



Optimisation of a misfit function

$$\phi(\mathbf{m}) = \|\mathbf{d} - g(\mathbf{m})\|_2^2 + \alpha^2 \|\mathbf{m}\|_2^2$$

Ensemble method



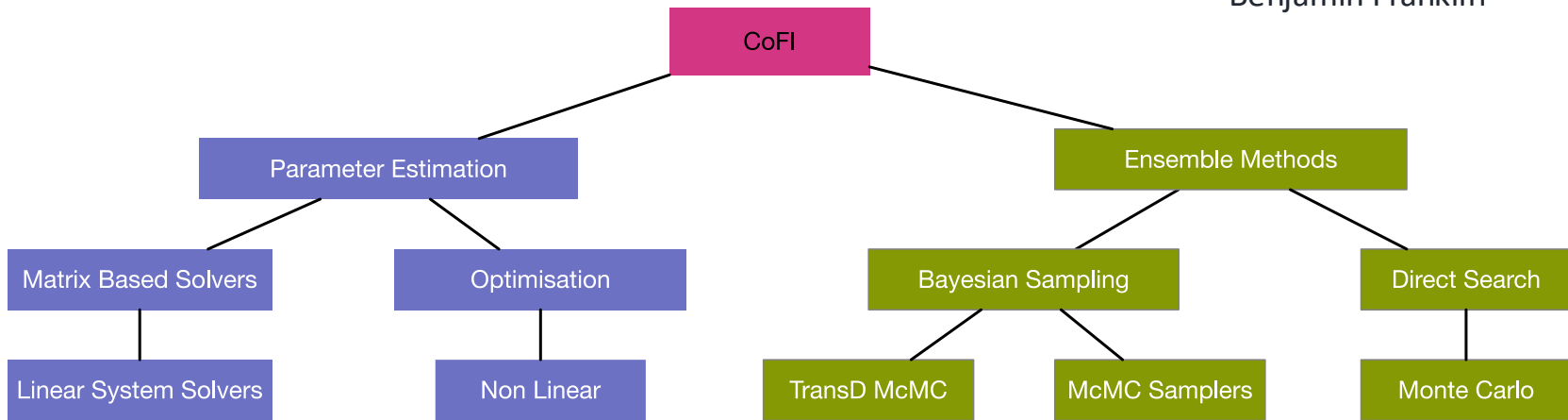
Sample a target pdf

$$p(\mathbf{m}|\mathbf{d}) = k \times p(\mathbf{d}|\mathbf{m}) p(\mathbf{m})$$



# Method tree

A good example is the best sermon  
– Benjamin Franklin



[www.inlab.au/inlab-explorer](http://www.inlab.au/inlab-explorer)

Build on existing and emerging software packages

**Example driven** – we only add a method if there is an example that needs it  
Findable, accessible, interoperable and reusable software





# Capturing an inverse problem

## Base Problem

```
inv_problem = BaseProblem()  
inv_problem.set_objective(DEFINE ME)  
inv_problem.set_jacobian(DEFINE ME)  
inv_problem.set_initial_model(DEFINE ME)
```

Jacobian  
Residuals  
Log Likelihood  
...

## Inversion Options

```
inv_options = InversionOptions()  
inv_options.set_tool("scipy.linalg.lstsq")
```

Proposal Strategy  
Convergence Criteria  
Number of iterations  
...

## Inversion

```
inv = Inversion(inv_problem, inv_options)  
result = inv.run()
```

An inverse method needs to only access a subset of features of a forward problem

Capturing a rich set of examples