Machine Learning

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January 22, 2019

Outline

General Definition

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"Machine learning is the science (and art) of programming computers so they can learn from data"
-Aurélien Géron, 2017 (Hands-On Machine Learning with Scikit-Learn and TensorFlow)

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"A field of study that gives computers the ability to learn without being **explicitly** programmed"
-Arthur Samuel, 1959 (Some Studies in Machine Learning Using the Game of Checkers)

Formal Definition

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"A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E"
- *Thomas Mitchel, 1998 (Machine Learning)*

This definition applies to all machine learning algorithms!

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Example

From Mitchel, Machine Learning, chapter 1
Task T: Playing checkers
Performance Measure P: Percent of games won
Training Experience E: Games played against itself

Supervised Learning

The program is given a set of N labeled data points $A = \{a_1, a_2, \ldots, a_N\}$ and each data point $a_i \in A$ has M features such that $a_i = (y_i, x_{i1}, x_{i2}, \ldots, x_{iM})$.

- For any given data point a_i we will identify y_i as the label and the rest as the feature vector x_i.
- We train the program on the feature vectors x_i to try and predict the corresponding y_i with better accuracy every time.

Another way to think about supervised learning is that the program is given a target goal (labels) and it tries to predict that goal based on what input it's given each time (features). And throughout the whole process, it's told which predictions are right and which are wrong.

Supervised Learning

	TV	Sales
1	230.1	22.1
2	44.5	10.4
3	17.2	9.3
4	151.5	18.5
⋮		
197	94.2	9.7
198	177	12.8
199	283.6	25.5
200	232.1	13.4

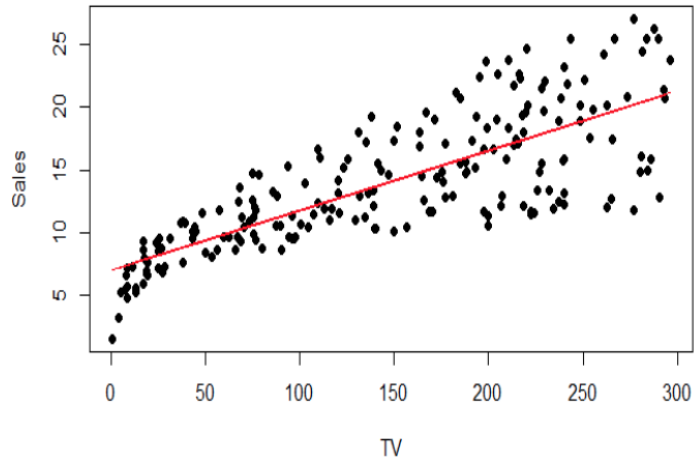

Figure: An example of a supervised learning algorithm trying to predict sales based on dollars spent on TV ads from 200 advertising campaigns. *Image Source*

Supervised Learning

There are two main sub divisions of supervised learning.

1. Classification
   The labels are classes (discrete values) and the program tries to predict in which class a data point should be in.
   Example: Predicting whether a picture of an animal is a cat, a dog, a horse, etc.
2. Regression
   The labels are real numbers (continuous values) and the program tries to guess a number based on the input data point with as little error as possible.
   Example:Predicting the values of certain stock prices based on previous values.

Unsupervised Learning

The program is given a set of N **unlabeled** data points $A = \{a_1, a_2, \ldots, a_N\}$ and each data point $a_i \in A$ has M features such that $a_i = (x_{i1}, x_{i2}, \ldots, x_{iM})$.

For all data points there is no defined label. Thus the program tries to measure the similarity (or dissimilarity) between all the data points and group them into clusters to infer more about the data set as a whole.

Example: Clustering people with similar likes and dislikes together in order to better market a product for them.

Unsupervised Learning

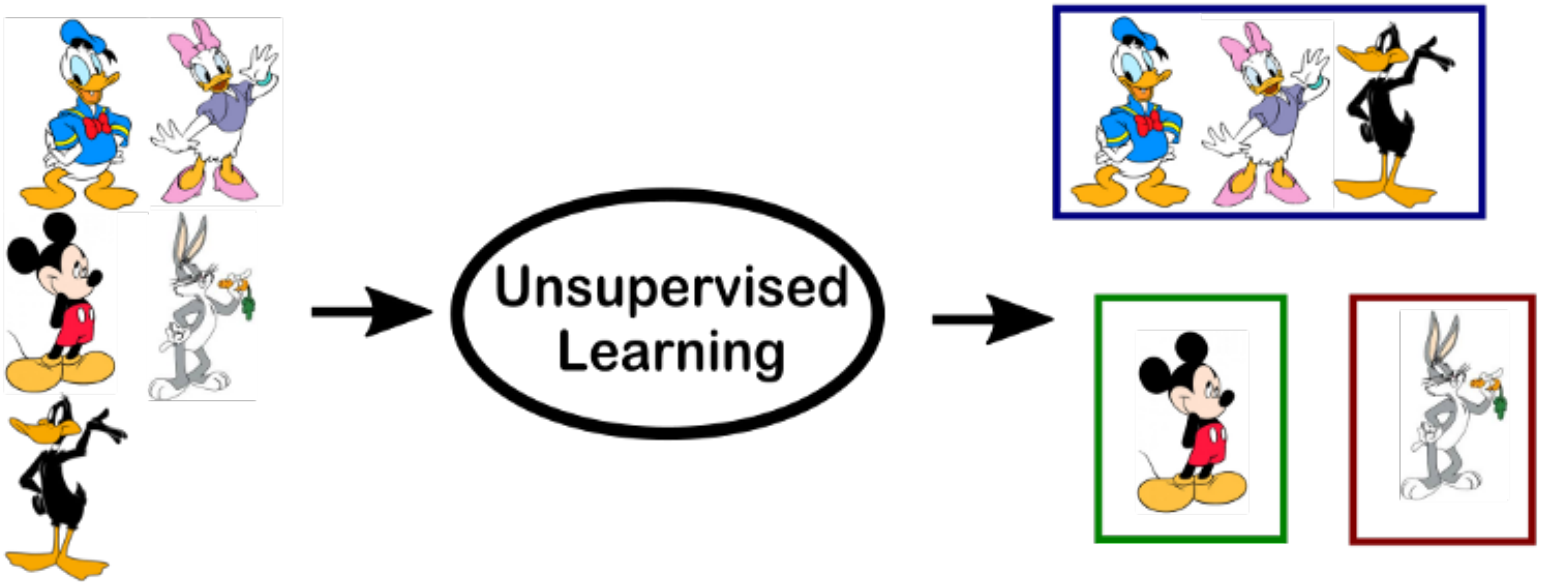

Figure: An example of what clustering is supposed to do with a dummy data set. *Image Source*

Reinforcement Learning

The branch of machine learning that is concerned with making decisions.

The program, referred to as the agent, is placed in an environment that it doesn't know and is given the chance to take actions from a set of actions. Based on those actions it may receive a reward or a punishment. Depending on all those criteria, the agent tries to maximize the reward it can obtain.

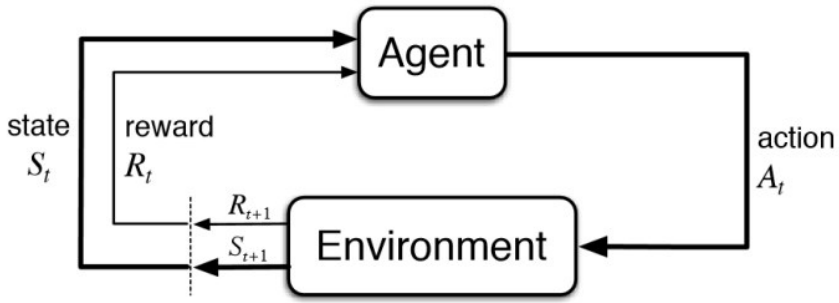

Figure: The agent-environment reward cycle. *Image Source*

Other Kinds of Machine Learning

- Semi-supervised Learning
  A fusion between supervised and unsupervised learning. In it a program trains on large amounts of data some of which are labeled, and some are not. So a combination of both learning techniques can net desired results.
  Many facial recognition systems use both semi-supervised learning to classify certain people then cluster unlabeled points close to the labeled ones.
- Transfer Learning
  Involves using models that were already trained to solve a problem and adjusting them in some way so that they may solve a completely different problem.
  Taking a model for a self driving car and using it to make a self driving motorbike.