Applied Machine Learning

Fundamentals and Geostatistics

Michael Pyrcz and **Didi Ooi**

@geostatsguy and @didiooi

Lecture (and Course) Outline

The agenda of the day…

Outline of this lecture

- Motivation / Goals
- Class Description / Objectives
- Challenges in Geoscience
- Python: A new geoscience toolkit?
- Resources

Class outline

Introduction

Data Analytics

Inferential Methods

Predictive Methods

Advanced Methods

Conclusions

What Will You Learn?

Expectations and hope

Goals:

- Awareness
- Opportunities in Data Science and Machine Learning

Our hope:

- Inspire you to start using new tools
- Impact your capabilities

Who we are? Michael Pyrcz

Pyrcz: is pronounced "perch"

Spring 2018 Class of Introduction to Geostatistics

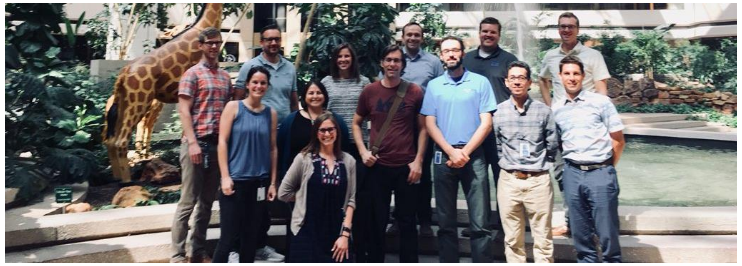
I'm New: new to UT PGE, started August 2017.

1. **I have practical experience**: over 17 years of experience in consulting, teaching and industrial R&D in statistical modeling, reservoir modeling and uncertainty characterization.

2. **Flexible**: got ideas, feedback to improve the learning opportunities. Let's work together to reach our learning objective.

3. **An Engineer, but**: My B.Sc. was Mining Engineering, my M.Sc. started as Geotechnical Engineering (then skipped to Ph.D.) and my Ph.D. was in Quantitative Geology. I spent 13 years in Earth Science R&D working with geological and geophysical reservoir modeling. I speak geo.

Oil and Gas University, Florence, Italy



Anadarko, Midland, TX

Who we are? Michael Pyrcz

Pyrcz: is pronounced "perch"

AAPG SEPM Panel Discussion on Modeling

CPGE Webinar on Big Data

Active in Outreach, Social Media and Professional Organizations

- Associate editor with Computers and Geosciences, editorial board of Mathematical Geosciences for the International Association of Mathematical Geosciences
- Program chair for SPE Data Analytics Technical Section
- Associate editor with Computers and Geosciences
- Author of the textbook "Geostatistical Reservoir Modeling"
- Board member for Mathematical Geosciences
- GeostatsGuy on Twitter, GitHub GeostatsGuy Lectures on YouTube

I'm committed to supporting / partnering for development opportunities of working professionals

Who we are? Didi Ooi

Ooi: is pronounced "Oo-ee"

Passionate in innovating and hacking reservoir characterization using geology AND emerging technologies!

1. **Practical experience**: over 7 years of research and industrial experience in sedimentology, numerical modeling, water-rock interaction and subsurface data science (hacking!)

2. **A Hybrid Geologist**: Yes, both quantitative and "arm-waving". BSc, PhD in University of Bristol, UK. Carbonate and Evaporites. Areal experience in the Middle East, Greece, SE Asia, UK. Worked with Shell and ExxonMobil. Now, emerging Technology Geologist with AAET, Anadarko (and loving it!)

Who we are? Didi Ooi

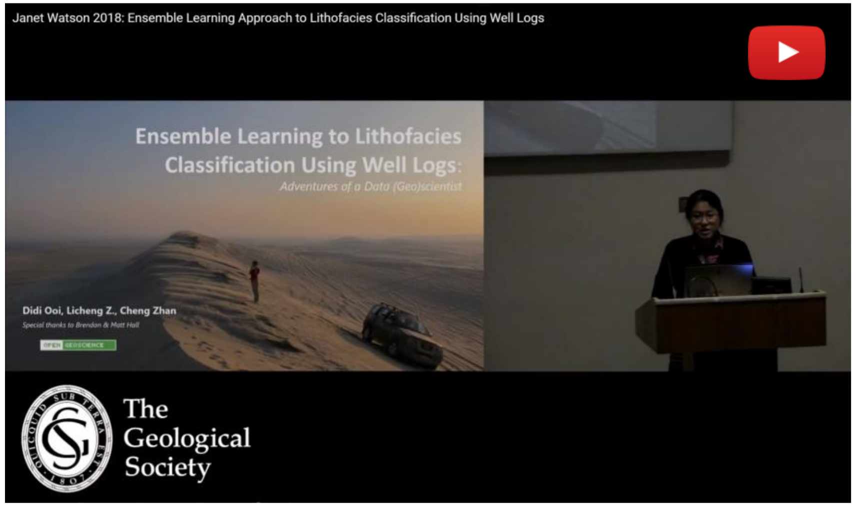
Ooi: is pronounced "Oo-ee"

Passionate in innovating and hacking reservoir characterization using geology AND emerging technologies!

3. **Outreach:** SEPM ISGC Scientific Advisor, Chair of AAPG ML Unsession, Houston ML Meetup Co-Organizer

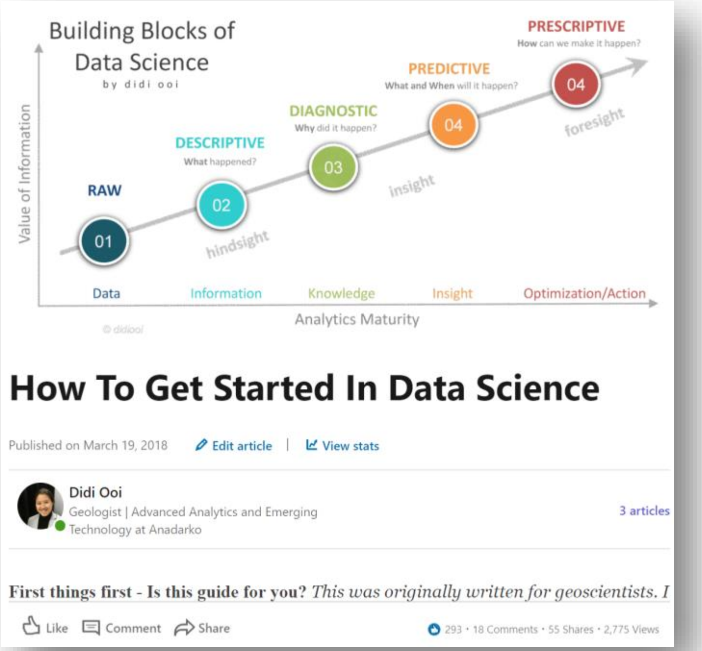
4. **Data Science started as my hobby:** 3 times winner in subsurface hackathons, projects in github.com/didiooi

Lead Instructor in Bristol for grad students



Big Data in Geoscience Conference, UK

Geophysics Hackathon 2017, 2018 winner



The article that inspired outreach

Introduction

Your turn to tell us about you and your expectations

Short Introductions

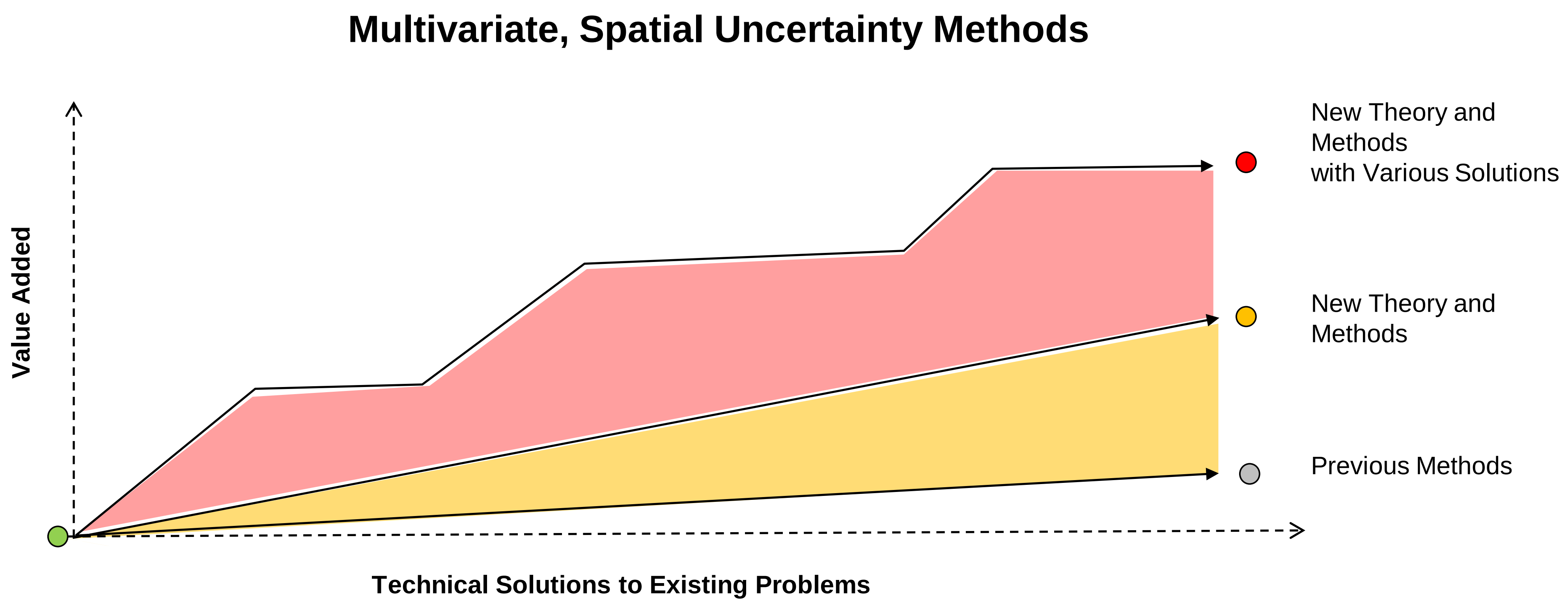
- **Name**
- **Role**
- **Expectations from this course**

What Will You Learn?

Theory, methods and solutions

This time is an investment in learning

- Build operational capability
- Provide incremental value.



What Will You Learn

Reaching our goals

Today we will:

- Build up from zero
- Provide an overview of the methods
- Demonstrate well-documented, practical workflows

Of course, full workflow development would require time to investigate the problem and available data.

p/s: Michael Pyrcz has a lot of content for more advanced topics!

“If I haved erred it is on the side of simplicity.”

Data Science Matrix (Simplified)

What do I want to find out?

	Supervised Learning	*Unsupervised Learning*
Discrete	I want to predict **categories**	I want to discover **structure**
Continuous	I want to predict **values**	I want my dataset **decluttered**

Data Science Matrix (Simplified)

What techniques do I use?

	Supervised Learning	*Unsupervised Learning*
Discrete	**CLASSIFICATION**	**CLUSTERING**
Continuous	**REGRESSION**	**DIMENSIONALITY REDUCTION**

**Does not include domain-specific adaptations such as NLP and CV*

Data Science Matrix (Simplified)

What algorithms are there for me?

	Supervised Learning	*Unsupervised Learning*
Discrete	Logistic Regression Classification Tree Support Vector Machine Naïve Bayes	K-Means Affinity Propagation Hierarchical/Agglomerative DBSCAN
Continuous	Linear Regression Decision Tree (Ensembles) Poisson	Principal Component (PCA) Linear Discriminant (LDA) IsoMap Truncated SVD t-SNE Autoencoders

Reinforcement Learning

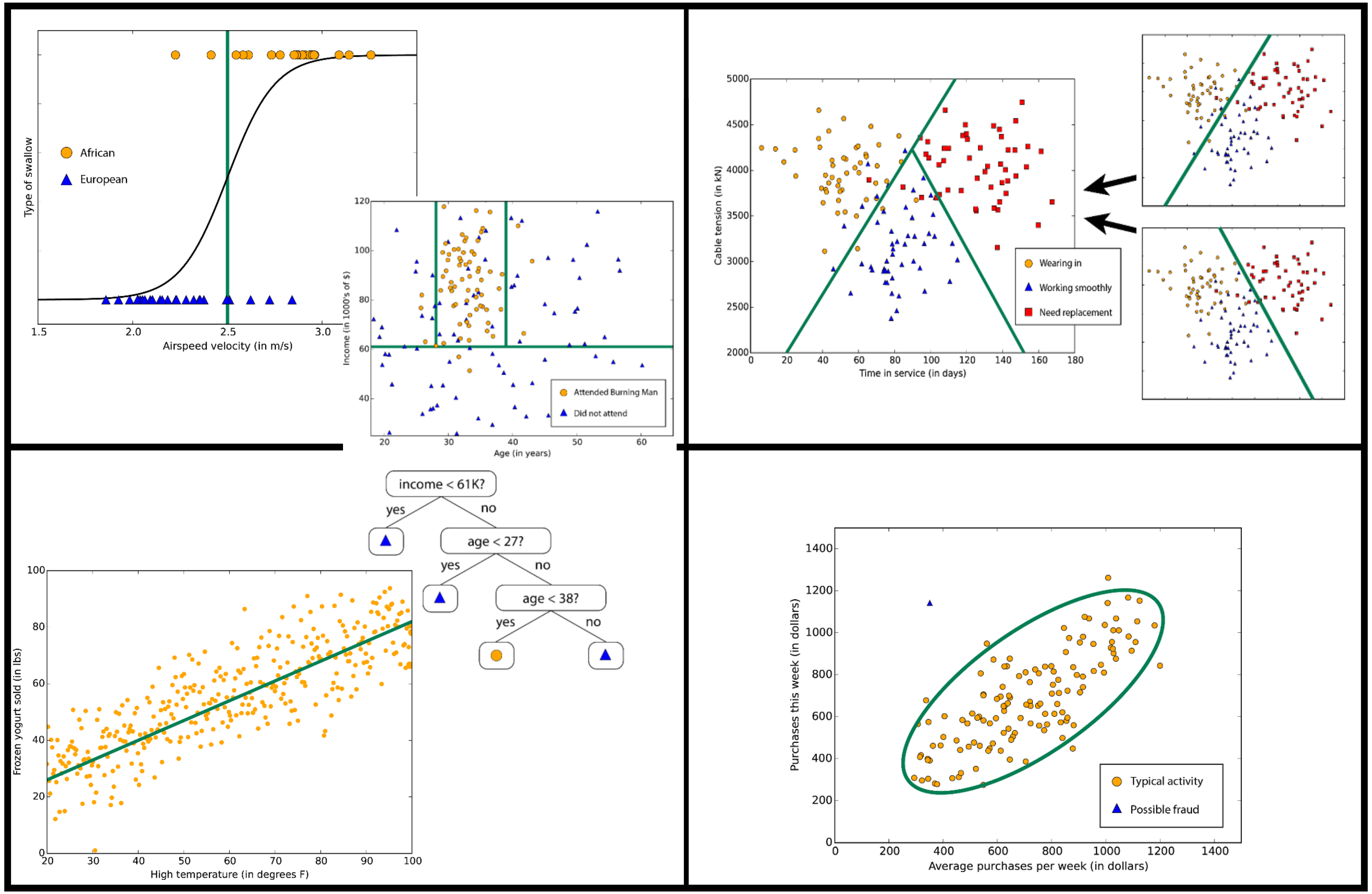
Data Science Matrix (Simplified)

Algorithms

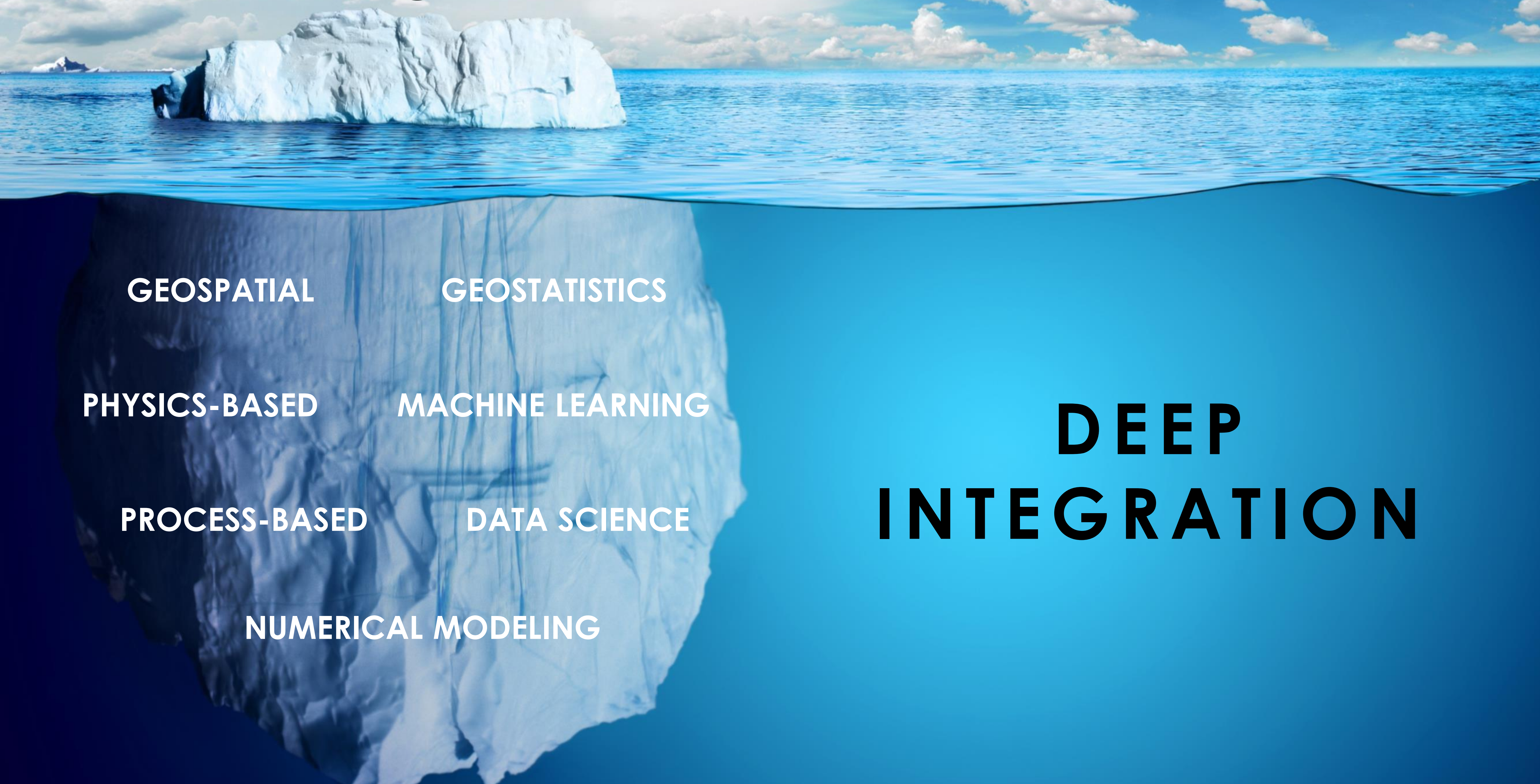
Supervised Learning | Unsupervised Learning

Discrete

Continuous



The new geoscience toolkit?



Data in oil and gas

1. Measured (raw)
2. Observed (raw)
3. Processed and Corrected
4. Interpretations
5. Models from Interpretations
6. Predictions from models

Challenges in Geoscience

Schematic Diagram

1. Primary vs Secondary
2. Multi-scale
3. Multi-resolution
4. Spatio-temporal
5. Curse of Dimensionality
6. Heterogeneity
7. Noise vs Signal
8. Uncertainty
9. Sampling bias
10. Lack of Ground Truth

Python: The new geoscientist toolkit

Why Python language?

- Is very powerful, the most resources and assistance
- Packages allow us to put together workflows with limited old-fashioned ‘coding’
- Leverage the world’s brilliance
- Can help automate workflows in O&G softwares! ArcGIS, IP, Techlog,

Certainly there’s a phenomenon around open source. You know free software will be a vibrant area. ‘There will be a lot of neat things that get done there.’

- Bill Gates

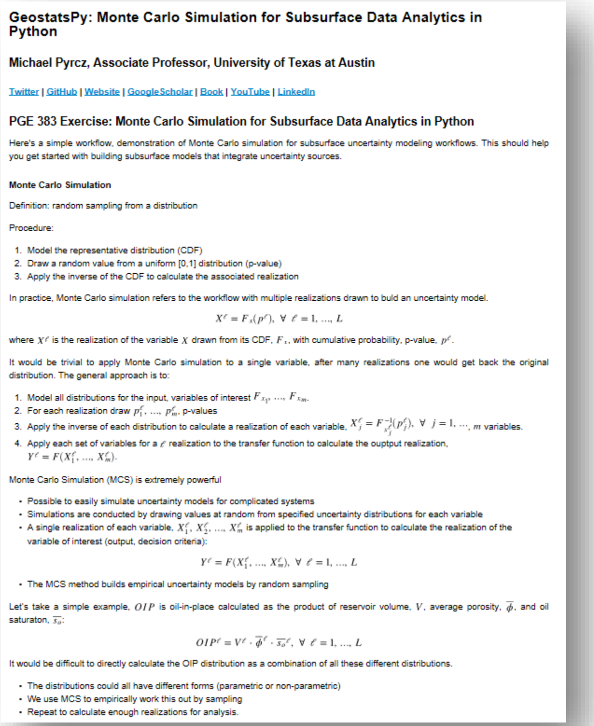
‘20 years with C++ and FORTRAN, but with Python I code less, but get more done.’

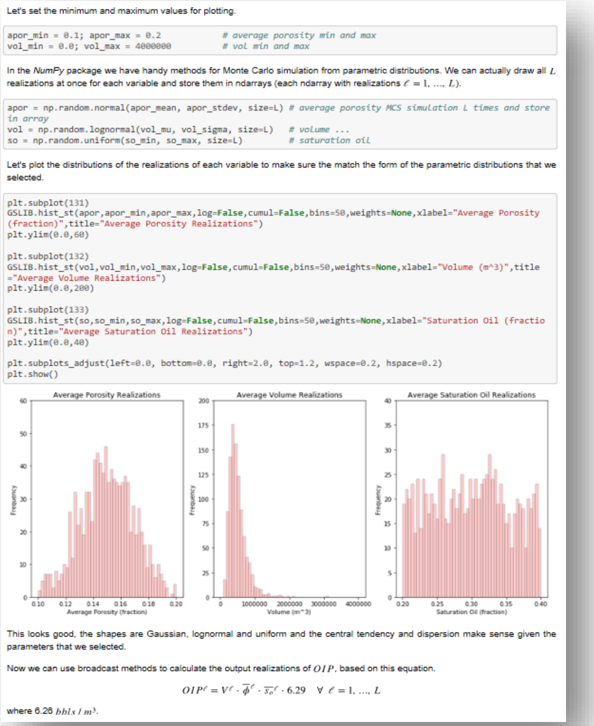
- Michael Pyrcz

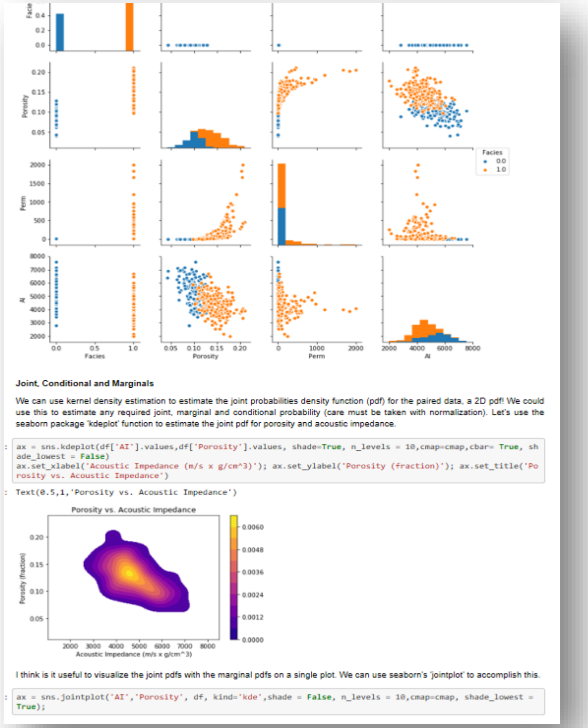
Python: The new geoscientist toolkit

Jupyter Notebooks

- Workflows that integrate blocks of code, documentation, results







- Work with a variety of kernels (Python, R, C, JavaScript, etc.)
- Make and deploy professional workflows with Markdown docs
- Use containers and run online (e.g. Docker)

Python: The new geoscientist toolkit

Useful Python libraries

Geostatspy

- Set of Python functions for most of the required workflow steps
- Much is reimplemented in Python
- Package written by Michael Pyrcz - we will tailor, augment to support training
- Open-source: anyone can use it
- Free for any use
- Download it from PyPi with:

'pip install geostatspy'

Others: scikit-learn, pyclustering

Project description

GeostatsPy Package

The GeostatsPy Package brings GSLIB: Geostatistical Library (Deutsch and Journel, 1998) functions to Python. GSLIB is extrememly robust and practical code for building spatial modeling workflows. I specifically wanted it in Python to support my students in my **Data Analytics, Geostatistics** and **Machine Learning** courses. I find my students benefit from hands-on opportunities, infact it is hard to imagine teaching these topics without providing the opportunity to handle the numerical methods and build workflows.

This package includes 2 parts:

1. geostatspy.gslib includes low tech wrappers of GSLIB functionality (note: some functions require access to GSLIB executables)
2. geostatspy.geostats includes GSLIB functions rewritten in Python.

Package Inventory

Here's a list and some details on each of the functions available.

geostatspy.gslib Functions

Utilities to support moving between Python DataFrames and ndarrays, and Data Tables, Gridded Data and Models in Geo-EAS file format (standard to GSLIB):

1. **ndarray2GSLIB** - utility to convert 1D or 2D numpy ndarray to a GSLIB Geo-EAS file for use with GSLIB methods
2. **GSLIB2ndarray** - utility to convert GSLIB Geo-EAS files to a 1D or 2D numpy ndarray for use with Python methods

Python: The new geoscientist toolkit

Reasons to learn some coding

- **Transparency** – *no compiler accepts hand-waving!* Coding forces your logic to be uncovered for any other scientist or engineer to review.
- **Reproducibility** – *run it, get an answer, hand it over, run it, get the same answer.* This is a main principle of the scientific method.
- **Quantification** – *programs need numbers.* Feed the program and discover new ways to look at the world.
- **Open-source** – *leverage a world of brilliance.* Check out packages, snippets and be amazed with what great minds have freely shared.
- **Break Down Barriers** – *don't throw it over the fence*. Sit at the table with the developers and share more of your subject matter expertise for a better product.
- **Deployment** – *share it with others and multiply the impact*. Performance metrics or altruism, your good work benefits many others.
- **Efficiency** – *minimize the boring parts of the job*. Build a suite of scripts for automation of common tasks and spend more time doing science and engineering!
- **Always Time to Do it Again!** – *how many times did you only do it once?* It probably takes 2-4 times as long to script and automate a workflow. Usually worth it.
- **Be Like Us** – *it will change you*. Users feel limited, programmers truly harness the power of their applications and hardware.

Python: The new geoscientist toolkit

More on coding…

This is not a coding / software workshop

- We cannot teach Python in 1 day!
- Michael Pyrcz has partnered with tech company to provide data analytics and coding training for oil and gas professionals

https://daytum.org/

Expectations:

- Appreciation for what can be done
- We will show some code Michael has prepared to highlight how easy it is to get things done

Python: The new geoscientist toolkit

Caveats to previous reasons for coding

1. Any type of coding, scripting, workflow automation matched to your working environment is great. We don't all need to be C++ experts.

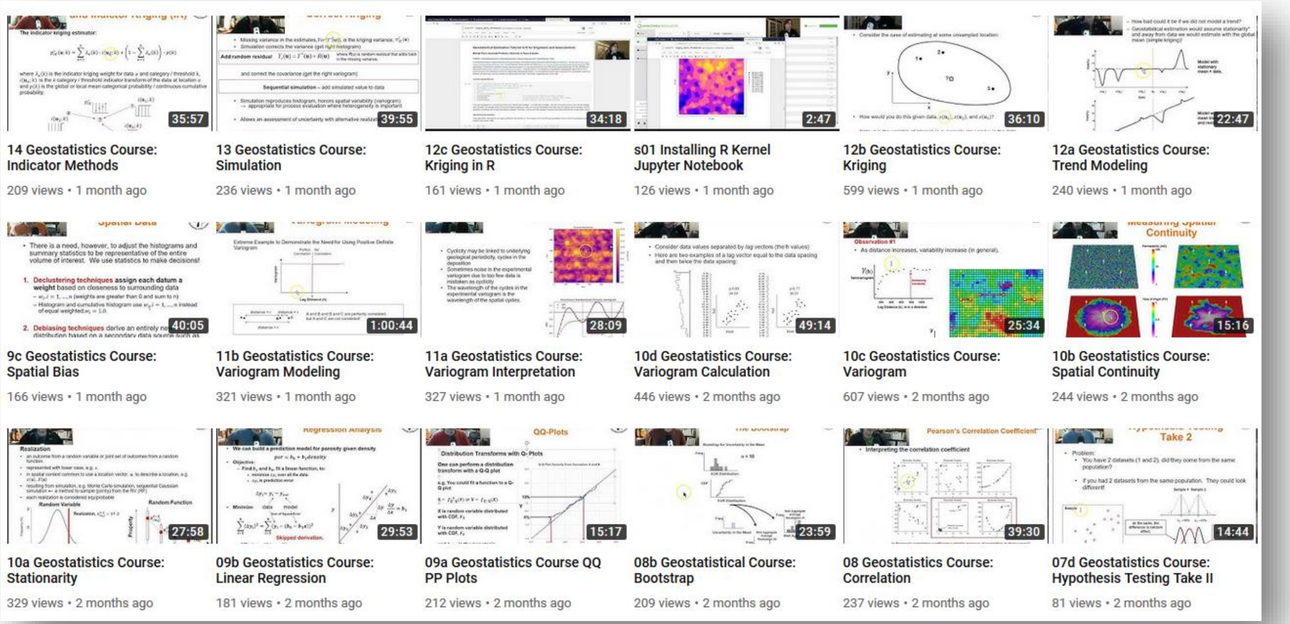
2. I respect the experience component of geoscience and engineering expertise. This is beyond coding and is essential to workflow logic development, best use of data etc.

3. Some expert judgement will remain subjective and not completely reproducible. I'm not advocating for the geoscientist or engineer being replaced by a computer.

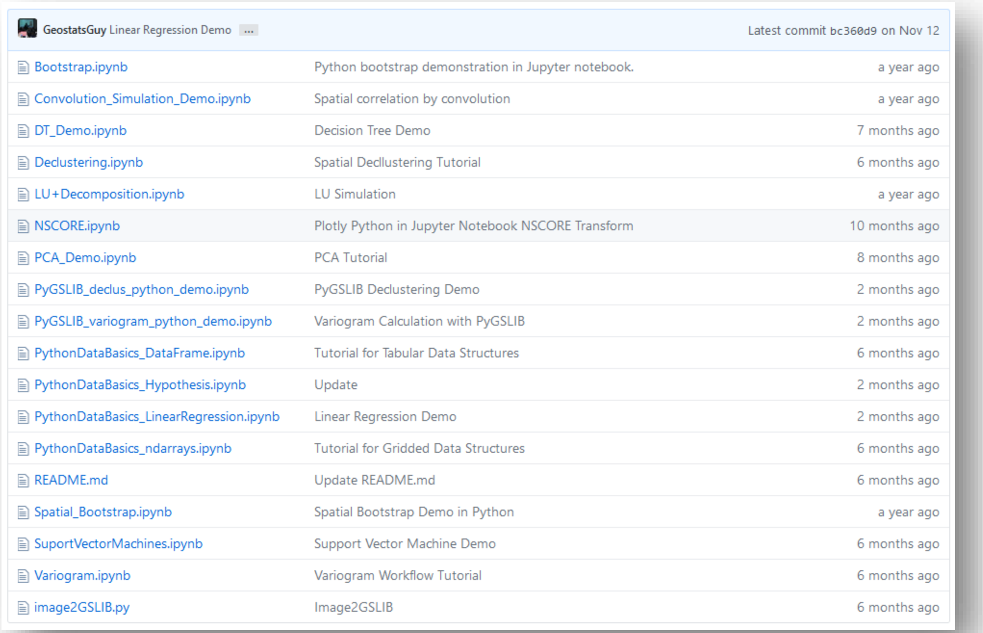
Resources outside this (very) short course

during and after workshop

1. Lecture material in .pdf format.
2. All lectures, demos and workflows from the Michael Pyrcz's undergraduate class are available to you (YouTube and GitHub)
3. Michael Pyrcz is always happy to discuss! ☺



GeostatsGuy Lectures Channel on YouTube



GeostatsGuy Repositories on GitHub

Now let’s BEGIN…

Are you excited?

Introduction

Definitions
Prerequisites

Data Analytics

Probability
Spatial Bias
Uncertainty
Spatial

Inferential Methods

PCA
Clustering

Predictive Methods

Decision Tree
Support Vector Machines
Neural Nets

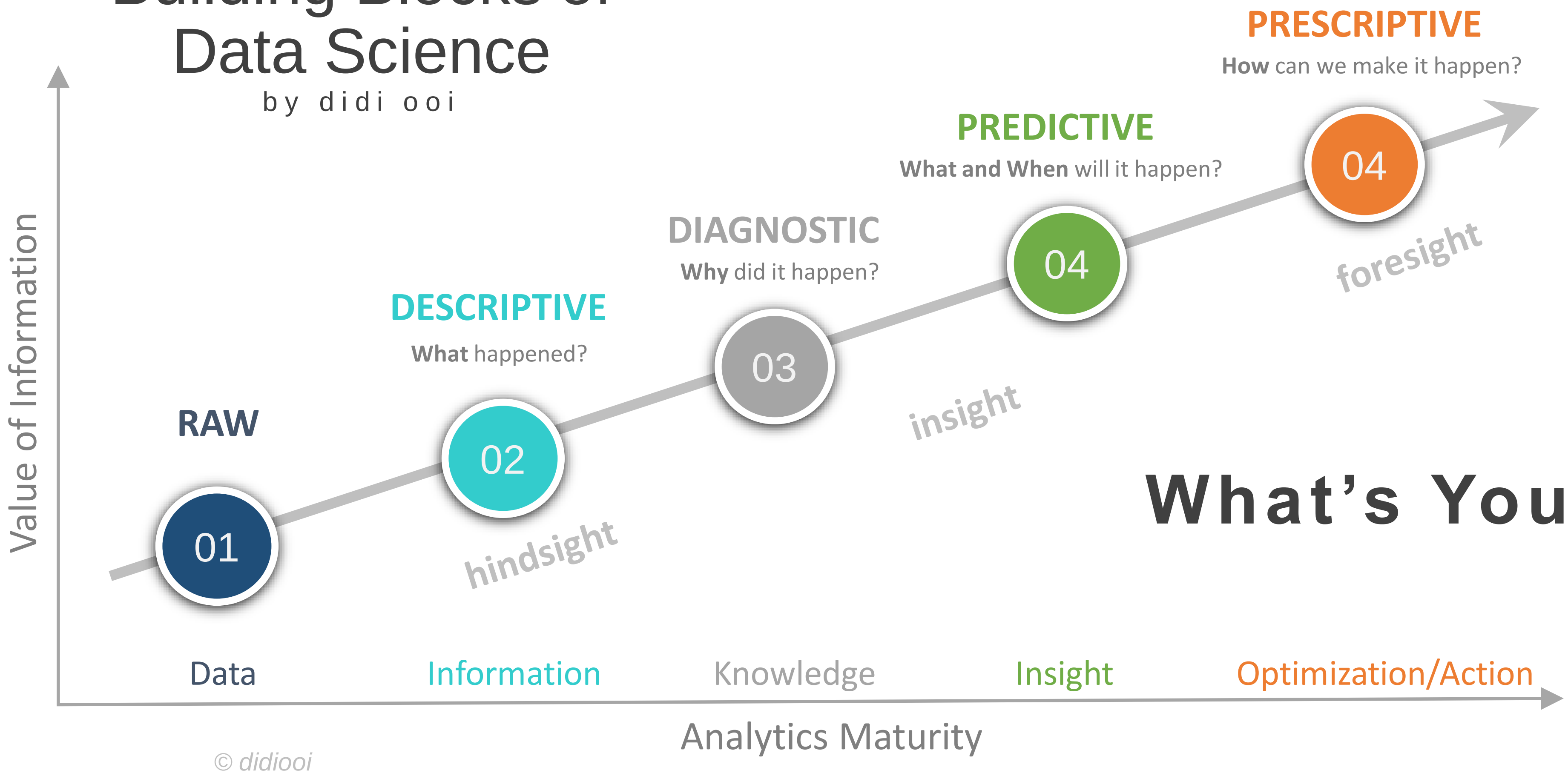
Advanced Methods

Convolutional Neural Nets
Recurrent Neural Nets

Conclusions

Building Blocks of Data Science

by didi ooi



What's Your Goal?

Data Science

- Data Source
- Data Format
- Data Visualization
- Data Preparation
- Data Training

Data Discovery
& Visualization

Data Wrangling

Predictive
Analytics

Spatial
Analytics