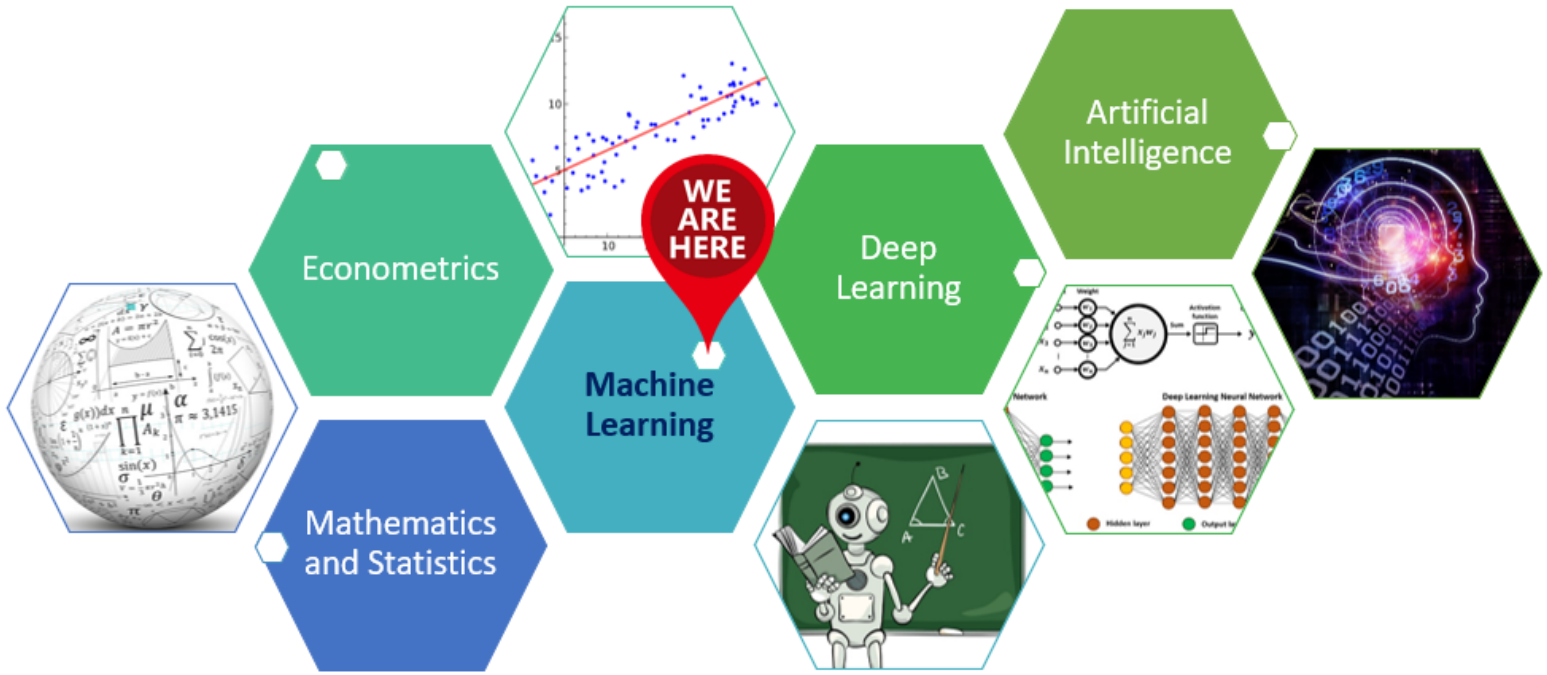
Module 1- Part I
Welcome to the magic world of Machine Learning



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Big picture: Econometrics vs Machine Learning

What are we trying to do as a researcher?

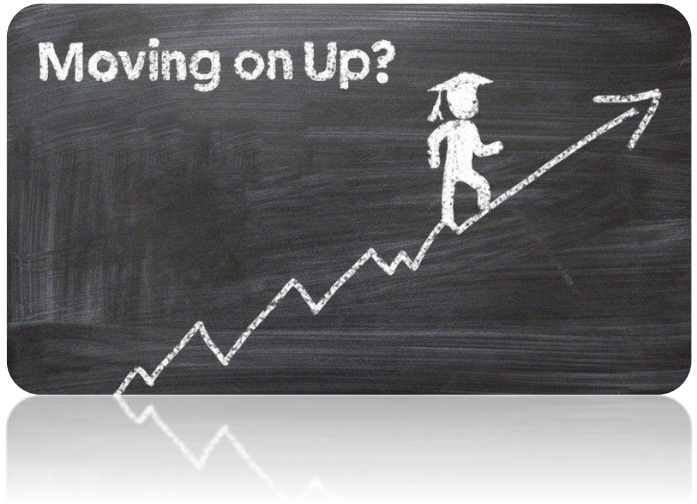
Solve real world problems, right?

Is there a theory?

What is the relationship between

- Sales and advertisement / R&D expenditure / seasonality / industry / … ?
- Quantity demanded and price / income / technology / price of competitors / … ?
- Wage and education/ age/ gender/ experience/ …?

A simple example



- Quantifying wage components! (is there a theory?)
- What are the drivers:
  - Education, age, experience, IQ, …
  - Ethnicity, race, gender, …
  - Industry, location, working hours, …
- Let's build a model (assuming a linear functional form!)

$$wage = \beta_0 + \beta_1 educ + \beta_2 age + \beta_3 exper + \beta_4 IQ + \cdots + \beta_k hours + u$$

- Can you interpret this model? Do you care about the interpretability?
- Can you make predictions using your model?
- Can you make this functional form more flexible? What are the caveats?

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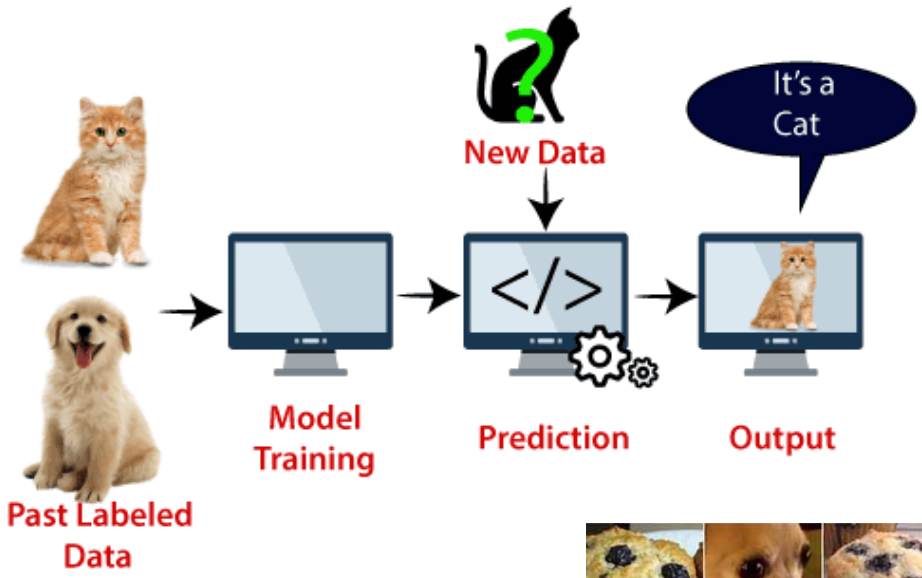
A different example

- Cat vs dog classification problem (image classification)



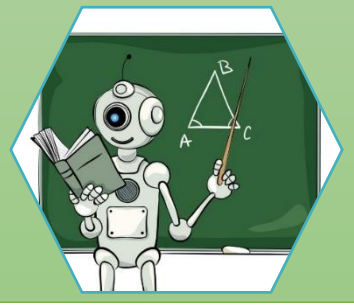
- Do you really care about interpretability of the model here?
- What about accuracy of your predictions?

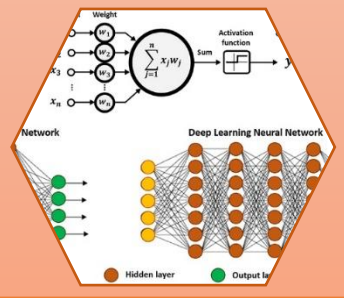
Artificial intelligence vs Machine learning vs Deep learning

Artificial intelligence: Any technique which enables machines to mimic human behavior

Machine Learning: Subset of AI that enables computers to learn from data. the model is trained with a set of algorithms

Deep Learning: Subset of ML that extract patterns from data using neural networks.





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Statistical learning vs machine learning

	Statistical Learning	Machine Learning / Deep Learning
Focus	Hypothesis testing & interpretability	Predictive accuracy and extracting complex patterns
Driver	Math, theory, hypothesis	Fitting data
Data size	Any reasonable set	Big data
Data type	Structured	Structured, unstructured, semi-structured
Dimensions / scalability	Mostly low dimensional data	High dimensional data
Strength	Understand **causal** relationship & behavior	Prediction (forecasting and nowcasting)
Interpretability	High	Medium to Low

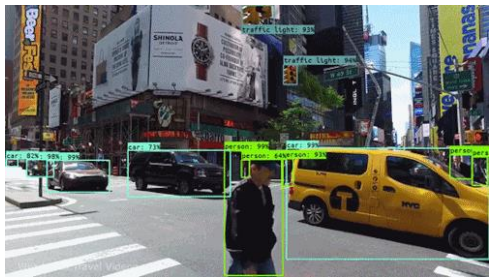
Limitations of Econometrics/Structured ML

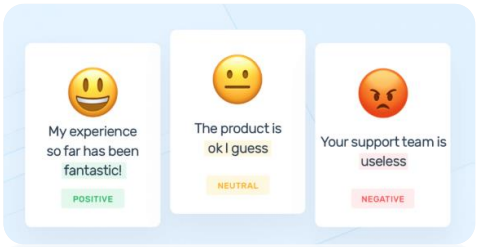
Econometrics/structured ML can only handle structured data (tabular data)!

Structured Data

	A	B	C	D
1	Date	Account	Transaction Type	Amount
2	2017-01-12	123	Credit	6089.78
3	2017-01-12	123	Fee	9.99
4	2017-01-12	456	Debit	1997
5	2017-01-12	123	Debit	20996.12
6	2017-01-13	123	Debit	17
7	2017-01-13	123	Debit	914.36
8	2017-01-14	789	Credit	11314
9	2017-01-14	789	Fee	9.99
10	2017-01-14	456	Debit	15247.89
11	2017-01-14	123	Debit	671.28
12	2017-01-15	456	Credit	5072.1
13	2017-01-15	456	Fee	9.99
14	2017-01-16	456	Debit	5109.07
15	2017-01-19	123	Credit	482.01

Unstructured Data (everything else!!)





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A more complex example

Stock price prediction $$$

- What are the classical drivers:
  - Company's fundamentals (balance sheet, income statement, cash flow statement)
  - Competitors (comparing multiples)
  - Technical analysis!
  - Seasonality (holidays, months, days, …)

What else?

- Market sentiment (news, tweets, blogger opinions, conference calls, …)
- Satellite images from parking lots!

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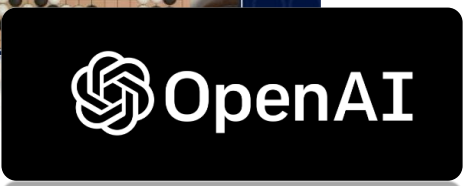
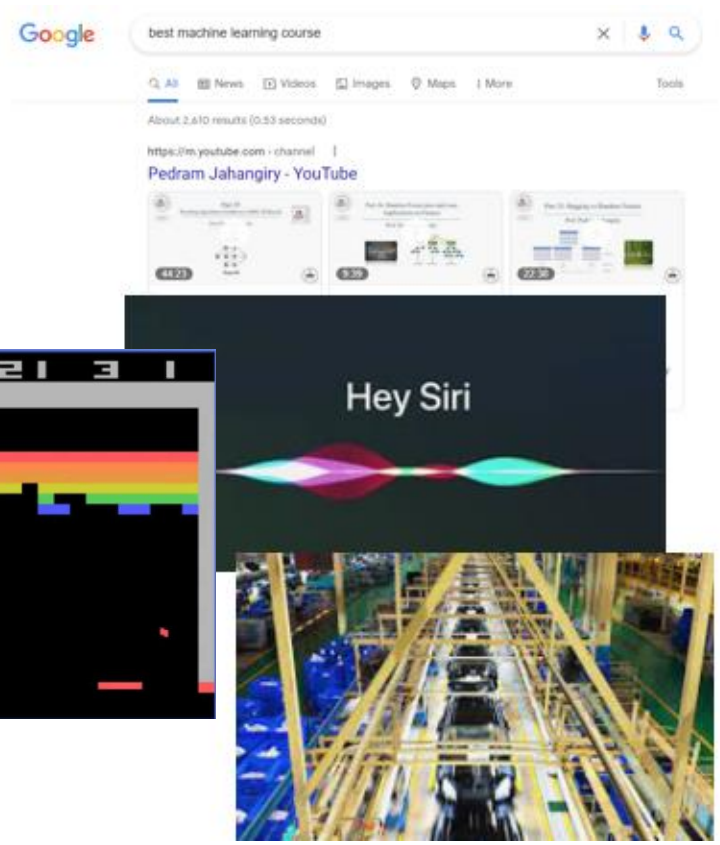
Why should I learn it?

- It’s a bid deal, it is everywhere!
- Better career opportunities
- Hedge against next recession





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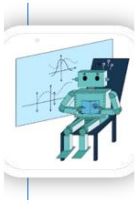
Class Modules

- Module 1- Introduction to Machine Learning
- Module 2- Setting up Machine Learning Environment
- Module 3- Linear Regression (Econometrics approach)
- Module 4- Machine Learning Fundamentals
- Module 5- Linear Regression (Machine Learning approach)
- Module 6- Penalized Regression (Ridge, LASSO, Elastic Net)
- Module 7- Logistic Regression
- Module 8- K-Nearest Neighbors (KNN)
- Module 9- Classification and Regression Trees (CART)
- Module 10- Bagging and Boosting
- Module 11- Dimensionality Reduction (PCA)
- Module 12- Clustering (KMeans – Hierarchical)

Module 1- Part II
What is Machine Learning?

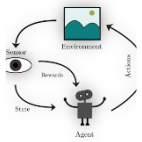
Supervised
- Regression
- Classification



Unsupervised
- Clustering
- Anomaly detection
- Dimensionality reduction

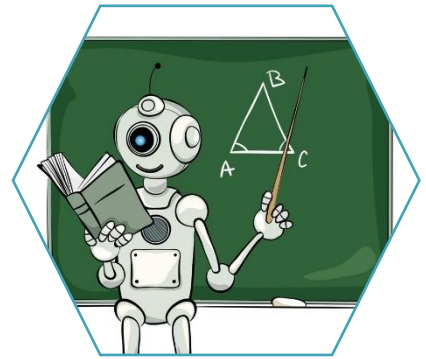
Semi-supervised

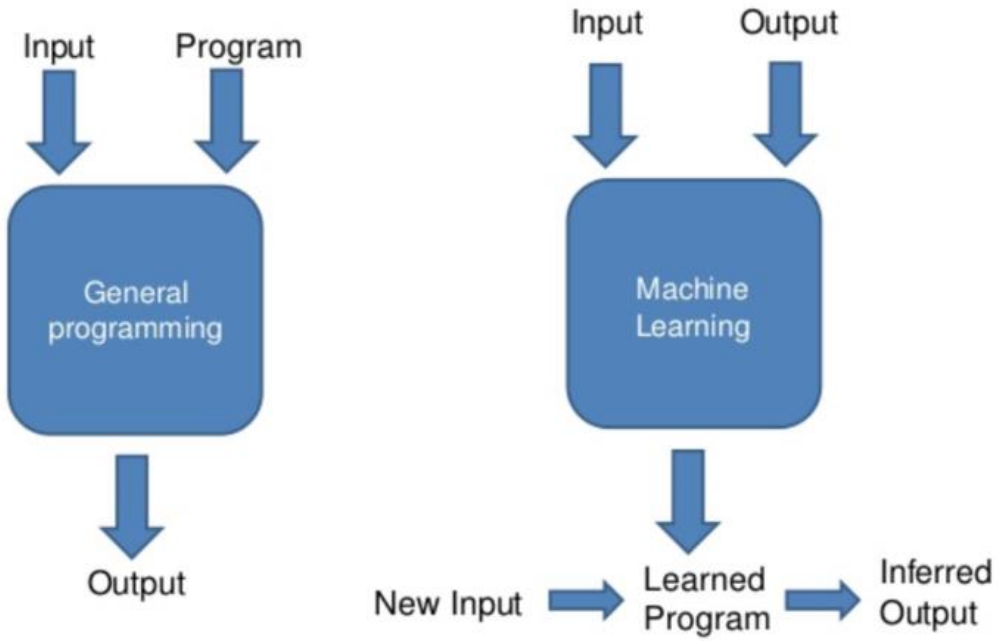
Self-supervised



Reinforcement Learning

General programming vs Machine learning

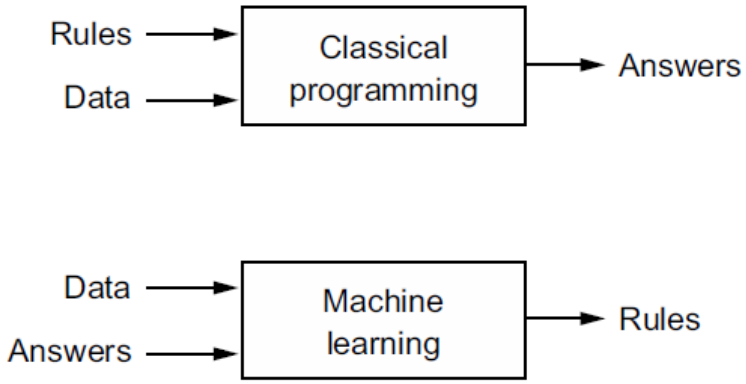




- Machine Learning: Involves automated detection of meaningful patterns in data and apply the pattern

What is Machine Learning?

- A machine learning system is **trained** (with algorithms) rather than explicitly **programmed**.
- Machine Learning is a subset of AI that enables computers to learn from data.
- ML involves automated detection of meaningful patterns in data and apply the pattern to make predictions on unseen data!
- This is done by minimizing the loss on the training data.
- The goal is to maximize the performance on the unseen data.



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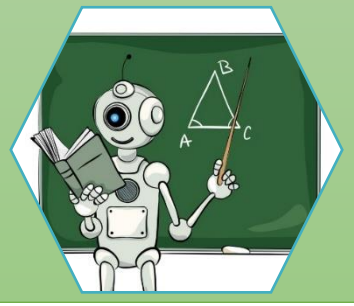

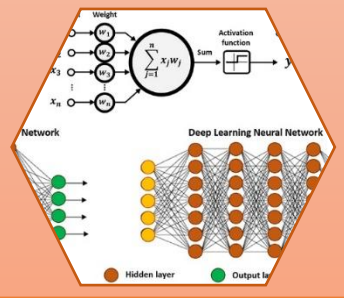

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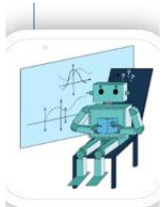
Types of Machine Learning

Supervised

- Regression
- Classification

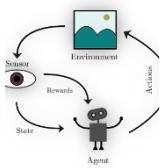


Unsupervised

- Clustering
- Anomaly detection
- Dimensionality reduction

Semi-supervised

Self-supervised



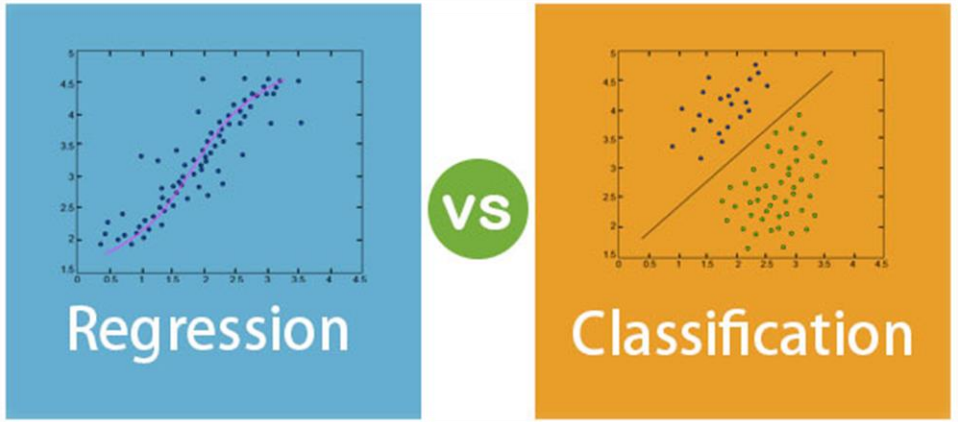
Reinforcement Learning

Supervised Learning

- Supervised learning is a type of machine learning where the algorithm is trained on labeled data.
- The data is labeled, meaning that the data has been tagged with the correct output.
- The model is then able to learn the relationship between the input data and the corresponding output labels and can make predictions on new data.

- Regression:
  - Predicting housing price
  - Predicting stock market returns

- Classification:
  - Generating buy, sell, hold signals.
  - Predicting credit default rate.

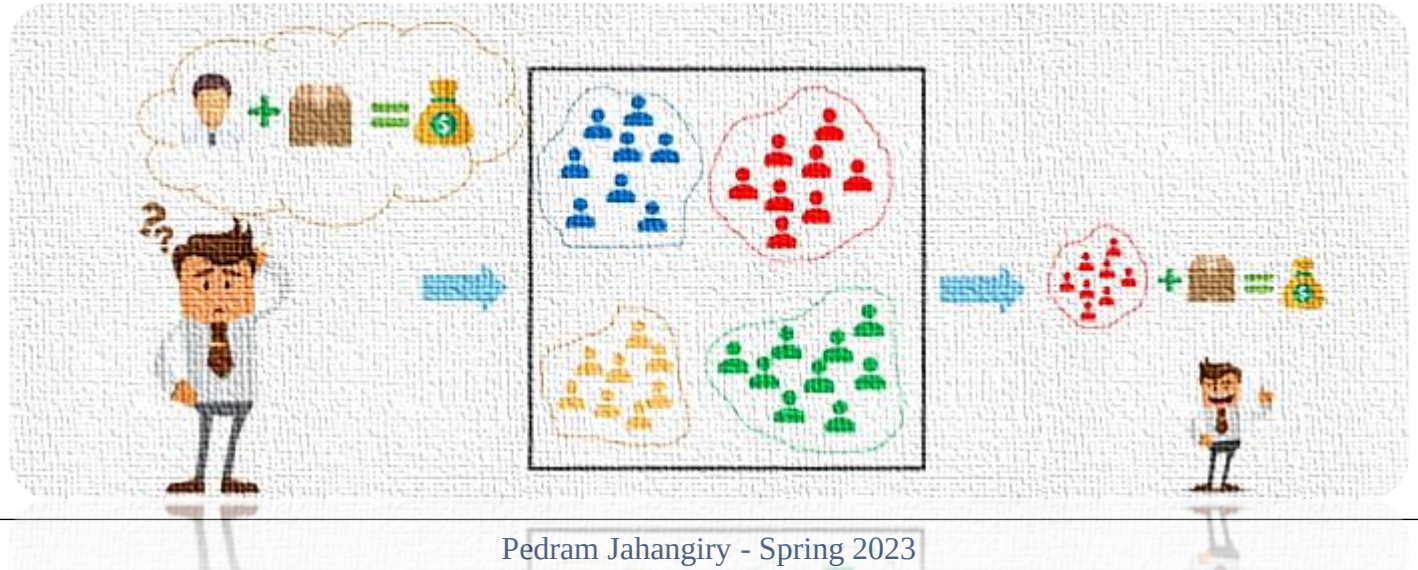


Class exercise

- Can you think of an example of Regression? Classification?

Unsupervised Learning

- Unsupervised learning is a type of machine learning where the algorithm is not given any labeled training data.
- The goal is to discover the underlying patterns and find groups of samples that behave similarly. Find something interesting!
- Clustering: group similar data points together
  - ✓Mall customer segmentation
  - ✓Client profiling and asset allocation



Unsupervised Learning

- Unsupervised learning is a type of machine learning where the algorithm is not given any labeled training data.

- Anomaly detection: Find anomalies (unusual data points)
  - ✓Fraud detection

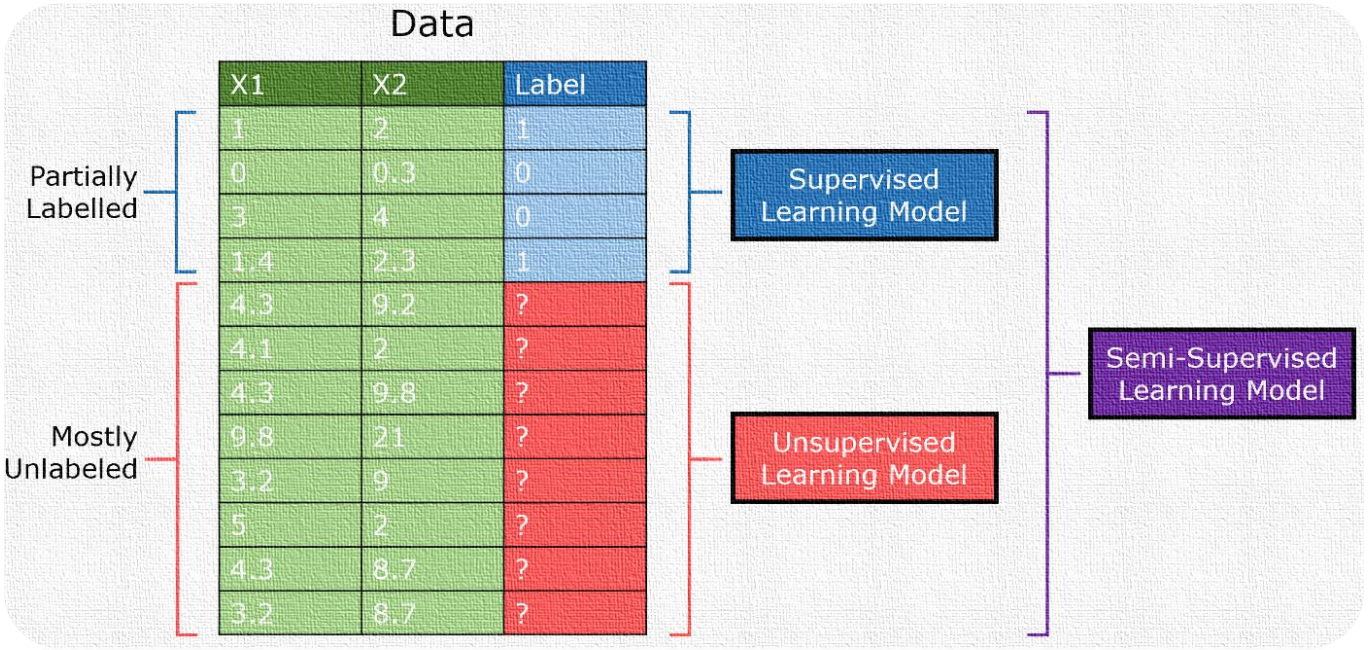
- Dimensionality Reduction: compress data in lower dimension
  - ✓Identify the most predictive factors underlying asset price models.

Class exercise

- Can you think of an example of Clustering? Anomaly detection?

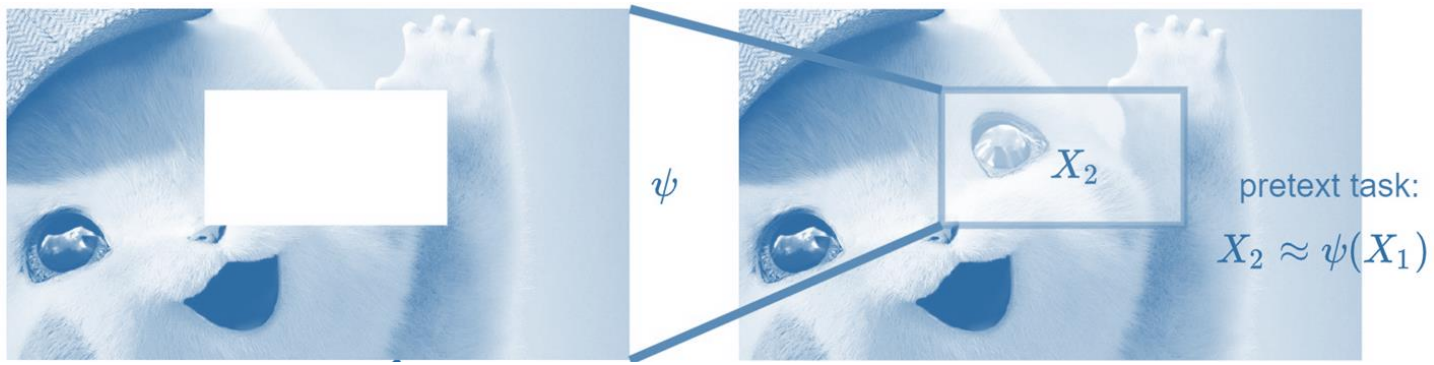
Semi-Supervised

- Semi-supervised learning is a combination of supervised and unsupervised learning.
- It's used when you have a large dataset with some labeled examples and many unlabeled examples.
- The goal is to use the labeled examples to learn a mapping from inputs to outputs, and then use that mapping to make predictions on the unlabeled examples (pseudo labels)



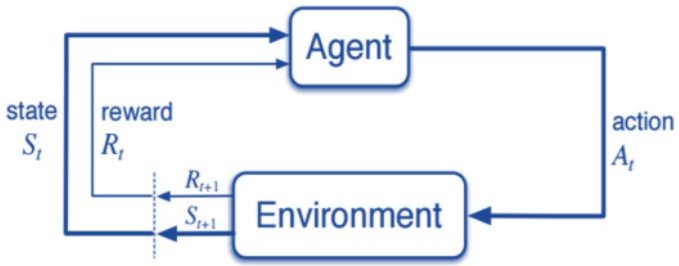
Self-Supervised

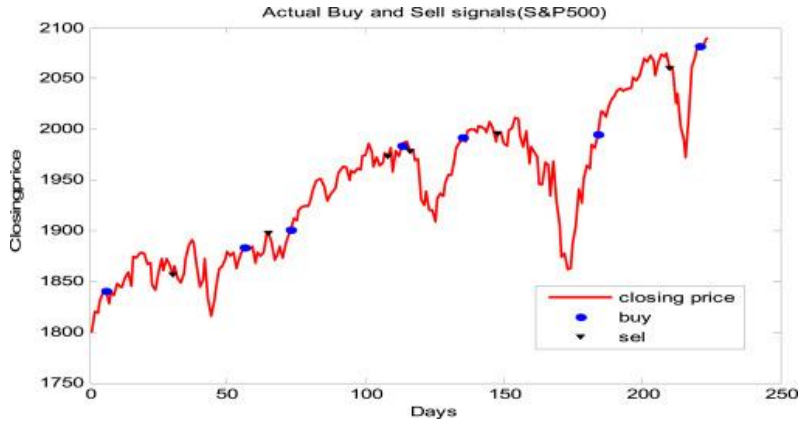
- Self-supervised learning is a type of unsupervised learning, but it has the property that the learning process is being fed with the data itself (and not a human annotation).
- The goal of self-supervised learning is learning useful representations from the data (representation learning)
- The model learns a representation of the data by predicting properties of the input data itself.
- Example:
  - Predicting missing part of an input (text, image, …)



Reinforcement Learning

- Reinforcement learning is a type of machine learning where an agent learns to interact with its environment in order to maximize a reward.
- The agent receives rewards for performing actions that lead to successful outcomes and learns to repeat successful actions and avoid unsuccessful ones. (Explore and Exploit)



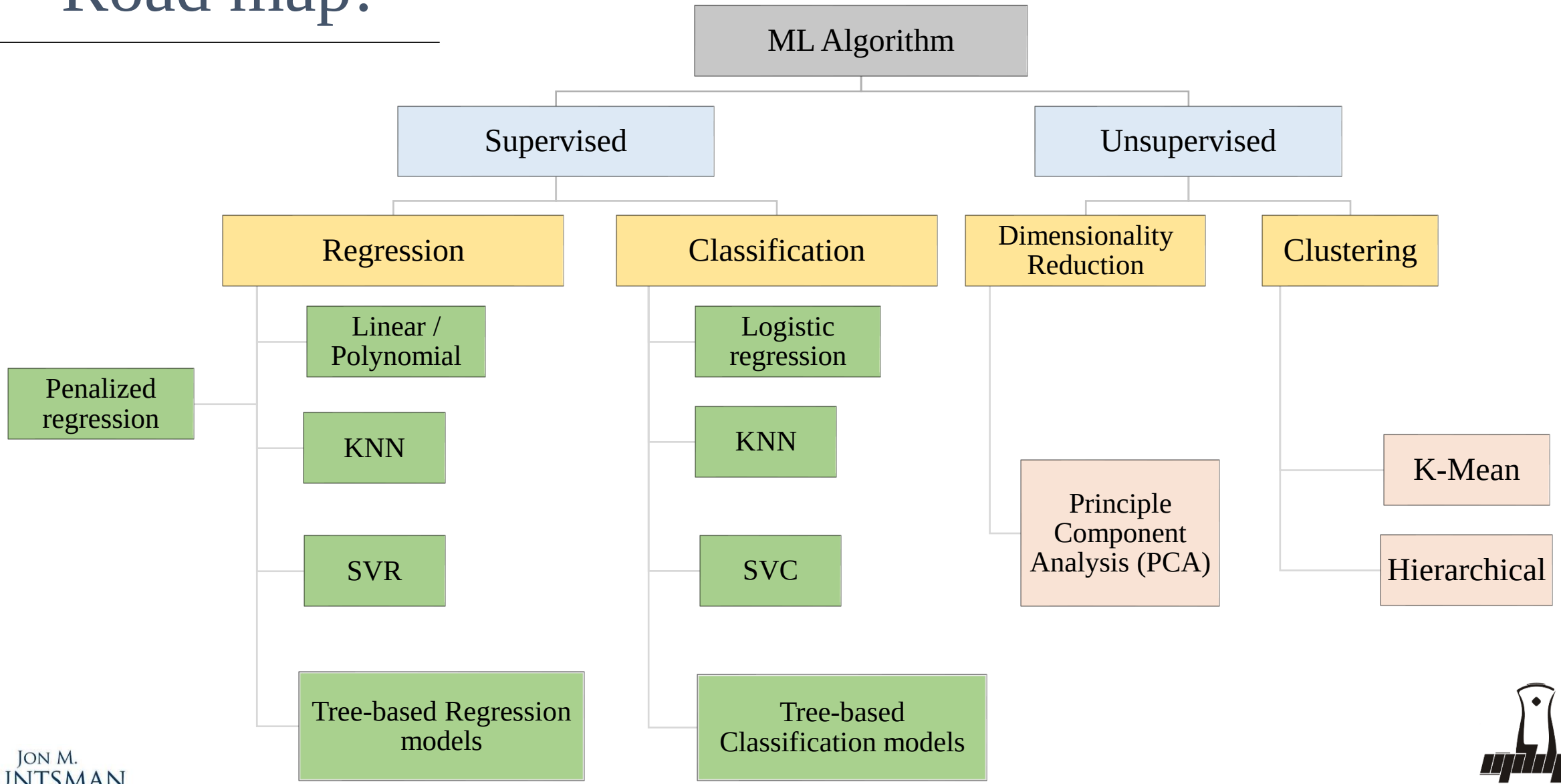


- Example: a virtual trader (agent) who follows certain trading rules (actions) in a specific market (environment) to maximize its profits (reward).

Class exercise

- Can you think of an example of reinforcement learning?

Road map!


ML Algorithm
Supervised
Unsupervised
Regression
Classification
Dimensionality Reduction
Clustering
Linear / Polynomial
Penalized regression
KNN
SVR
Tree-based Regression models
Logistic regression
KNN
SVC
Tree-based Classification models
Principle Component Analysis (PCA)
K-Mean
Hierarchical

What's on GitHub

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Having said that…

- **Warning**: A ML algorithm will always find a pattern, even if there is none.