Data Science With Python

Mosky

Data Science

- = Extract knowledge or insights from data.
- Data science includes:
  - Visualization.
  - Statistics.
  - Machine learning.
  - Deep learning.
  - Big data.
  - And their related methods.
- ≈ Data mining.

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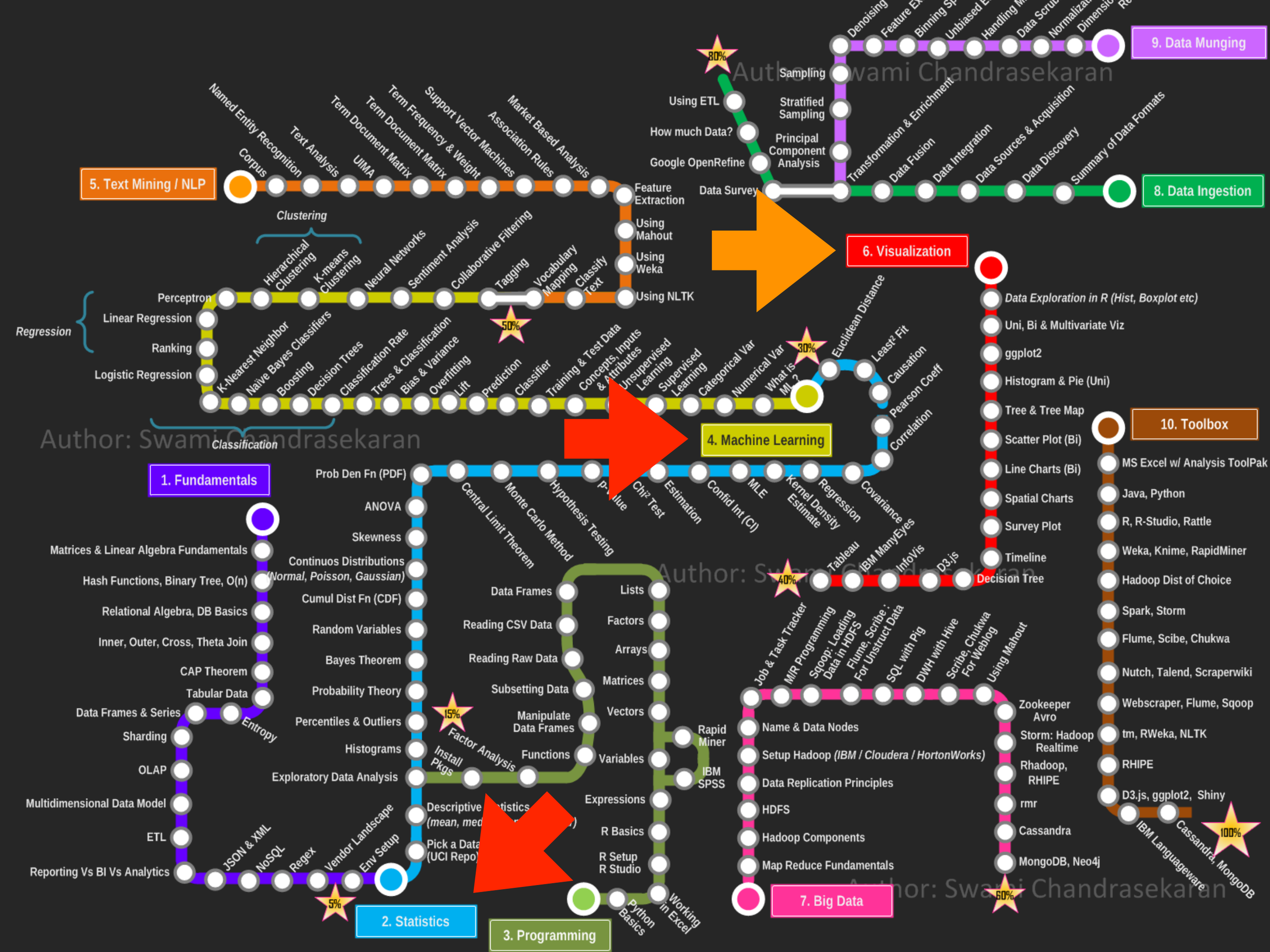
We will introduce.

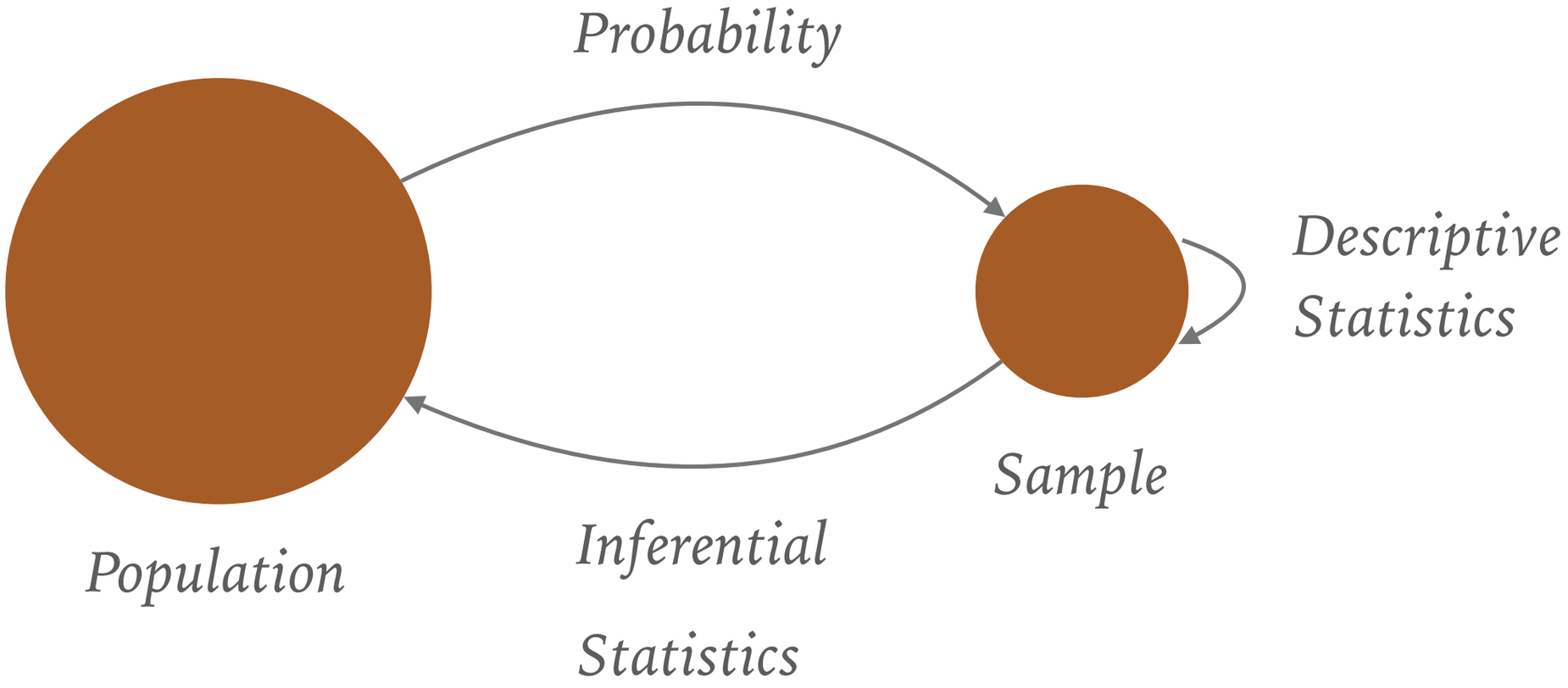

Author: Swami Chandrasekaran
1. Fundamentals
Matrices & Linear Algebra Fundamentals
Hash Functions, Binary Tree, O(n)
Relational Algebra, DB Basics
Inner, Outer, Cross, Theta Join
CAP Theorem
Tabular Data
Data Frames & Series
Entropy
Sharding
OLAP
Multidimensional Data Model
ETL
Reporting Vs BI Vs Analytics
JSON & XML
NoSQL
Regex
Vendor Landscape
Env Setup
5%
2. Statistics
Prob Den Fn (PDF)
ANOVA
Skewness
Continuos Distributions
(Normal, Poisson, Gaussian)
Cumul Dist Fn (CDF)
Random Variables
Bayes Theorem
Probability Theory
Percentiles & Outliers
Histograms
Exploratory Data Analysis
Central Limit Theorem
Monte Carlo Method
Hypothesis Testing
p-value
Chi² Test
Estimation
Confid Int (CI)
MLE
Kernel Density Estimate
Regression
Covariance & Correlation
Causation
Pearson Coeff
Least² Fit
Euclidean Distance
4. Machine Learning
What is ML ?
30%
Categorical Var
Numerical Var
Supervised Learning
Unsupervised Learning
Concepts, Inputs & Attributes
Training & Test Data
Classifier
Prediction
Lift
Overfitting
Bias & Variance
Trees & Classification
Classification Rate
Decision Trees
Boosting
Naive Bayes Classifiers
K-Nearest Neighbor
Regression
Linear Regression
Ranking
Logistic Regression
Classification
Perceptron
Hierarchical Clustering
K-means Clustering
Clustering
Neural Networks
Sentiment Analysis
Collaborative Filtering
Tagging
Vocabulary Mapping
Classify Text
50%
Using NLTK
Using Weka
Using Mahout
Feature Extraction
Named Entity Recognition
Text Analysis
UIMA
Term Document Matrix
Term Document Matrix
Term Frequency & Weight
Support Vector Machines
Association Rules
Market Based Analysis
Corpus
5. Text Mining / NLP
Data Survey
Google OpenRefine
How much Data?
Using ETL
Principal Component Analysis
Stratified Sampling
Sampling
80%
Summary of Data Formats
Data Discovery
Data Sources & Acquisition
Data Integration
Data Fusion
Transformation & Enrichment
8. Data Ingestion
Reduction
Dimensionality
Normalization
Data Scrubbing
Handling Missing Data
Unbiased Estimators
Binning Sparse Data
Feature Extraction
Denoising
9. Data Munging
6. Visualization
Data Exploration in R (Hist, Boxplot etc)
Uni, Bi & Multivariate Viz
ggplot2
Histogram & Pie (Uni)
Tree & Tree Map
Scatter Plot (Bi)
Line Charts (Bi)
Spatial Charts
Survey Plot
Timeline
Decision Tree
D3.js
InfoVis
IBM ManyEyes
Tableau
40%
10. Toolbox
MS Excel w/ Analysis ToolPak
Java, Python
R, R-Studio, Rattle
Weka, Knime, RapidMiner
Hadoop Dist of Choice
Spark, Storm
Flume, Scibe, Chukwa
Nutch, Talend, Scraperwiki
Webscraper, Flume, Sqoop
tm, RWeka, NLTK
RHIPE
D3.js, ggplot2, Shiny
IBM Languageware
Cassandra, MongoDB
100%
7. Big Data
Name & Data Nodes
Setup Hadoop (IBM / Cloudera / HortonWorks)
Data Replication Principles
HDFS
Hadoop Components
Map Reduce Fundamentals
Job & Task Tracker
MR Programming
Sqoop: Loading Data in HDFS
Flume, Scribe : For Unstruct Data
SQL with Pig
DWH with Hive
Scribe, Chukwa For Weblog
Using Mahout
Zookeeper Avro
Storm: Hadoop Realtime
Rhadoop, RHIPE
rmr
Cassandra
MongoDB, Neo4j
60%
3. Programming
Data Frames
Reading CSV Data
Reading Raw Data
Subsetting Data
Manipulate Data Frames
Functions
Factor Analysis
15%
Install Pkgs
Lists
Factors
Arrays
Matrices
Vectors
Variables
Expressions
R Basics
R Setup
R Studio
Rapid Miner
IBM SPSS
Python Basics
Working in Excel

- MrMimic/data-scientist-roadmap – GitHub
- Becoming a Data Scientist – Curriculum via Metromap

Statistics vs. Machine Learning

- Machine learning = statistics - checking of assumptions 😆
- But does resolve more problems. 👍🏻
- Statistics constructs more solid inferences.
- Machine learning is more result-oriented.

Probability, Descriptive Statistics, and Inferential Statistics



Machine Learning vs. Deep Learning

- Deep learning is a renowned part of machine learning. 🔥
  - ∵ AlphaGo.
- Deep learning uses artificial neural networks (NNs).
- Which are especially good at:
  - Computer vision.
  - Speech recognition.
  - Natural language processing (NLP).
  - Machine translation.

Big Data

- The “size” is constantly moving.
  - As of 2012, ranges from 10n TB to n PB, which is 100x.
- Has high-3Vs:
  - Volume, amount of data.
  - Velocity, speed of data in and out.
  - Variety, range of data types and sources.
- A practical definition:
  - A single computer can't process in a reasonable time.
  - Distributed computing is a *big* deal.

Today,

- “Models” are the math models.
- “Statistical models” emphasize inferences.
- “Machine learning models” are the result-oriented models.
- Deep learning and big data are gigantic subfields.
- We won't introduce.
- But the learning resources are listed at the end.

Mosky

- Python Charmer at Pinkoi.
- Has spoken at
  - PyCons in
    TW, MY, KR, JP, SG, HK,
    COSCUPs, and TEDx, etc.
- Countless hours
  on teaching Python.
- Own the Python packages:
  - ZIPCodeTW,
    MoSQL, Clime, etc.
- http://mosky.tw/

The Outline

- The Learning Flow
- The Analysis Steps
- “Data”
- Visualization
- Preprocessing
- Dimensionality Reduction
- Statistical Models
- Machine Learning Models

The Packages

- `$ pip3 install jupyter numpy scipy sympy matplotlib ipython pandas seaborn statsmodels scikit-learn`
- Or
- `> conda install jupyter numpy scipy sympy matplotlib ipython pandas seaborn statsmodels scikit-learn`

Common Jupyter Notebook Shortcuts

`Ctrl-Enter`	Run the cell.
`B`	Insert cell below.
`D, D`	Delete the current cell.
`M`	To Markdown cell.
`Cmd-/`	Comment the code.
`Esc`	Edit mode → command mode.
`H`	Show keyboard shortcuts.
`P`	Open the command palette.

Checkpoint: The Packages

- Open *00_preface_the_packages.ipynb* up.
- Run it.

The Learning Flow

The Facts

- ∵
  - You can't learn *all* things in the data science!
- ∴
  - “Let's do something after learning all things” ❌
  - “Let's do something *while learning*.” ✅

The Four Steps

1. Ask a question.
   - ➤ “How to tell the differences confidently?”
2. Identify the topic.
   - ➤ “Hypothesis testing.”
3. Explore the references of the topic
   - ➤ “T-test, ANOVA, ...”
4. Digest the references by the breadth-first way.
   - ➤ Write the code.
   - ➤ Make it work, make it right, finally make it fast.

The Analysis Steps

The Major Two Steps

1. Define the problem.
2. Resolve the problem.

1. Define the Problem

- Discuss the *feasible* goal.
  - It must come from the understanding of business.
  - Including all the gain and loss like users, resources, etc.
- Write the *exact* problem.
  - Rewrite it in a formal form, e.g.,
    - Statistical hypotheses.
    - Equations.

2. Resolve the Problem

- Collect the data.
- List the candidate methods.
  - Selecting Statistical Tests – Bates College
  - Choosing a statistical test – HBS
  - Choosing the right estimator – Scikit-Learn
  - A method also can be a simple median or a combination.
- Evaluate the candidate methods.
  - Understand the data by visualizing and *asking*.
  - Check the *assumptions* and the *metrics*.

- The best method achieves the goal?
  - Yes → Congrats! 🎉
  - No → Check:
    - Method; note the assumptions.
    - Data; note the confounding variables, the correlations.
    - Problem; note the formalization.
    - Goal; it may be unachievable.

Industry Changes Rapidly

- Need a fast iteration.
  - Resolve the small problems first.
  - Resolve the high C/P problems first.
  - One week to get a quick result and improve rather than one year to get the best result.
- Fail fast!

Checkpoint: Pick up a Method

- Think of an interesting problem at work or in life.
  - E.g., revenue is higher, but is it random?
- Pick one or more methods from the cheatsheets.
  - Selecting Statistical Tests – Bates College
  - Choosing a statistical test – HBS
  - Choosing the right estimator – Scikit-Learn
- Remember:
  - The Learning Flow.
  - The Analysis Steps.

"Data"

"Data"

- = Variables.
- = Labels + Features.
  - Features = Dimensions.

Data in Different Types

Categorical	Nominal		{male, female}
	Ordinal	↑ & can be ordered.	{great > good > fair}
Continuous	Interval	↑ & distance is meaningful.	temperatures
	Ratio	↑ & 0 is meaningful.	weights

Data in the X–Y Form

y	x
label	features
dependent variable	independent variables
response variable	explanatory variables
regressand	regressors
endogenous | endog	exogenous | exog
outcome	design

- Confounding variables:
  - May affect y, but not x.
  - May lead erroneous conclusions.
    - Controlling, e.g., fix the environment.
    - Randomizing, e.g, choose by computer.
    - Matching, e.g., drug-vs-placebo, before-and-after.
    - Statistical control, e.g., BMI rather than height.
    - Double-blind, even triple-blind trials.

Get the Data

- Logging.
- Experiments.
  - Strongly recommend Research Methods Knowledge Base.
- The existent dataset:
  - Kaggle
  - The Datasets Package – StatsModels

Visualization

Visualization

- Make Data Colorful – Plotting
  - *01_1_visualization_plotting.ipynb*
- In a Statistical Way – Descriptive Statistics
  - *01_2_visualization_descriptive_statistics.ipynb*

Checkpoint: Plot the Variables

- We have three datasets.
- Star98
  - `star98_df = sm.datasets.star98.load_pandas().data`
- Fair
  - `fair_df = sm.datasets.fair.load_pandas().data`
- Howell1
  - ```
    howell1_df = pd.read_csv(
        'dataset_howell1.csv', sep=';')
    ```
- Or your own datasets.
- Plot the variables that interest you among them.
    ```

Preprocessing

Feed the Data That Models Like

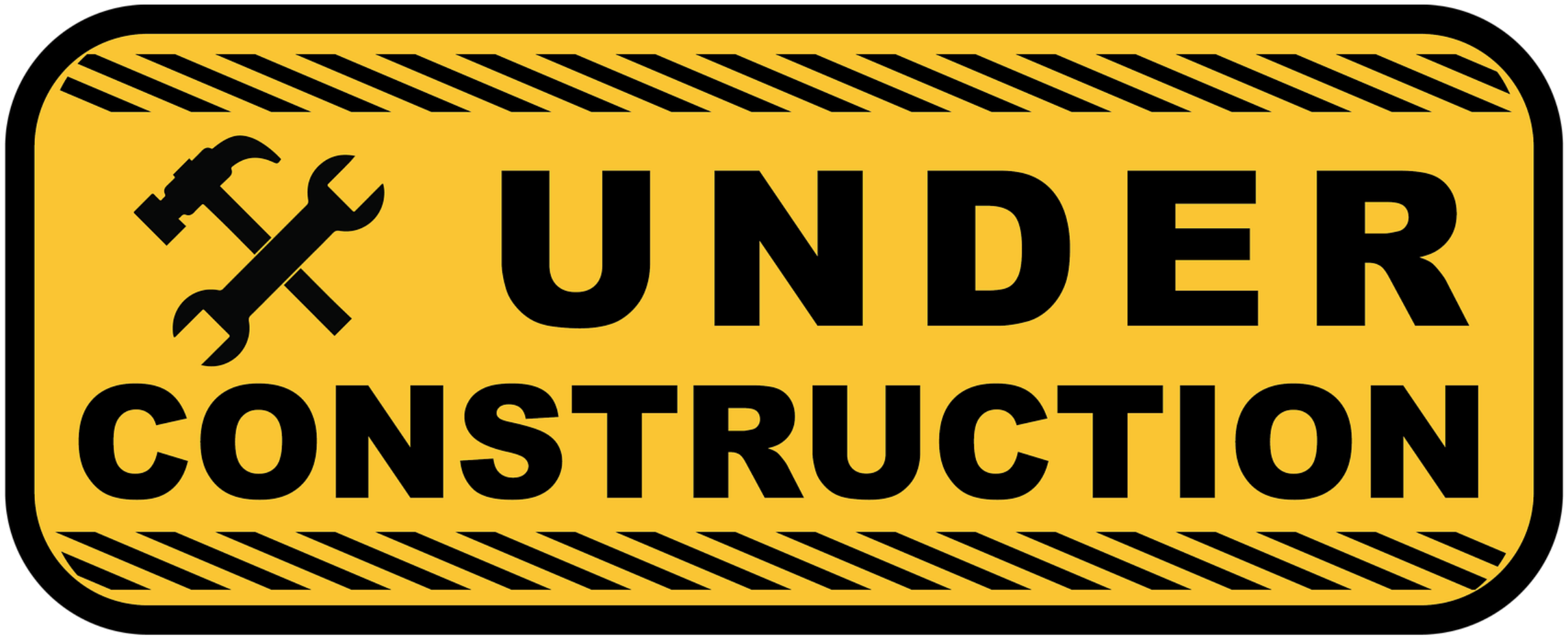
- Preprocess data for:
  - Hard requirements, e.g., corpus → vectors.
  - Assumptions, e.g.,
    - Samples are normally distributed.
    - Assuming features are centered around zero.
  - More representative features, e.g., total / units.
- Note that different models have different tastes.

Preprocessing

- The Dishes – Containers
  - *02_1_preprocessing_containers.ipynb*
- A Cooking Method – Standardization
  - *02_2_preprocessing_standardization.ipynb*
- Watch Out for Poisonous Data Points – Removing Outliners
  - *02_3_preprocessing_removing_outliners.ipynb*

Checkpoint: Preprocess the Variables

- You already have the variables that interest you, right?
- Try to standardize them.
- Try to remove the outliners.


UNDER
CONSTRUCTION

Dimensionality Reduction

The Model Sicks Up!

- Let's reduce the variables.
- Feed a subset → feature selection.
  - Feature Selection – Scikit-Learn
- Feed a transformation → feature extraction.
  - PCA, FA, etc.
  - Scikit-Learn defines it like non-numbers → numbers.

Dimensionality Reduction

- Principal Component Analysis
- Factor Analysis
  - *03_dimensionality_reduction.ipynb*

Checkpoint: Reduce the Variables

- You must have a dataset that you are most interested in.
- Try to *PCA (all variables) → the better components*, or FA.
- And then plot n-dimensional data onto 2-dimensional plane.

Statistical Models

Statistical Models

- Identify Boring or Interesting – Hypothesis Testings
- Identify X-Y Relationships – Regression
- Identify Differences Among Groups – ANOVA
  - *04_1_statistical_models_t_test.ipynb*
  - *04_2_statistical_models_reg_anova.ipynb*

Checkpoint: Apply a Statistical Method

- Understand the dataset more.
- Ask a question.
- Answer by the above methods.
- Try to apply the analysis steps.

Machine Learning Models

Machine Learning Models

- Apple or Orange? – Classification
- Without Labels – Clustering
- Predict the Values – Regression
- Who Are the Best? – Model Selection

- *05_1_machine_learning_models.ipynb*

Checkpoint: Apply a Machine Learning Method

- Understand the dataset more.
- Ask a question.
- Answer by the above methods.
- Try to apply the analysis steps.

Keep Learning

Keep Learning

- Statistics
  - Biological Statistics
  - scipy.stats + StatsModels
  - Research Methods
- Machine Learning
  - Scikit-learn Tutorials
  - Standford CS229
  - Hsuan-Tien Lin
- Deep Learning
  - TensorFlow
  - Standford CS231n
  - Standford CS224n
- Big Data
  - Spark
  - HBase
  - Hive
  - AWS