

MACHINE LEARNING

MEI/1

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Machine Learning? What is It?

- Arthur Samuel (1959)
 - *“Field of study that gives computers the ability to learn without being explicitly programmed”.*
- Yoshua Bengio
 - *“Part of research on artificial intelligence, seeking to provide knowledge to computers through data, observations and interacting with the world. That acquired knowledge allows computers to correctly generalize to new settings”.*
- Wikipedia
 - *“Is the scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead.”*
- NVIDIA
 - “Machine Learning at its most basic is the practice of using algorithms to parse data, learn from it, and then make a determination or prediction about something in the world.”

Machine Learning? Basics

- There are nowadays many different machine learning algorithms, which are typically grouped by the kind of learning (supervised/unsupervised), or their similarity strategy/function (classification, regression, grouping,...)
- At the bottom line, every machine learning algorithm consists of three components: 1) **Representation** (the language, or instances that the algorithm understands); 2) **Evaluation** (how to distinguish between two instances); and 3) **Optimization** (how to search for the optimal solution).

Representation	Evaluation	Optimization
Instances	Accuracy/Error rate	Combinatorial optimization
<i>K</i> -nearest neighbor	Precision and recall	Greedy search
Support vector machines	Squared error	Beam search
Hyperplanes	Likelihood	Branch-and-bound
Naive Bayes	Posterior probability	Continuous optimization
Logistic regression	Information gain	Unconstrained
Decision trees	K-L divergence	Gradient descent
Sets of rules	Cost/Utility	Conjugate gradient
Propositional rules	Margin	Quasi-Newton methods
Logic programs		Constrained
Neural networks		Linear programming
Graphical models		Quadratic programming
Bayesian networks		
Conditional random fields		

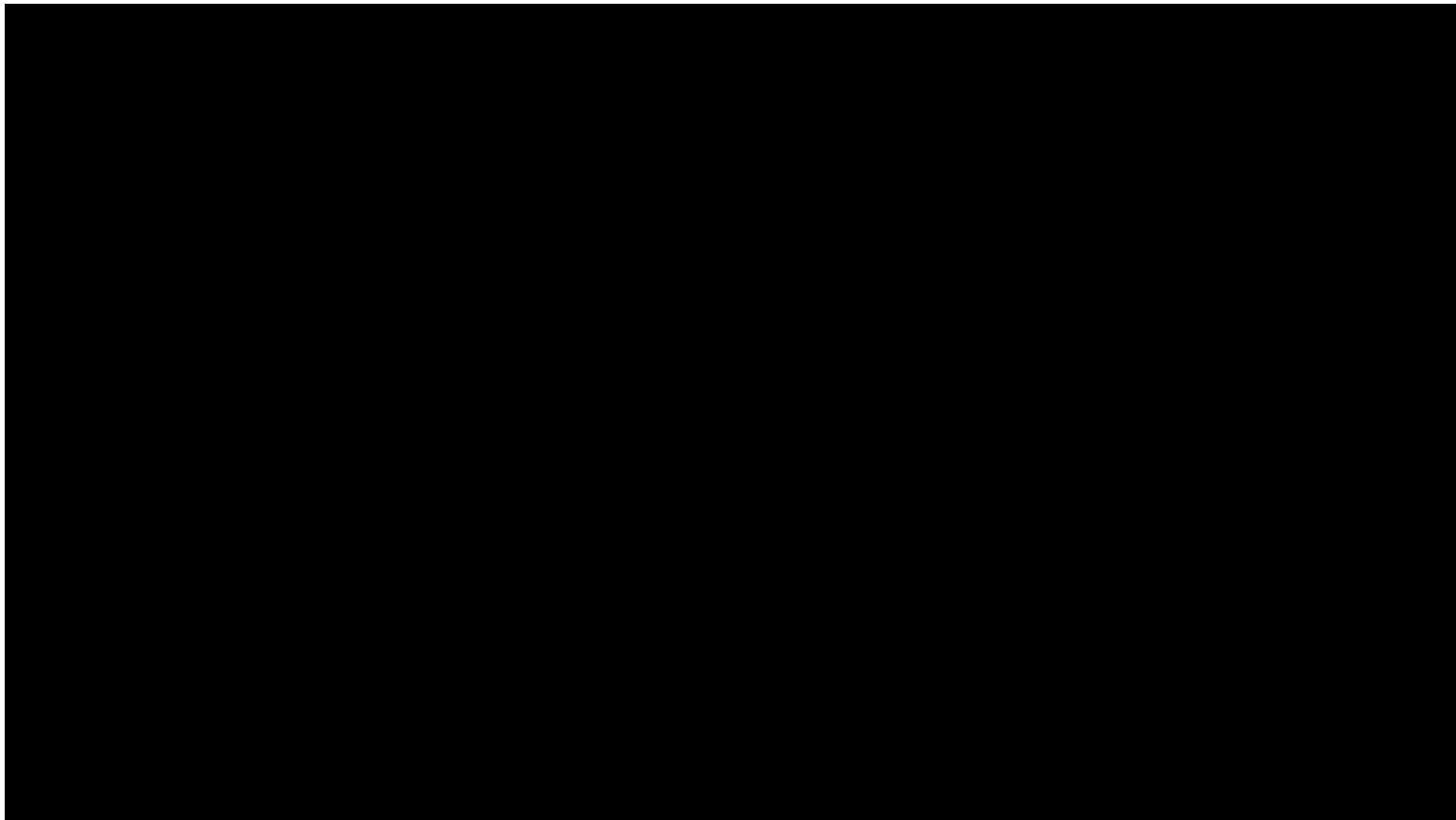
Machine Learning? Applications

- The use of sorting robots improves efficiency, accuracy and security during the sorting process and also saves 70% of manual work, dramatically reducing labor costs



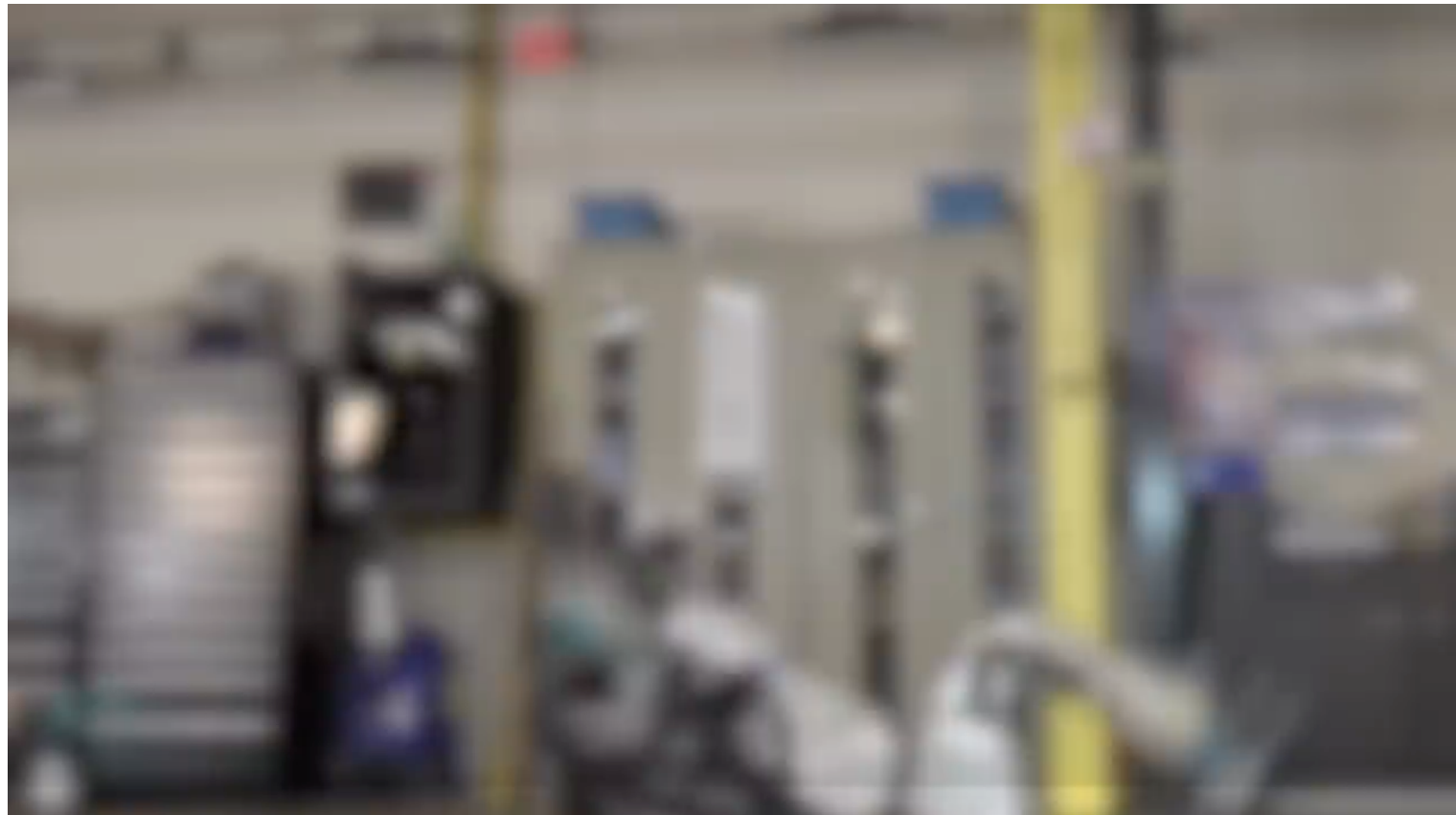
Machine Learning? Applications

- MOTOBOT 2 is capable of circulating a racetrack on its own. In September 2017, one of the project's milestones was reached as MOTOBOT successfully hit speeds exceeding 200 km/h. MOTOBOT then attempted to better the lap time set by MotoGP star, Valentino Rossi.



Machine Learning? Applications

- Atlas is capable of performing human movements, even a tad bit better than actual humans. This incredible robot can understand obstacles easily and can even jump on or over them conveniently.



Machine Learning? Applications

- Deep Blue
 - Twenty years ago IBM's Deep Blue defeated previously unbeaten chess grandmaster Gary Kasparov. Deep Blue won its first game against a world champion on 10 February 1996.
 - Deep Blue was the first computer system to defeat a reigning world champion in a match under standard chess tournament time controls. Kasparov accused IBM of cheating and demanded a rematch. IBM refused and dismantled Deep Blue.

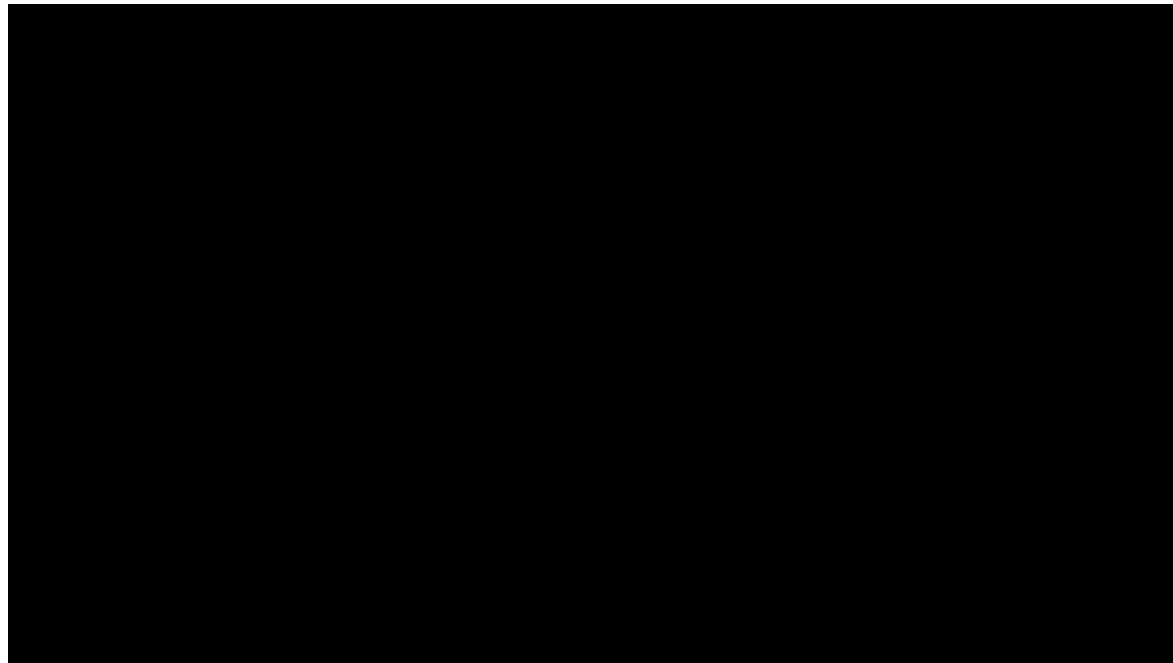


Machine Learning? Applications

- Self Driving Cars
 - Waymo cars (formerly known as “Google self-driving car”) might be the state-of-the-art in this extremely demanding application.

Machine Learning? Applications

- Watson is a question-answering computer system capable of answering questions posed in natural language, developed in IBM.
- The computer system was initially developed to answer questions on the quiz show Jeopardy! and, in 2011, the Watson computer system competed on Jeopardy! against human champions Brad Rutter and Ken Jennings, winning the first place prize of \$1 million.
 - "Jeopardy!" is a classic game show, with a twist. The answers are given first, and the contestants supply the questions.

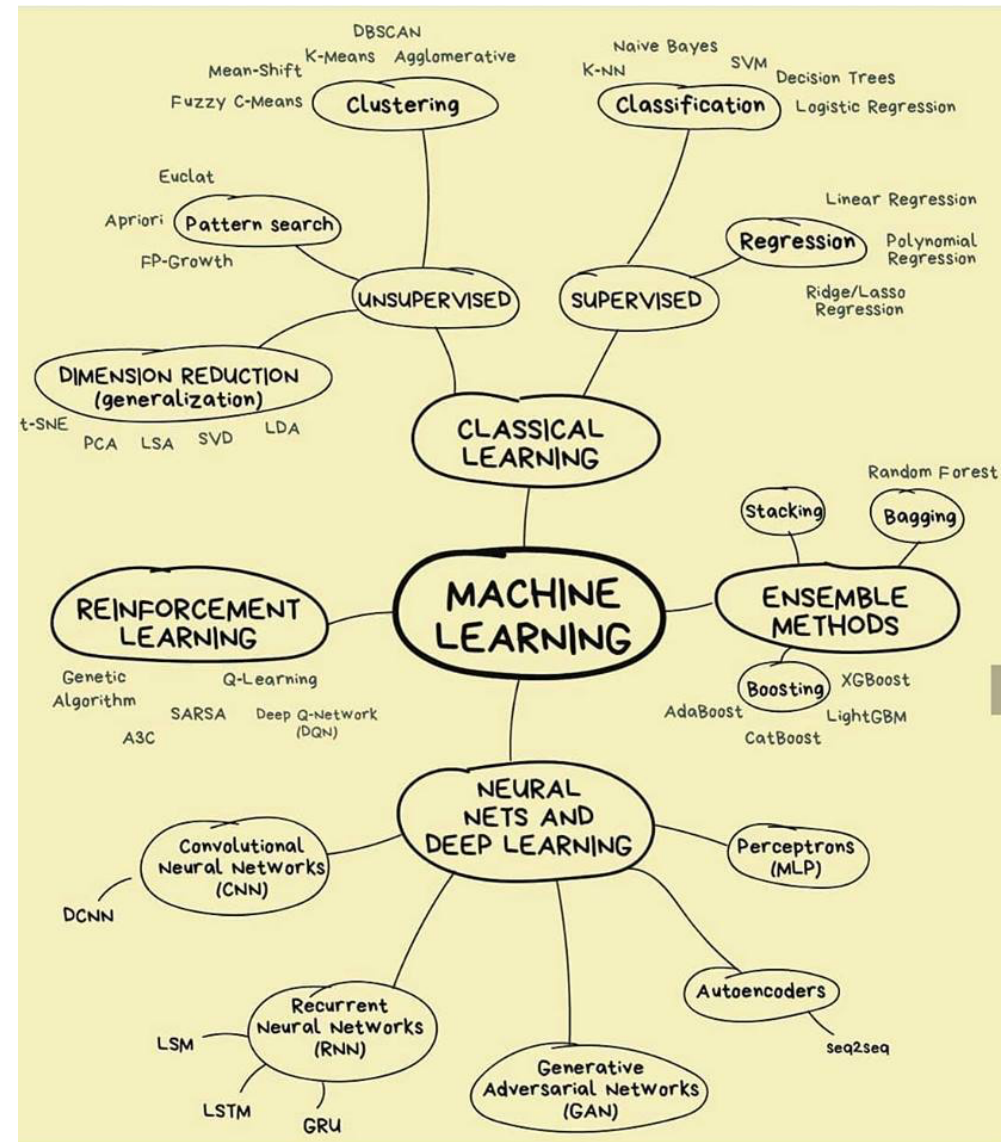


Machine Learning Algorithms



Machine Learning? A Taxonomy

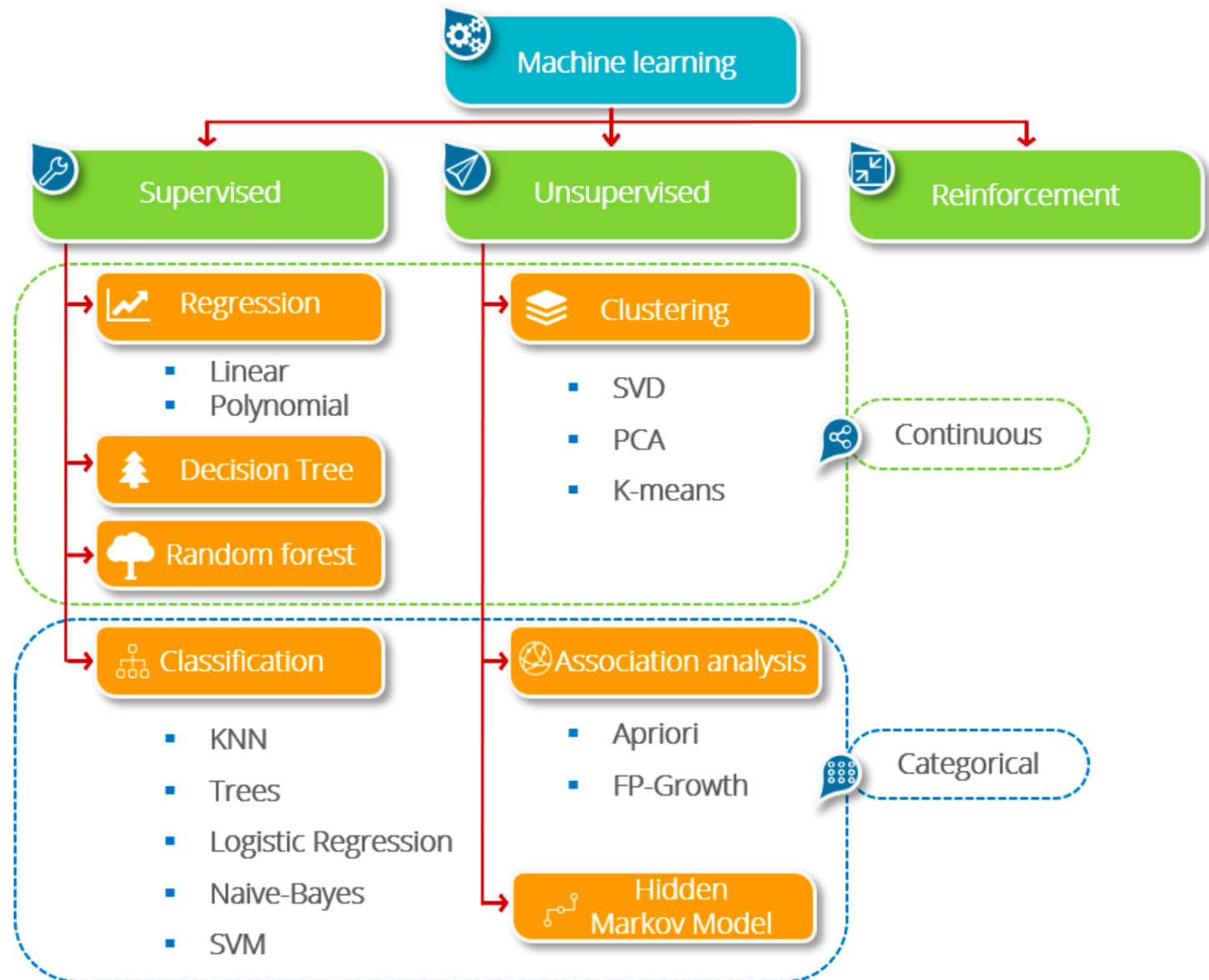
- The number of available Machine Learning algorithms is astonishing.
- However, there are some really important **keywords**: “supervised”, “unsupervised”, “statistical”, “neural” and “reinforcement learning” categories.



Machine Learning Taxonomy

Hence, Machine Learning algorithms can be divided into three main types:

- 1) *Supervised Learning;*
- 2) *Unsupervised Learning; and*
- 3) *Reinforcement Learning*



Machine Learning Taxonomy

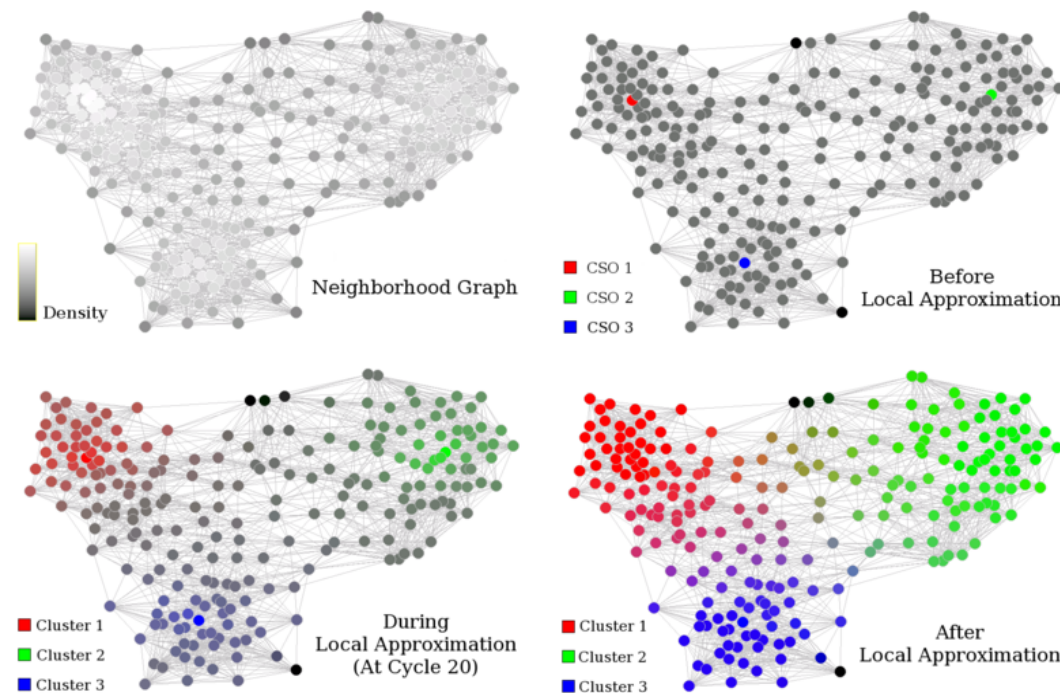
- **Supervised Learning**

- The input data is called the **training data**.
- Every instance has a known **label** or result, such as “spam”/”not-spam” (in case of **classification** problems) or a stock price at a time (for **regression** problems).
- A model is **inferred** through a training/optimization process in which it is required to make predictions. The model parameters are corrected when those predictions are wrong.
- The training process continues until the model achieves a desired level of accuracy on the training data.
- The typical problems in this family can be divided into **classification** and **regression**.
 - Classification problems typically evolve a “label” or “class” that should be automatically;
 - Regression problems evolve to predict one real value, by modelling the relationship between variables

Machine Learning Taxonomy

- **Unsupervised Learning**

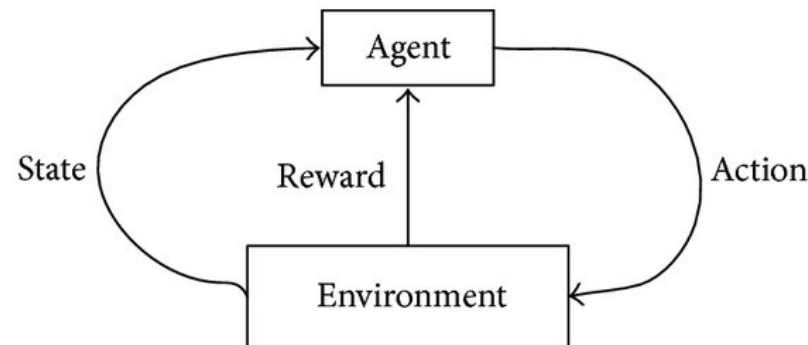
- The model learns through observation to **find structures** in the data, which are modelled as “clusters”
- It finds **patterns** and **relationships** in the dataset by creating such clusters.



Machine Learning Taxonomy

- **Reinforcement Learning**

- It is the ability of an automated agent to interact with the environment and find out what is the best outcome.
- It follows the concept of **hit and trial** method. The agent is rewarded or penalized with a point for a correct or a wrong answer, and on the basis of the positive reward points gained the model trains itself.



- Some of the most common algorithms in this family are Q-Learning, Temporal Difference and Deep Adversarial Networks.