Data Science Fundamentals

Data Science Retreat - 2023

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BA Economics
MSc Sustainable Development

DATA SCIENCE RETREAT®
SINCE 2014

Data Science Bootcamp

pmOne

Data Science
Consultant

Energy Analyst

SQL

Data Scientist

TEMPUS

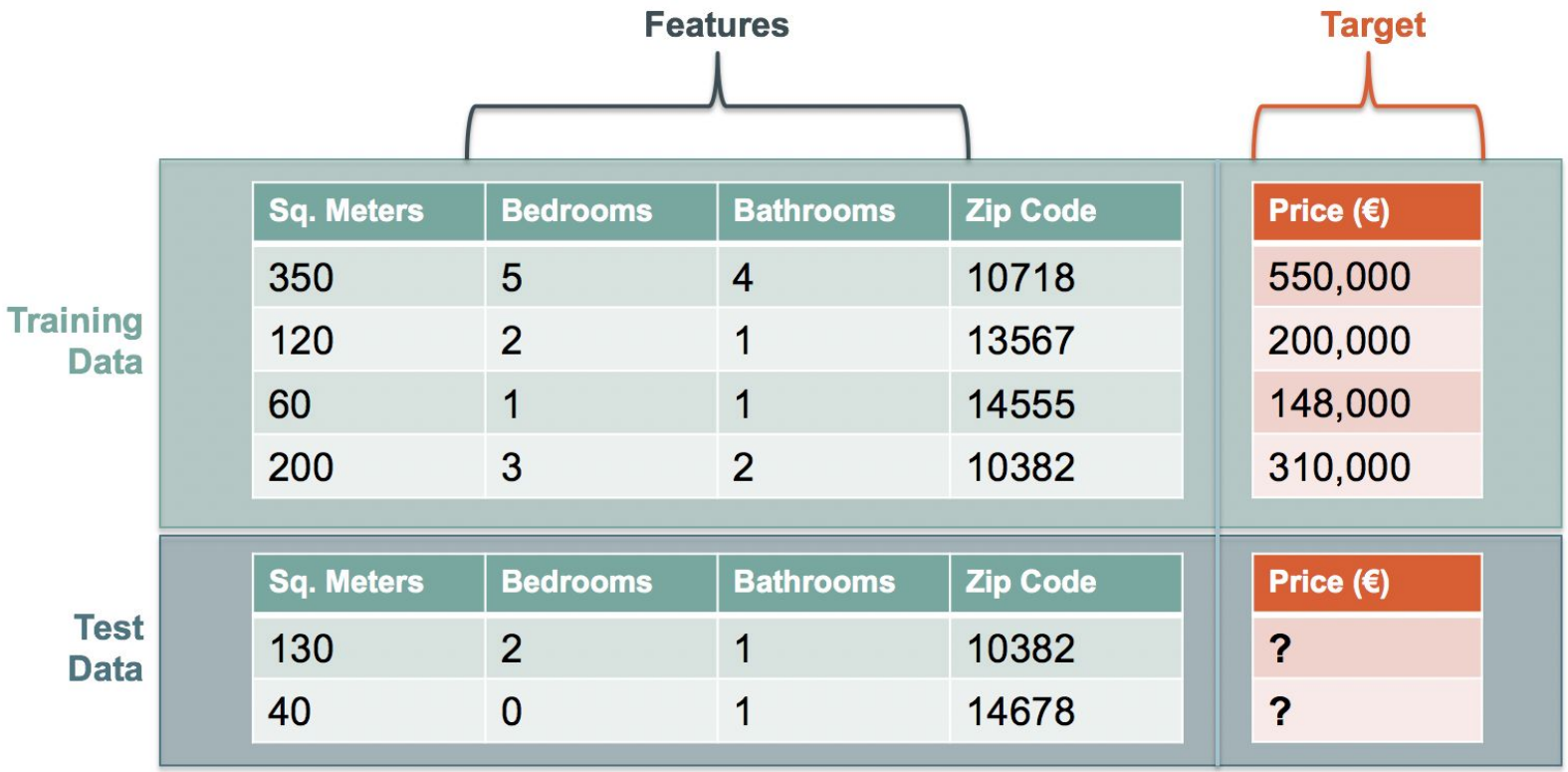
Data Scientist, Deputy Head
of AI CoE

50hertz

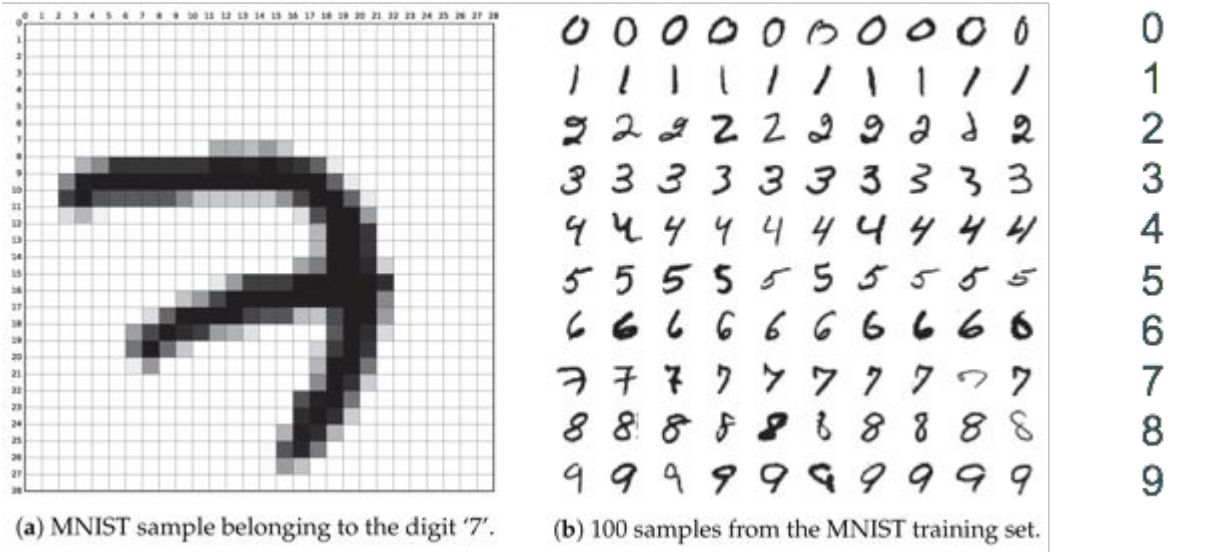
Machine Learning

Machine Learning is an application of artificial intelligence where a computer/machine learns from the past experiences (input data) and makes future predictions.

Example dataset

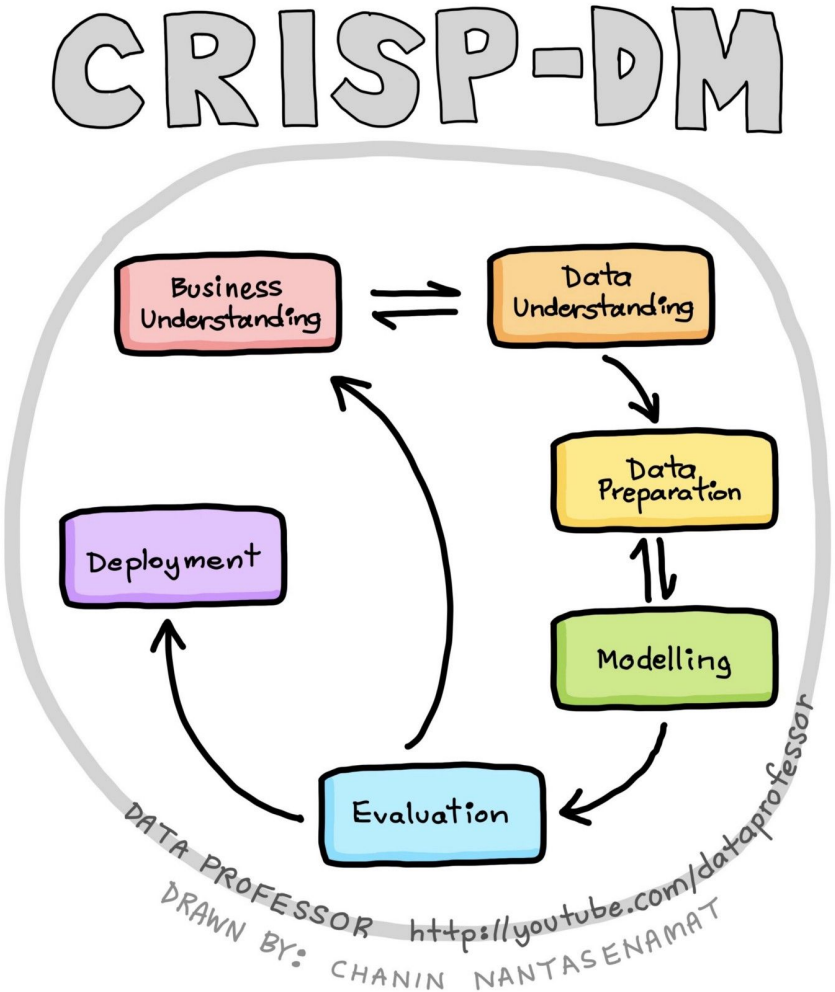


Example dataset



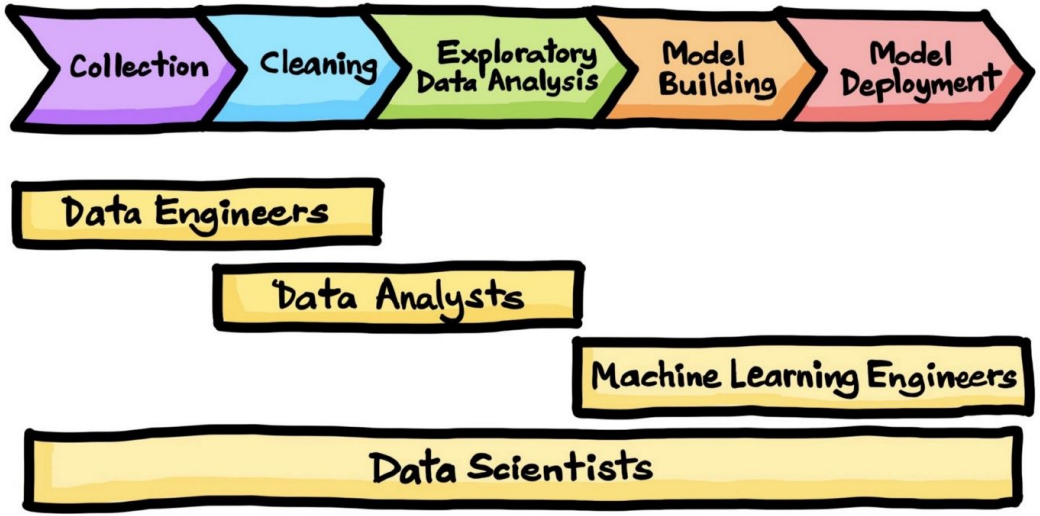
(a) MNIST sample belonging to the digit '7'.

(b) 100 samples from the MNIST training set.



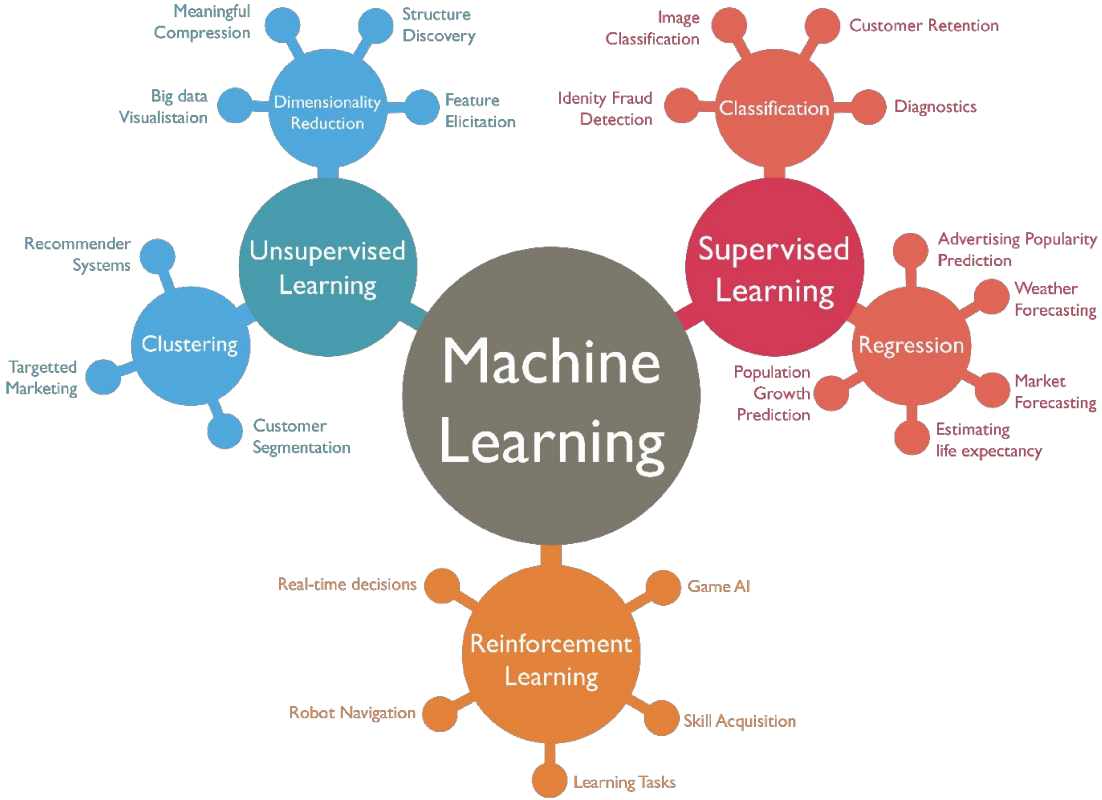
Source:
https://towardsdatascience.com/the-data-science-process-a19eb7ebc41b

THE DATA SCIENCE PROCESS




DATA SCIENCE LANDSCAPE
Software Engineering
Parallel Computing
Optimize Code
Software Development Best Practices
Tidy Code
Data Structure
Model Deployment
Web Development
Data Pre-processing
Handling Missing Data
Data Cleaning
Feature Engineering
Obtaining Data
Feature Selection
Mathematics
Discrete Mathematics
Matrices
Linear Algebra
Optimization
Probability Theory
Geometry
Calculus
Real analysis
Statistics
Inferential Statistics
Hypothesis Testing
Experimental Design
Descriptive Statistics
Programming
Scala
Julia
C/C++
SQL
Spark
Hadoop
R
Python
Bash
Java
Data Visualization
Exploratory Data Analysis
Types
Comparison
Composition
Relationship
Distribution
Machine Learning
Back-Propagation
GAN
Deep Learning
CNN
Neural Network
Support Vector Machine
Random Forest
Trees
XG Boost
Decision Trees
Algorithm
Classification
Regression
Supervised Learning
Principal Component Analysis
K-means
Clustering
Unsupervised Learning
Soft Skills
Lifetime Learning
Writing
Curiosity
Storytelling
Problem Solving
Presentation
Domain Knowledge
Grit
Creativity
Communication
Critical Thinking
BY: CHANIN NANTASENAMAT
DATA PROFESSOR
http://youtube.com/dataprofessor
FEBRUARY 14, 2020

0. Framing the Problem



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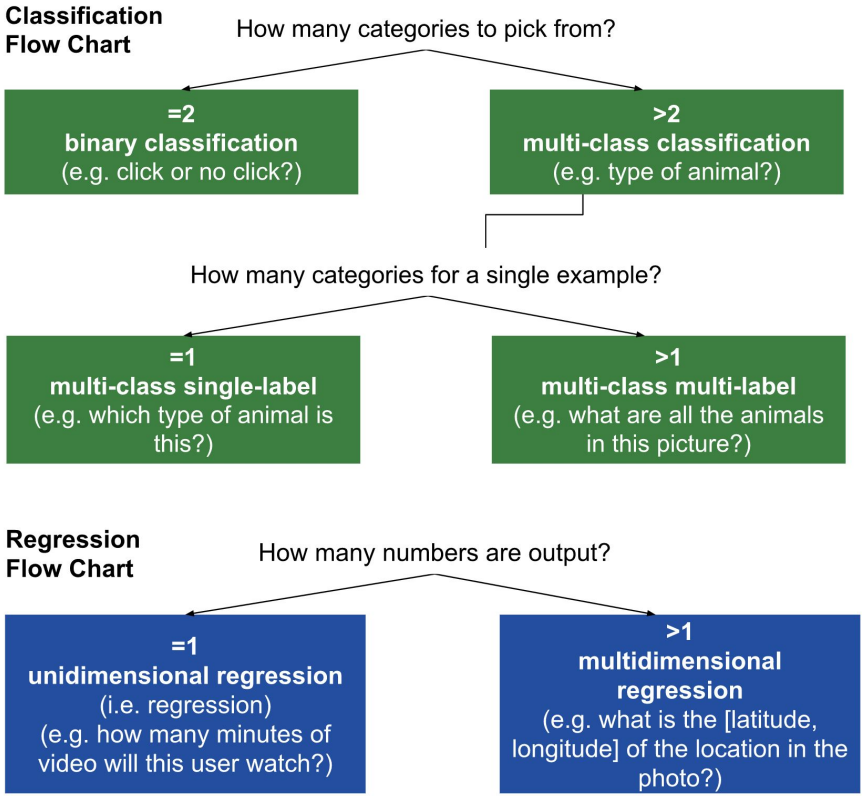
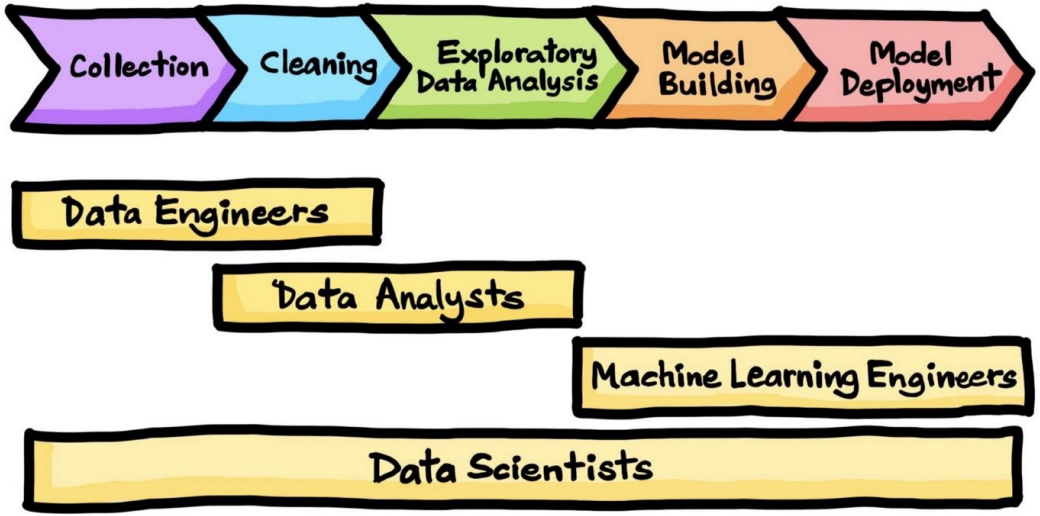


0. Framing the Problem

“Translate” your problem into an ML problem.

- Spam email filter
- Predicting popularity of newly posted youtube video
- Train a robot how to stand on its own
- Identify bias in tweets

THE DATA SCIENCE PROCESS



1. Collecting Data

Have to find the right data for your problem

- Both Target & Features

Is your dataset labeled? Do you need labels?

Where will you get data? Is it publicly available?

What form is your data in?

1. Collecting Data

Tabluar data formats:

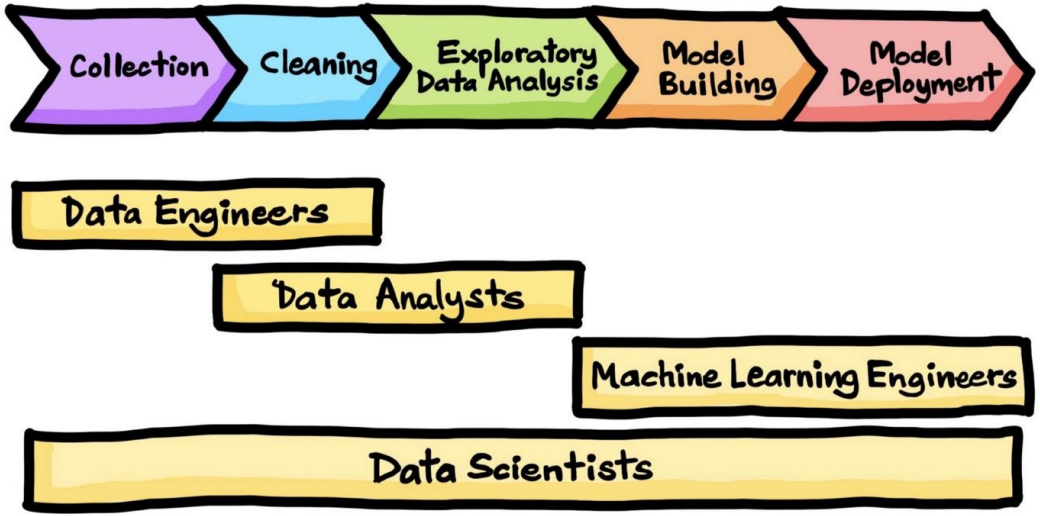
- Continuous
- Categorical
- Ordinal
- Binary
- Time

1. Collecting Data

Consider when starting your new ML project…

- Do I need to get data from other external sources?
- Do I actually need to use all the data I have?
- Is this data likely to help the model learn?
- Do you have enough data?
- Do you have enough positive labels?

THE DATA SCIENCE PROCESS



2. Cleaning Data

Data Characterization

- Quality: outliers / missing values
- Quantity: rows & columns
- Diversity: does the distribution match the test set
- Cardinality: number of unique values
- Dimensionality
- Sparsity

2. Cleaning Data

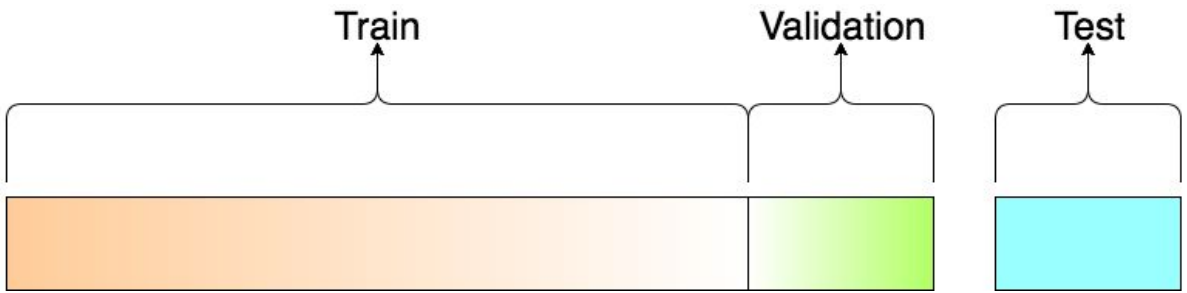
Data Characterization

- Stationarity
  - iterating on data
  - new / different / more customers
  - environment (interest rates changing)
  - model predictions influencing the data (recommendation, fraud)
- Duplicates
- Class imbalance
- Biased sampling

2. Train-test-validation split

Need to hold out the test set right away to prevent data leakage

Best to do this before making any new data/columns



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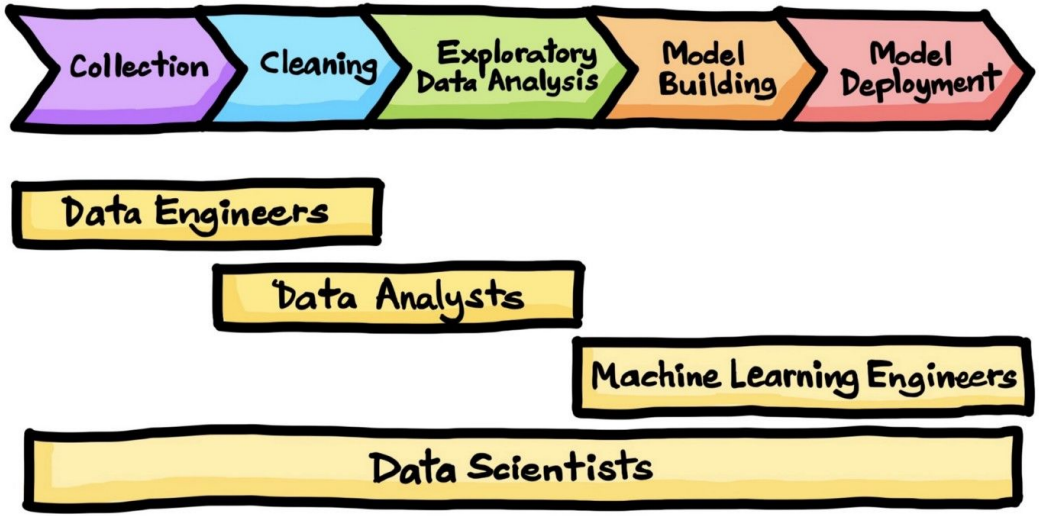


3. Data Exploration & Analysis

Understanding your data and features

Removing Outliers

Uni- and bi-variate analysis

Business understanding

VISUALIZATIONS

3. Data Exploration & Analysis

Visualization libraries

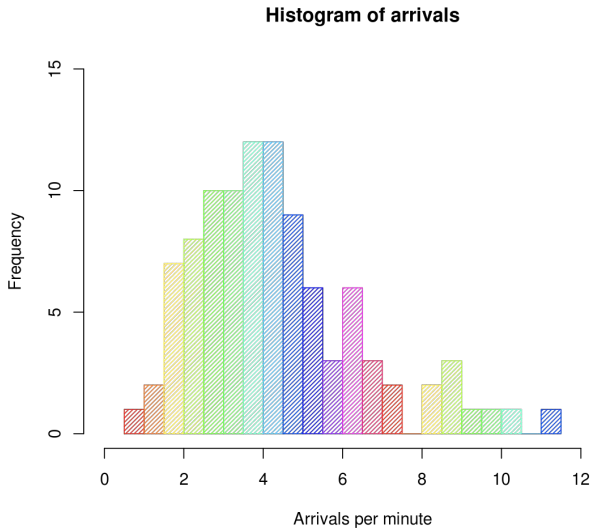
- Matplotlib
- Seaborn
- plotly

Visualization notebook on getting started

3. Data Exploration & Analysis

Visualization to always do

- Correlation matrix
- Plot the target



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Tailor your visualizations to the problem at hand

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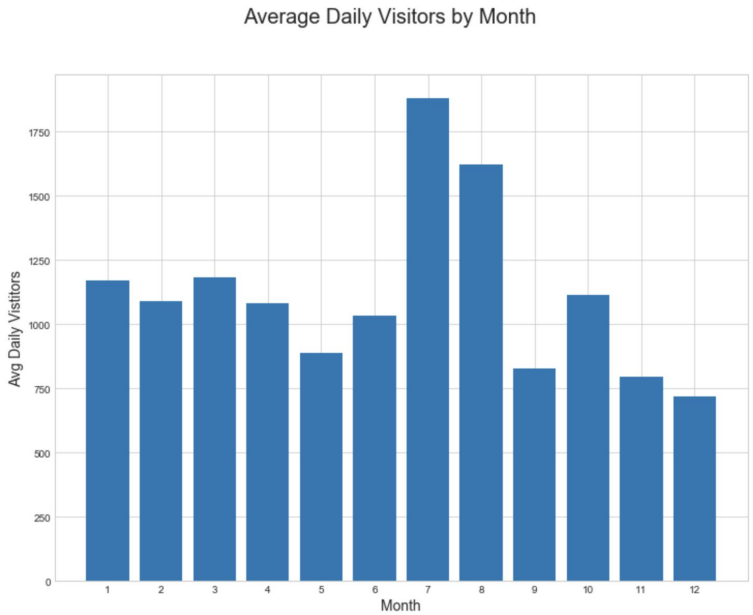

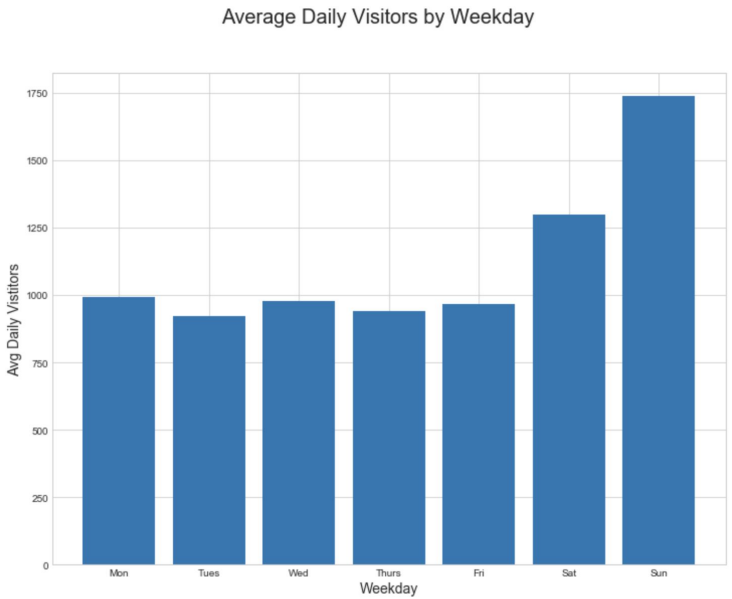

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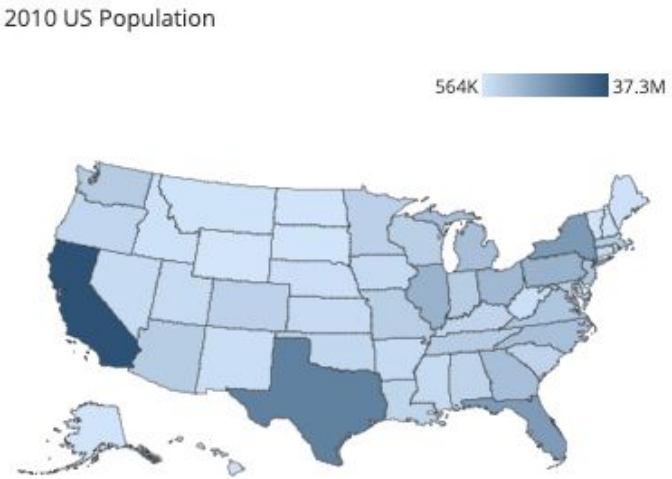

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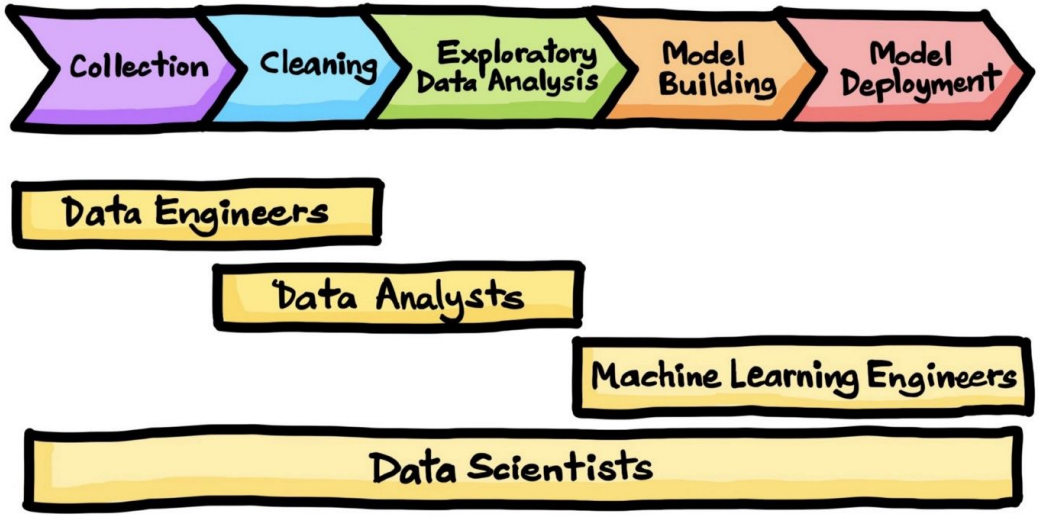


4. Model Building

Is your data model ready?

All data must be numeric!

Transforming non-numeric columns into numeric is called **encoding**.

4. Model Building - Data Encoding

Types of encoding:

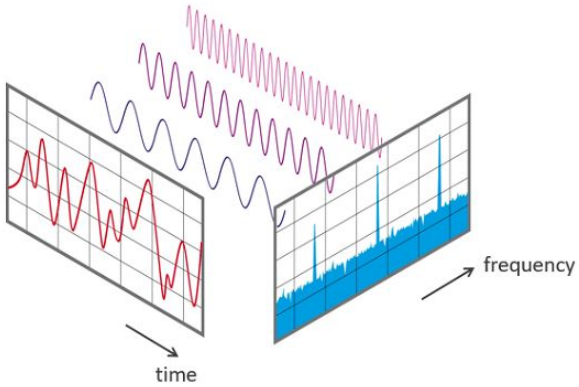
- One-Hot encoding
- Category encoding
- Ordinal encoding
- Frequency encoding
- Binary encoding
- Mean encoding

4. Model Building - Data Encoding for NLP

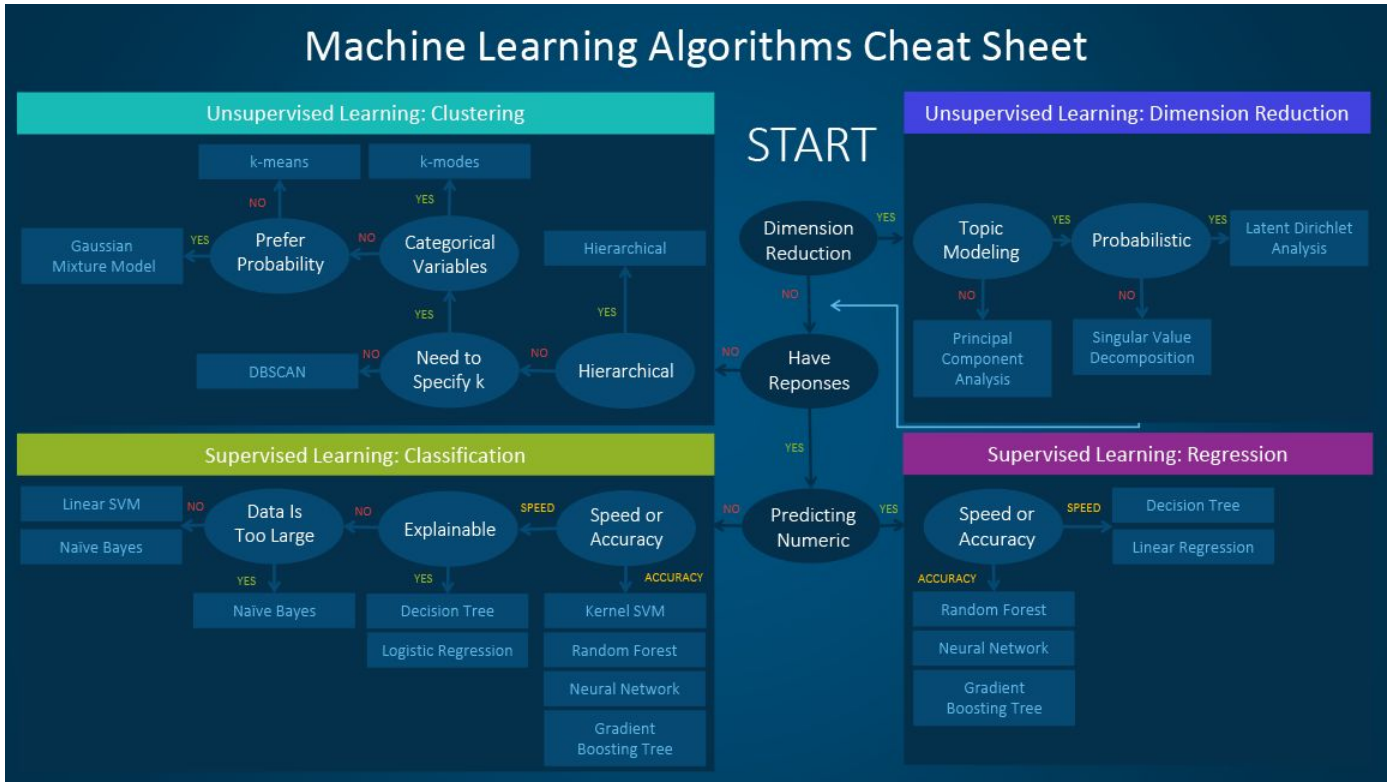
- Have to represent words as numbers
  - Tokenization
  - Removing stopwords
  - Lemming/stemming
  - N-grams
  - NLTK, SpaCy
  - TF-IDF matrix
- Blog on text encoding for real estate price prediction:
  https://medium.com/@data4help.contact/nlp-with-real-estate-advertisements-part-1-55200e0cb33c

4. Model Building - Data Encoding for Sound

- Have to represent sound as numbers
  - Fourier transformation
  - Feature extraction
- Blog on sound encoding for predicting car make from engine sounds: https://medium.com/@data4help.contact/signal-processing-engine-sound-detection-a88a8fa48344



4. Model Building - Algorithm Selection



Source: https://www.kdnuggets.com/2017/06/which-machine-learning-algorithm.html

4. Model Building - Algorithm Selection

What is important for your task and model?

- Accuracy?
- Explainability?
- Speed?

4. Model Building - Algorithm Selection

Lazy Estimator → Baseline Model → Further Models

Predict sensible value

Mean/median for regression problems, most common class for classification

Easy-to-implement ML Model

Linear/logistic regression, random forest

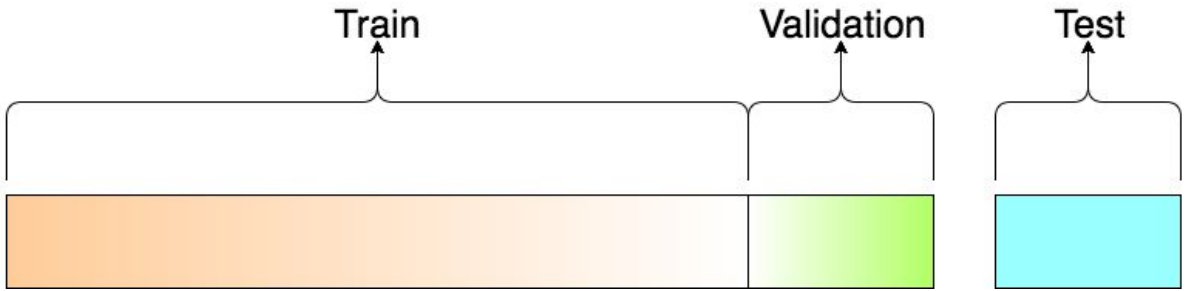
Sophisticated Algos

NNs, further feature engineering, hyperparameter tuning

4. Model Building - Model Evaluation

How do you know if your model is “good”?

- Hold data out to test on!



4. Model Building - Model Evaluation

To test how well your model is doing, have to use the correct metric for the problem!

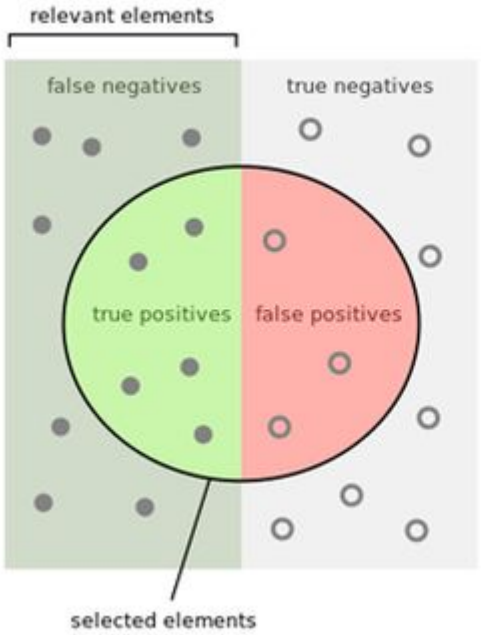
Classification:

- Accuracy
- Precision
- Recall
- Confusion Matrix
- F-Score
- ROC-curve

Regression:

- MAE
- MSE
- RMSE
- MAPE
- MASE
- Explained variance (infamous R2)
  - the proportion to which a model accounts for the variation (dispersion) of data
  - scaled
  - 0 = chance, 1 = perfect
  - only compare on the same dataset

4. Model Building - Model Evaluation



How many selected items are relevant?

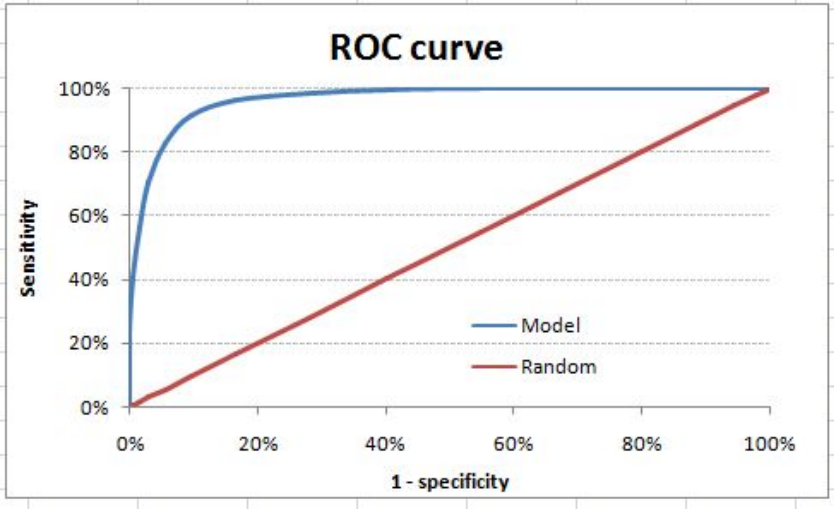
$$\text{Precision} = \frac{\text{true positives}}{\text{selected elements}}$$

How many relevant items are selected?

$$\text{Recall} = \frac{\text{true positives}}{\text{relevant elements}}$$

4. Model Building - Model Evaluation

Confusion Matrix		Target			
		Positive	Negative		
Model	Positive	a	b	*Positive Predictive Value*	a/(a+b)
	Negative	c	d	*Negative Predictive Value*	d/(c+d)
		Sensitivity	*Specificity*	**Accuracy** = (a+d)/(a+b+c+d)	
		a/(a+c)	d/(b+d)		



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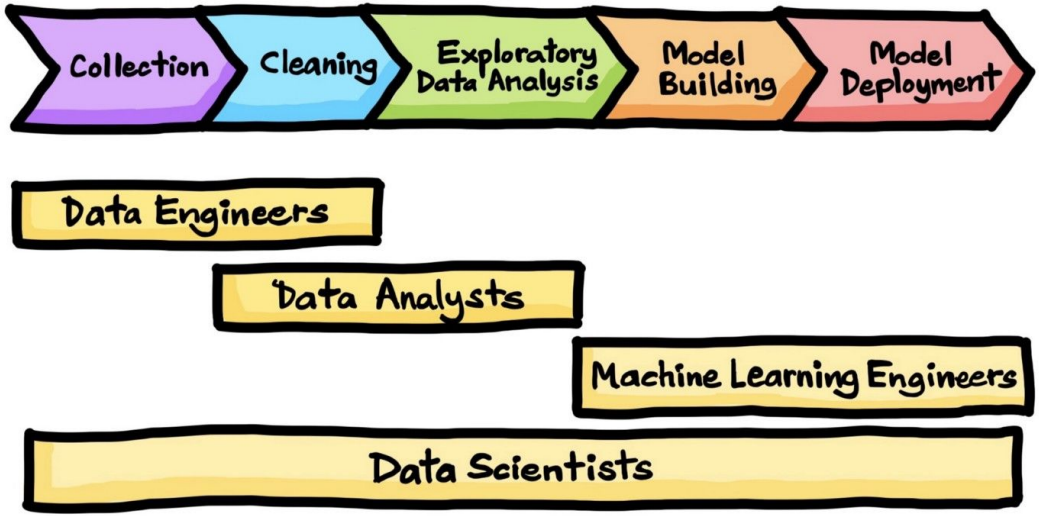

5. Model Deployment

Deployment is how you make your model, and its predictions, available.

Batch vs. Realtime predictions

Creating an API endpoint

- Flask
- Python Anywhere
- Heroku

Cloud:

- AWS
- Microsoft Azure

	Pattern 1 (REST API)	Pattern 2 (Shared DB)	Pattern 3 (Streaming)	Pattern 4 (Mobile App)
Training	Batch	Batch	Streaming	Streaming
Prediction	On the fly	Batch	Streaming	On the fly
Prediction result delivery	Via REST API	Through the shared DB	Streaming via Message Queue	Via in-process API on mobile
Latency for prediction	So so	High	Very Low	Low
System Management Difficulty	So so	Easy	Very Hard	So so