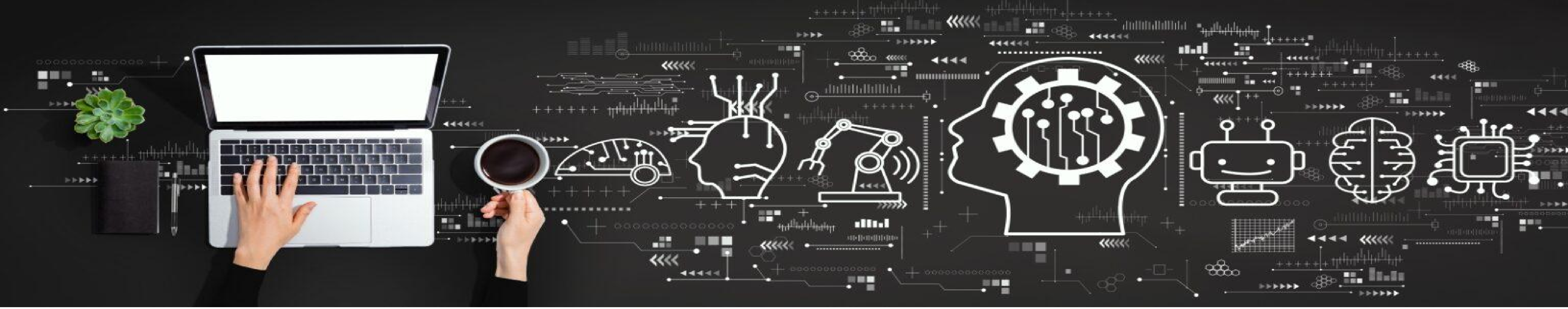

The Fundamentals of Machine Learning

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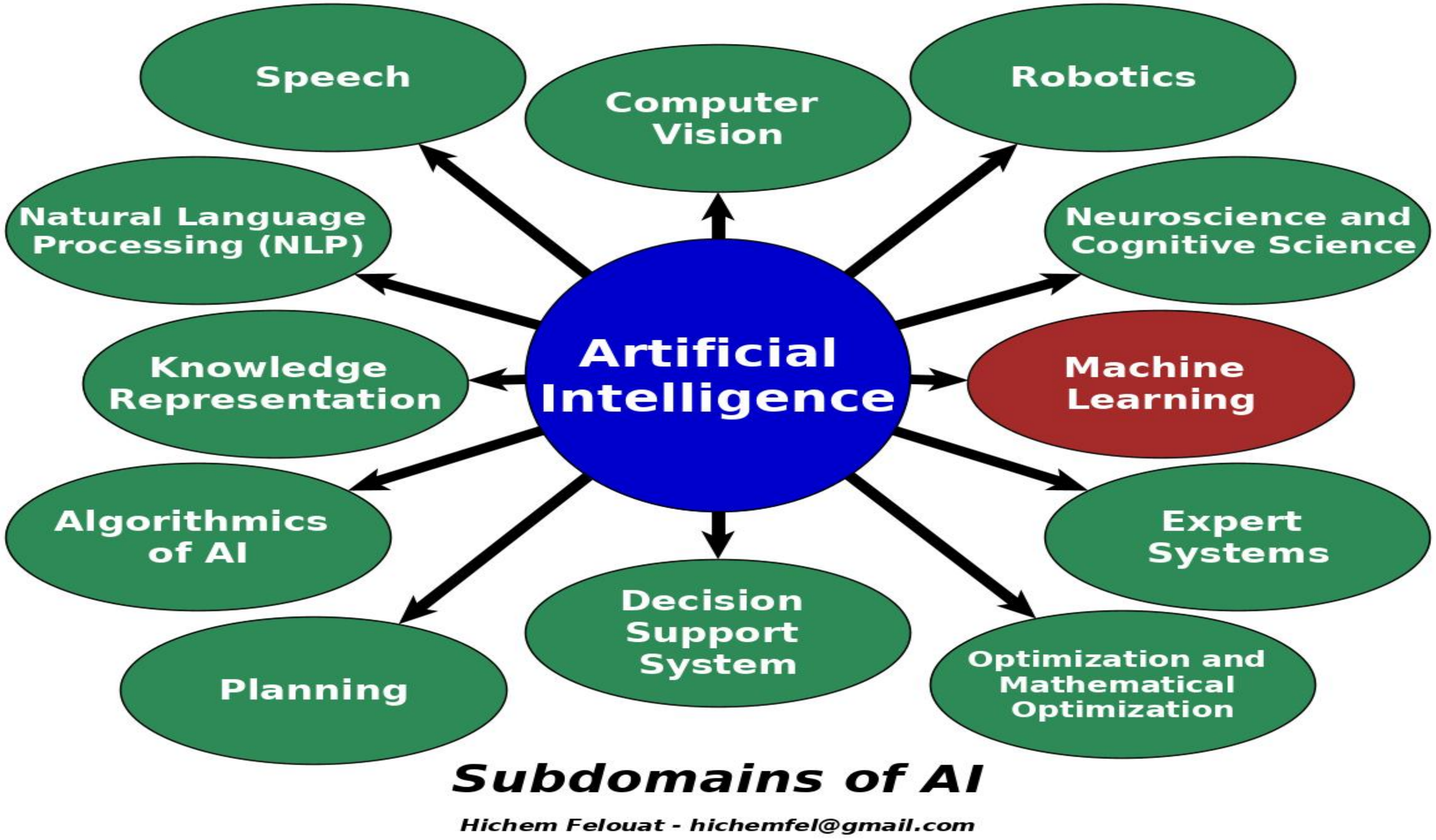
What Is Artificial Intelligence?

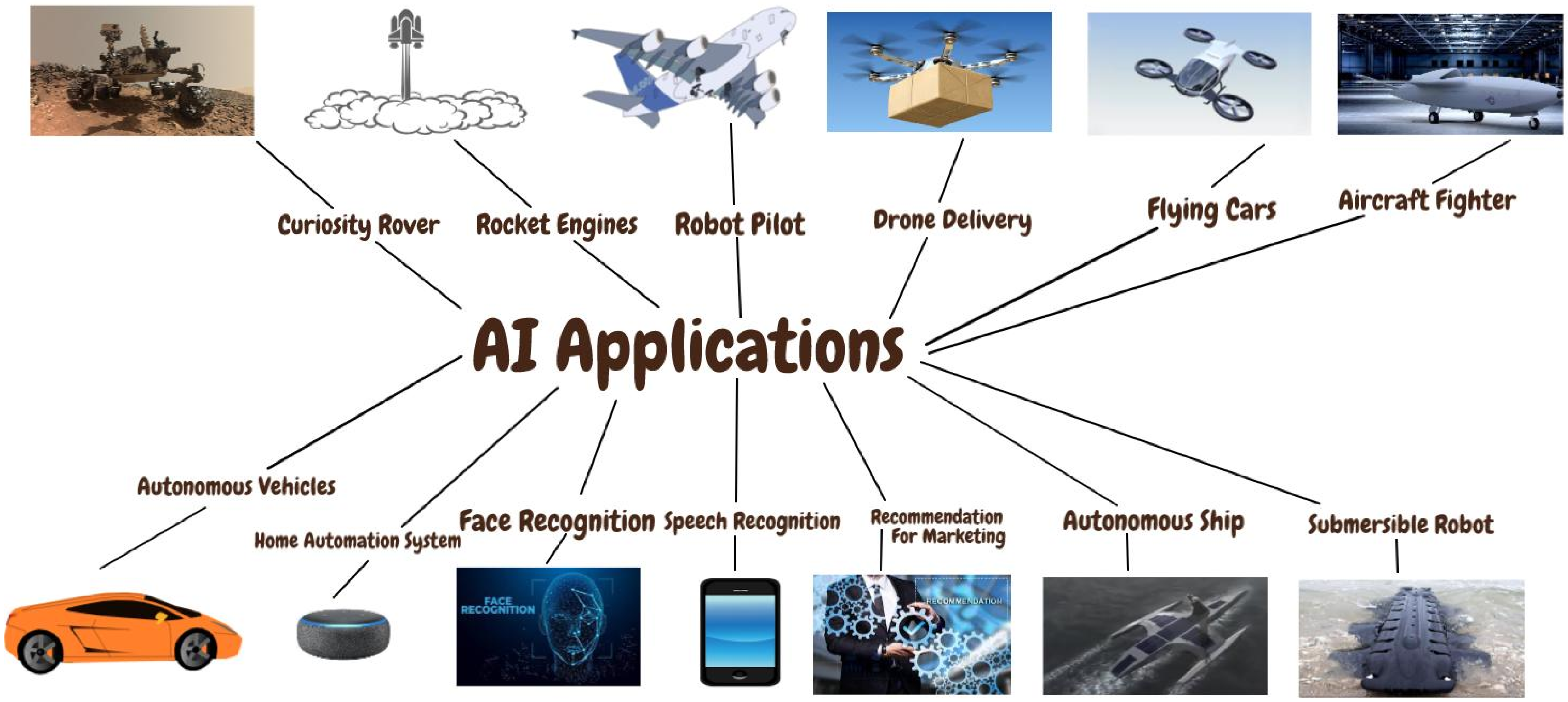
Artificial intelligence (AI) is an area of **computer science** that emphasizes **the creation of intelligent machines** that **work** and **react** like humans.

- **AI** is an interdisciplinary science with multiple approaches.
- **AI** has become an essential part of the technology industry.

Subdomains of Artificial Intelligence



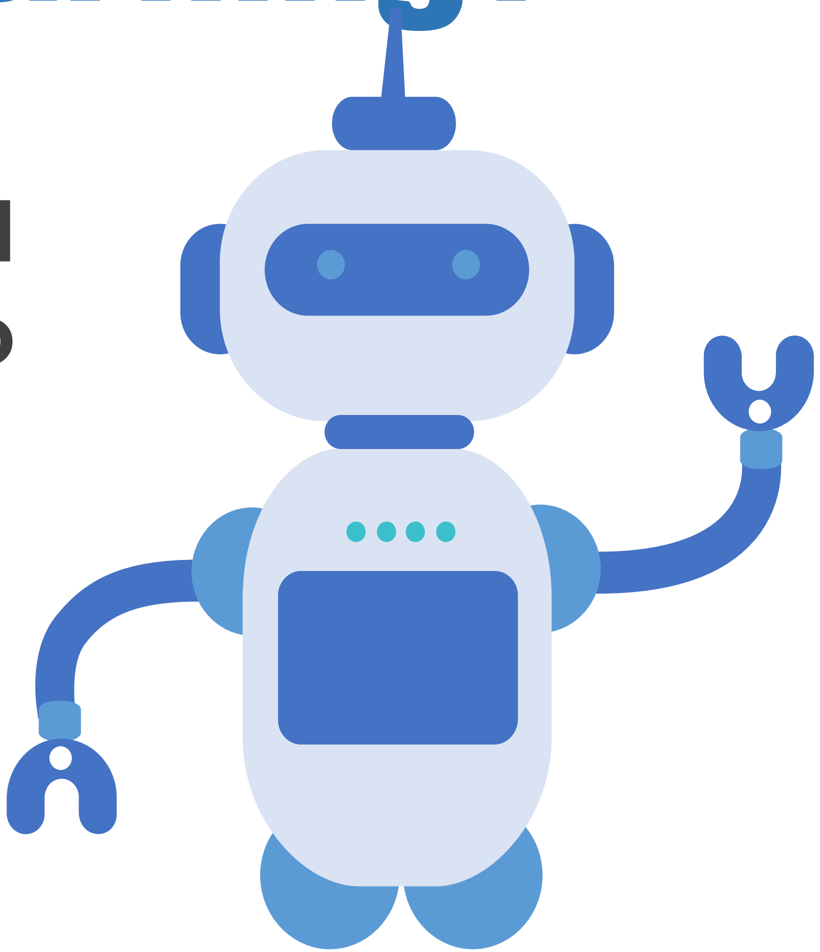
Artificial Intelligence Applications



What Is Machine Learning?

- **Machine Learning** is the science (and art) of programming computers so they can learn from **data**.

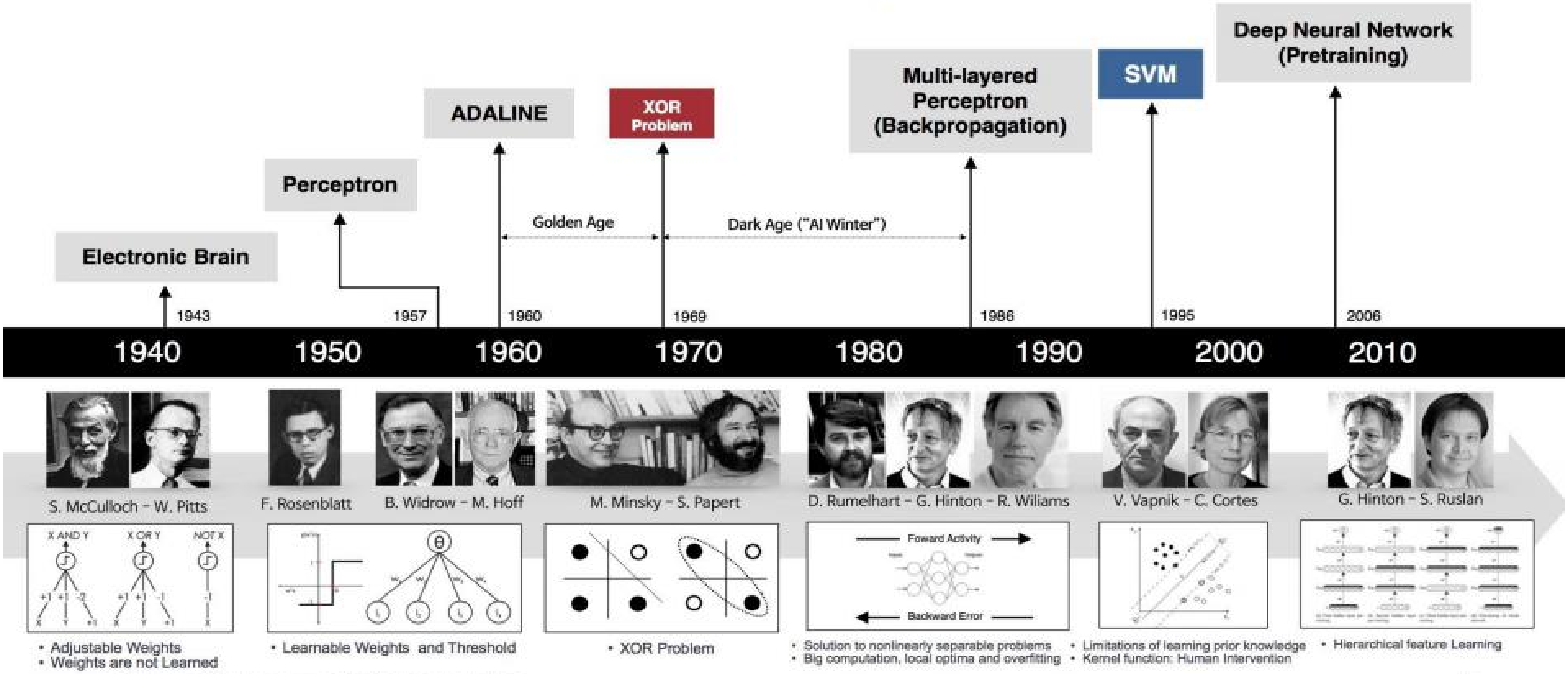
- Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed. - **Arthur Samuel, 1959**.



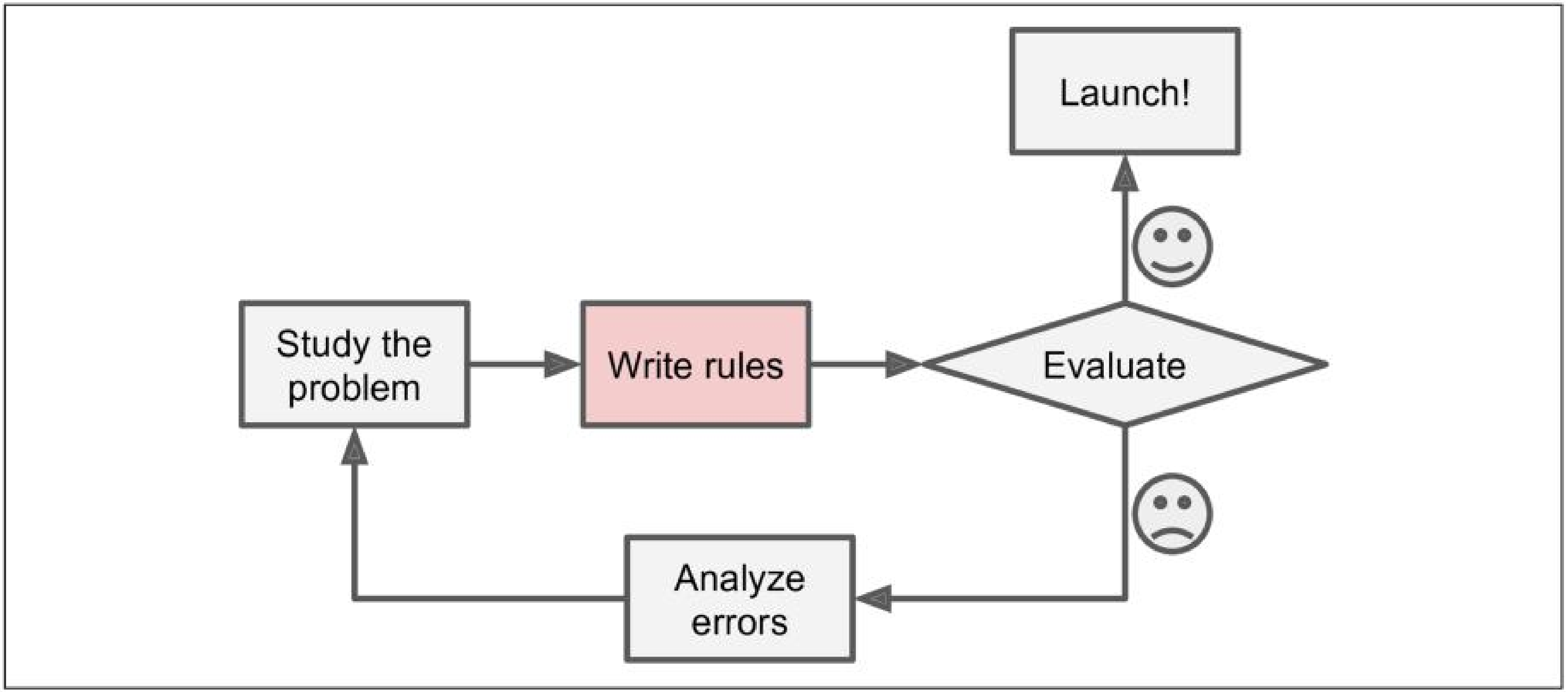
What Does Learning Mean?

A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E. —Tom Mitchell, 1997

Timeline of Machine Learning



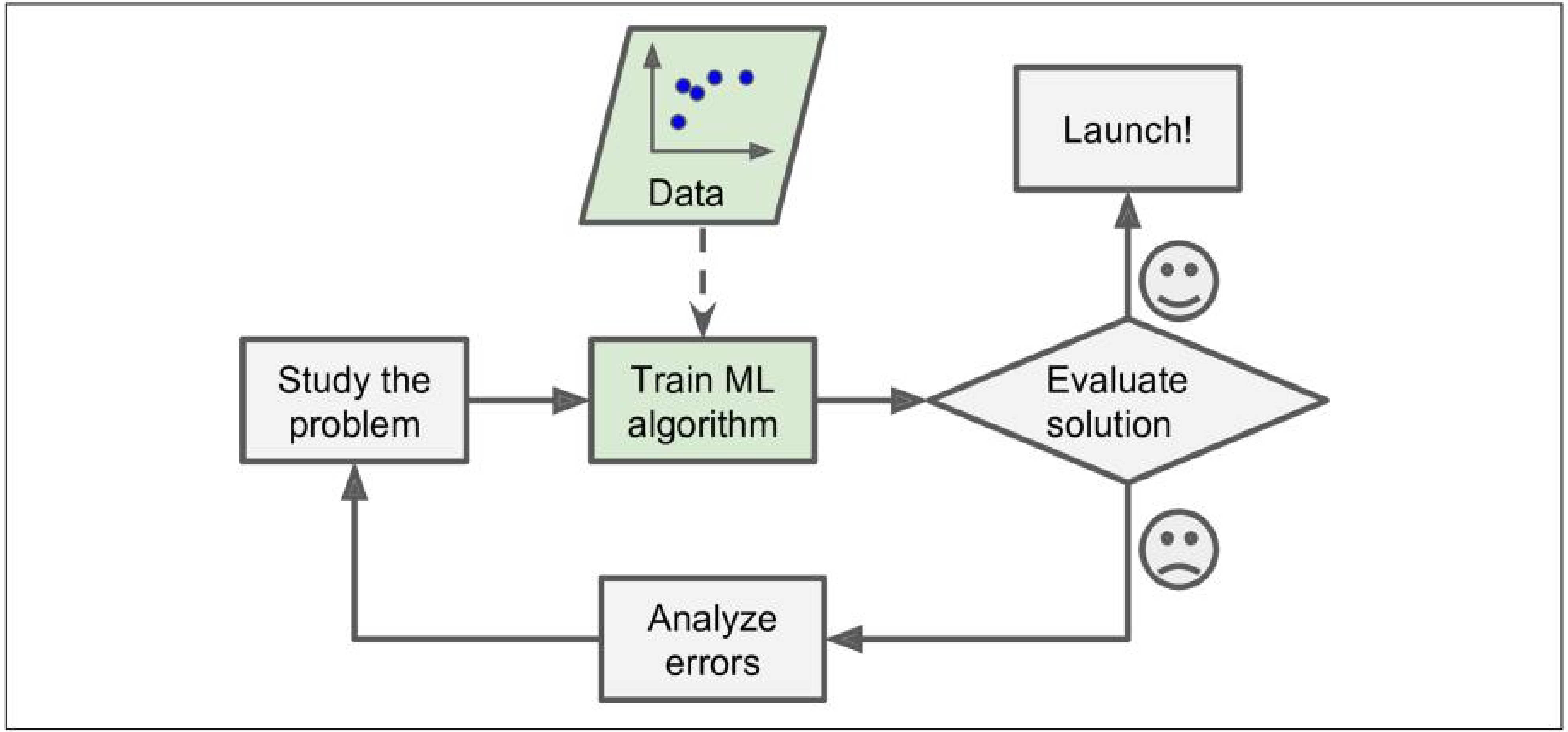
Why Use Machine Learning?



The traditional approach. ***If the problem is not trivial, your program will likely become a long list of complex rules pretty hard to maintain.***

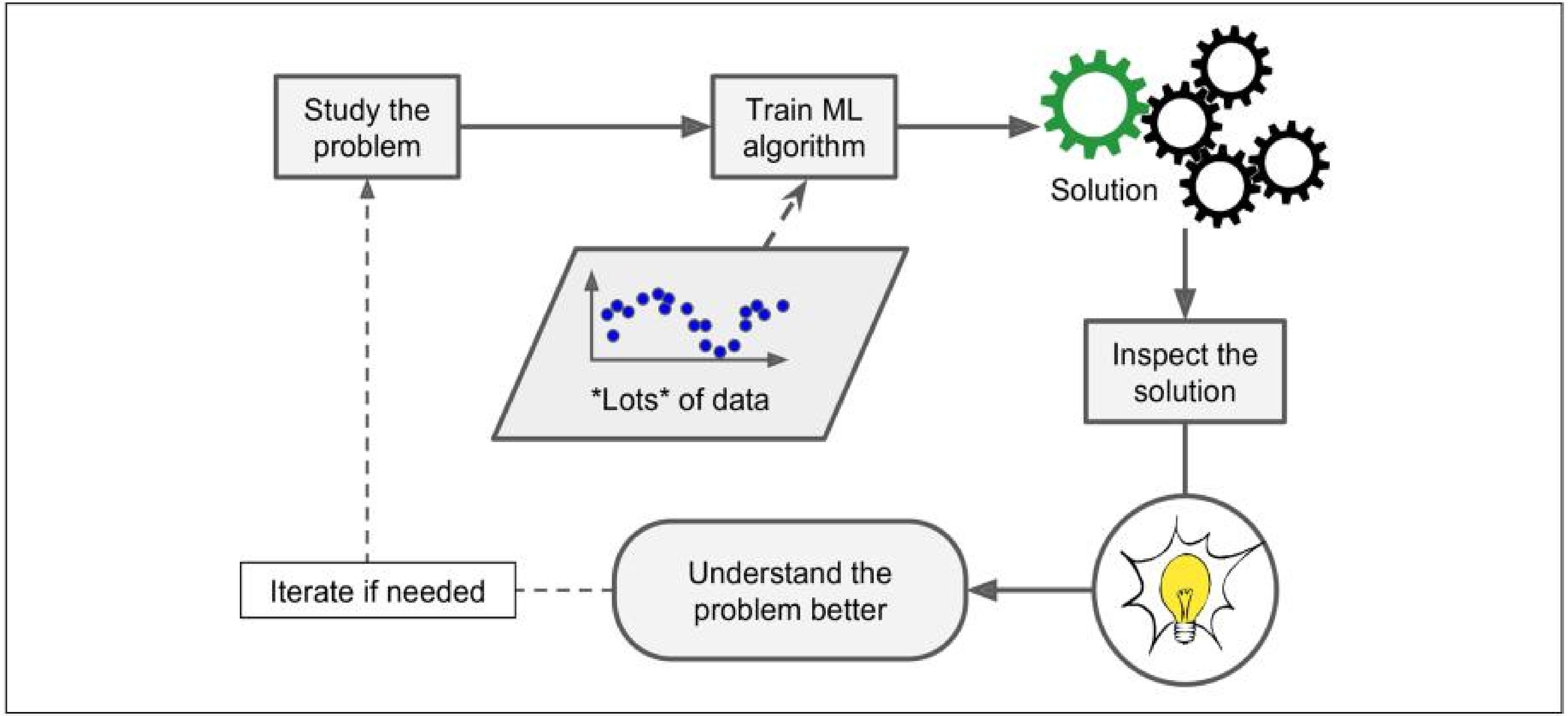
Why Use Machine Learning?

Why Use Machine Learning?



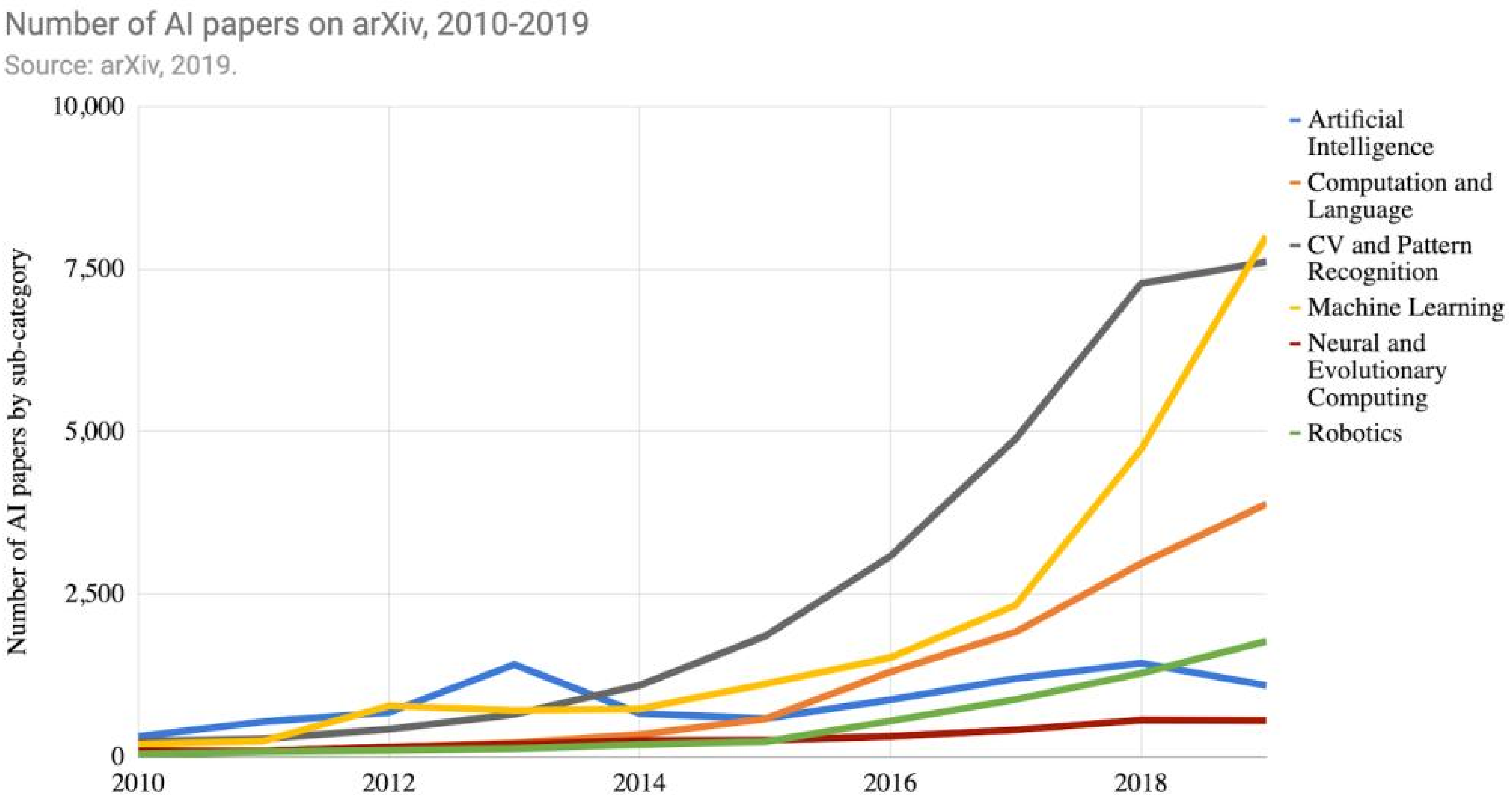
***Machine Learning approach**. The program is much shorter, easier to maintain, and most likely more accurate.*

Why Use Machine Learning?



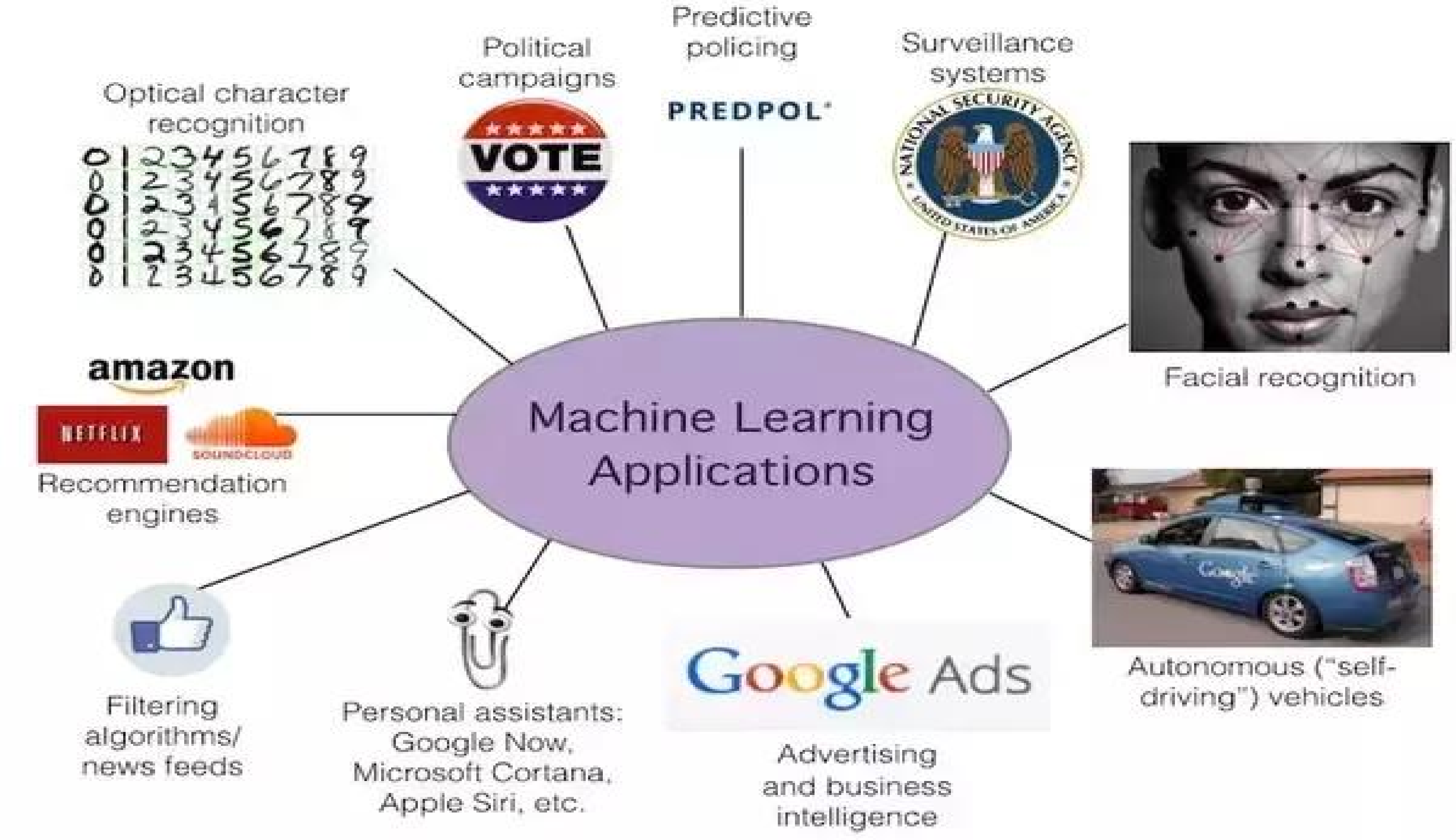
Machine Learning can help humans learn.

Why Use Machine Learning?



AI Index 2019 Annual Report.

Applications of **Machine** Learning



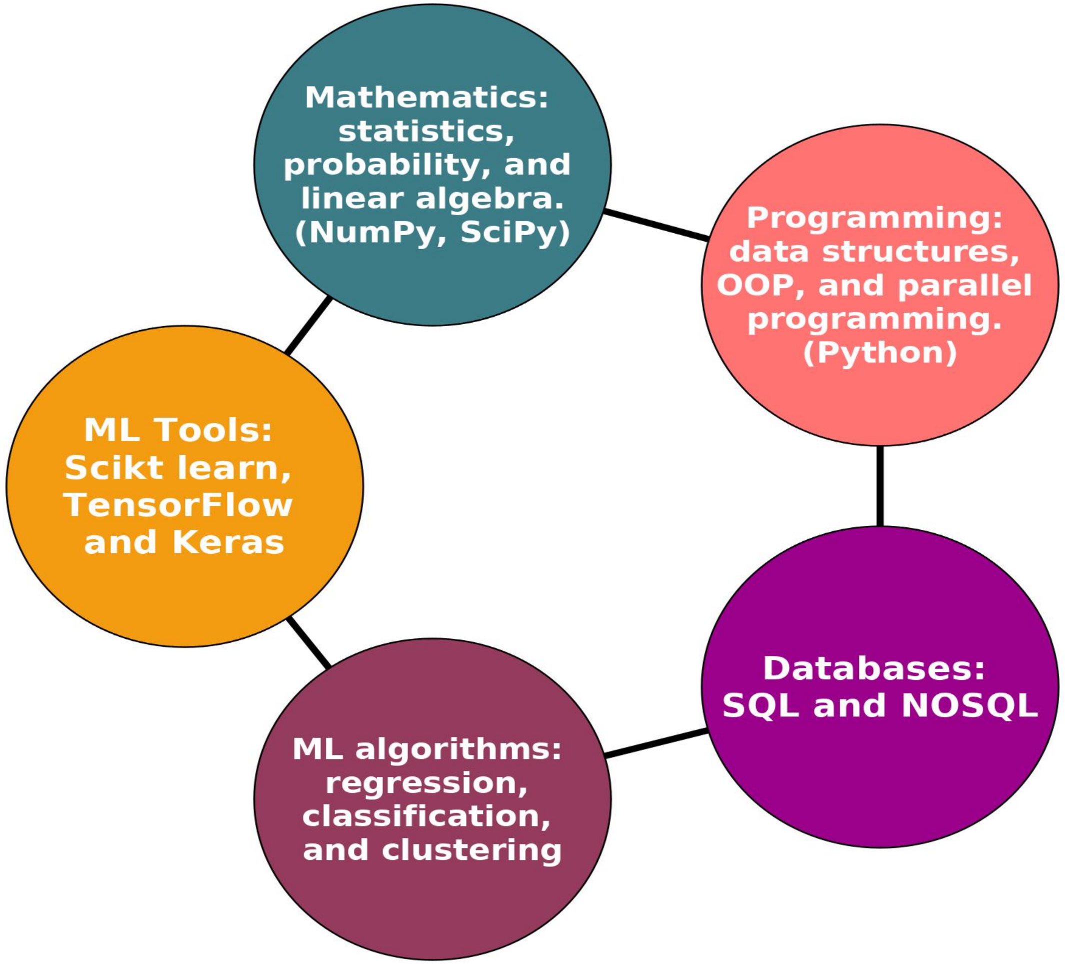
Applications of Machine Learning

To summarize, Machine Learning is great for:

- Problems for which existing solutions require a lot of hand-tuning or long lists of rules: one Machine Learning algorithm can often simplify code and perform better.

- Complex problems for which there is no good solution at all using a traditional approach: the best Machine Learning techniques can find a solution.

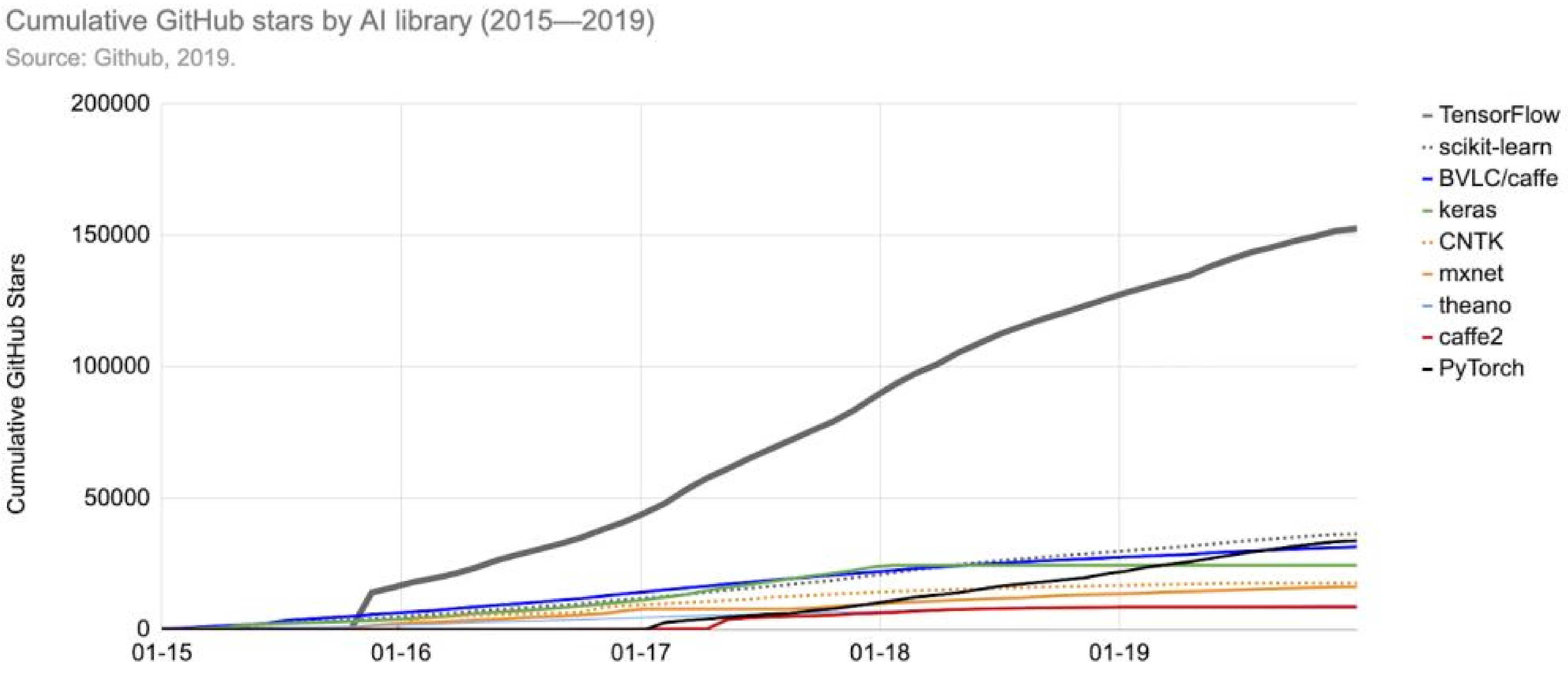
How to get started with ML



How to get started with Machine Learning

1) **Mathematics:** statistics, probability, and linear algebra.(NumPy, SciPy)
2) **Programming:** data structures, OOP, and parallel programming. (Python)
3) **Databases:** SQL and NOSQL.
4) **ML algorithms:** regression, classification, and clustering.
5) **ML Tools:** Scikt learn, TensorFlow and Keras.

How to get started with ML



Machine Learning Vocabulary 1

1) **Examples:** Items or instances of data used for learning or evaluation. In our spam problem, these examples correspond to the collection of email messages we will use for learning and testing.

2) **Training sample:** Examples used to train a learning algorithm. In our spam problem, the training sample consists of a set of email examples along with their associated labels.

3) **Labels:** Values or categories assigned to examples. In classification problems, examples are assigned specific categories, for instance, the spam and not-spam categories in our binary classification problem. In regression, items are assigned real-valued labels.

Machine Learning Vocabulary 2

4) **Features:** The set of attributes, often represented as a vector, associated to an example. In the case of email messages, some relevant features may include the length of the message, the name of the sender, various characteristics of the header, the presence of certain keywords in the body of the message, and so on.

5) **Test sample:** Examples used to evaluate the performance of a learning algorithm. The test sample is separate from the training and validation data and is not made available in the learning stage. In the spam problem, the test sample consists of a collection of email examples for which the learning algorithm must predict labels based on features. These predictions are then compared with the labels of the test sample to measure the performance of the algorithm.

6) **Loss function:** A function that measures the difference, or loss, between a predicted label and a true label.

Machine Learning Vocabulary

Features

Lab
el

Examples (Training sample + Test sample) = Dataset

	rank	discipline	yrs.since.phd	yrs.service	sex	salary
1	Prof	B	19	18	Male	139750
2	Prof	B	20	16	Male	173200
3	AsstProf	B	4	3	Male	79750
4	Prof	B	45	39	Male	115000
5	Prof	B	40	41	Male	141500
6	AssocProf	B	6	6	Male	97000
7	Prof	B	30	23	Male	175000
8	Prof	B	45	45	Male	147765
9	Prof	B	21	20	Male	119250
10	Prof	B	18	18	Female	129000

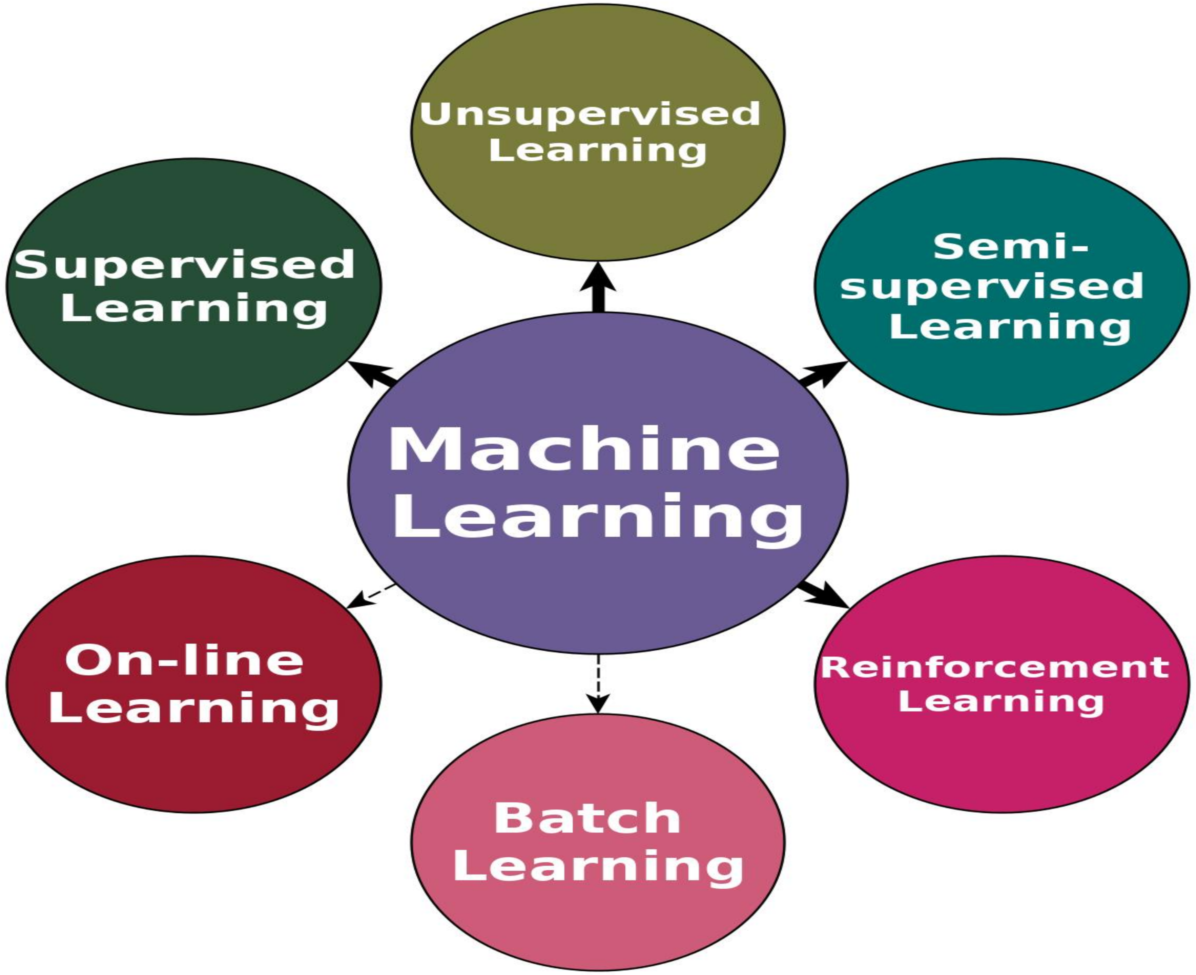
One Example

Types of Machine Learning Systems

There are so many different types of Machine Learning systems that it is useful to classify them in broad categories based on:

- Whether or not they are trained with human supervision (supervised, unsupervised, semisupervised, and Reinforcement Learning).
- Whether or not they can learn incrementally on the fly (online versus batch learning).
- Whether they work by simply comparing new data points to known data points, or instead detect patterns in the training data and build a predictive model, much like scientists do (instance-based versus model-based learning).

Types of Machine Learning Systems



The types of machine learning

Hichem Felouat

Types of Machine Learning Systems

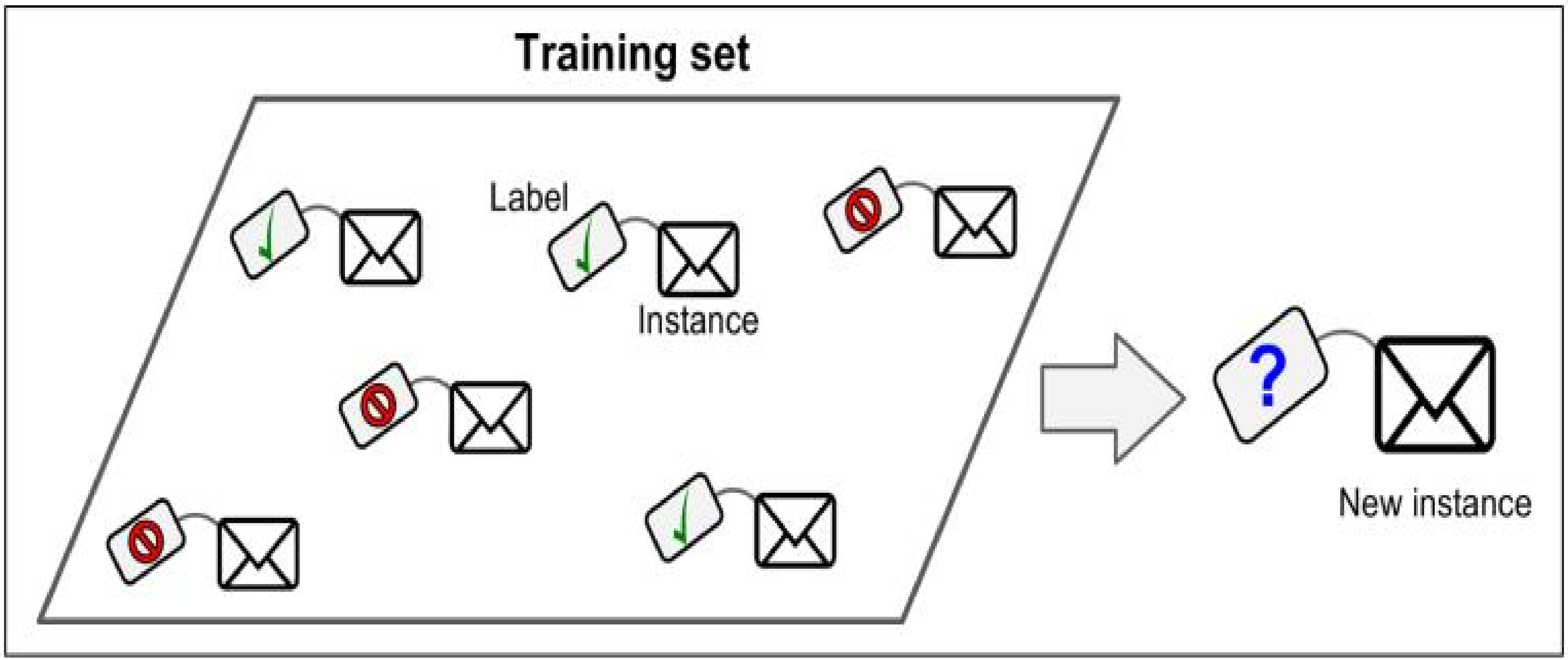
Supervised learning :

In supervised learning, the training data you feed to the algorithm includes the **desired solutions**, called **labels**.

$$\mathcal{D} = \{(\mathbf{x}^{(1)}, y^{(1)}), (\mathbf{x}^{(2)}, y^{(2)}), \cdots, (\mathbf{x}^{(n)}, y^{(n)})\}$$

- When ***y*** is real, we talk about ***regression***.
- When ***y*** is discrete, we talk about ***classification***.

Types of Machine Learning Systems



A labeled training set for supervised learning.

Types of Machine Learning Systems

Here are some of the most important supervised learning algorithms:

- k-Nearest Neighbors
- Linear Regression
- Logistic Regression
- Support Vector Machines (SVMs)
- Decision Trees and Random Forests
- Neural networks*

Types of Machine Learning Systems

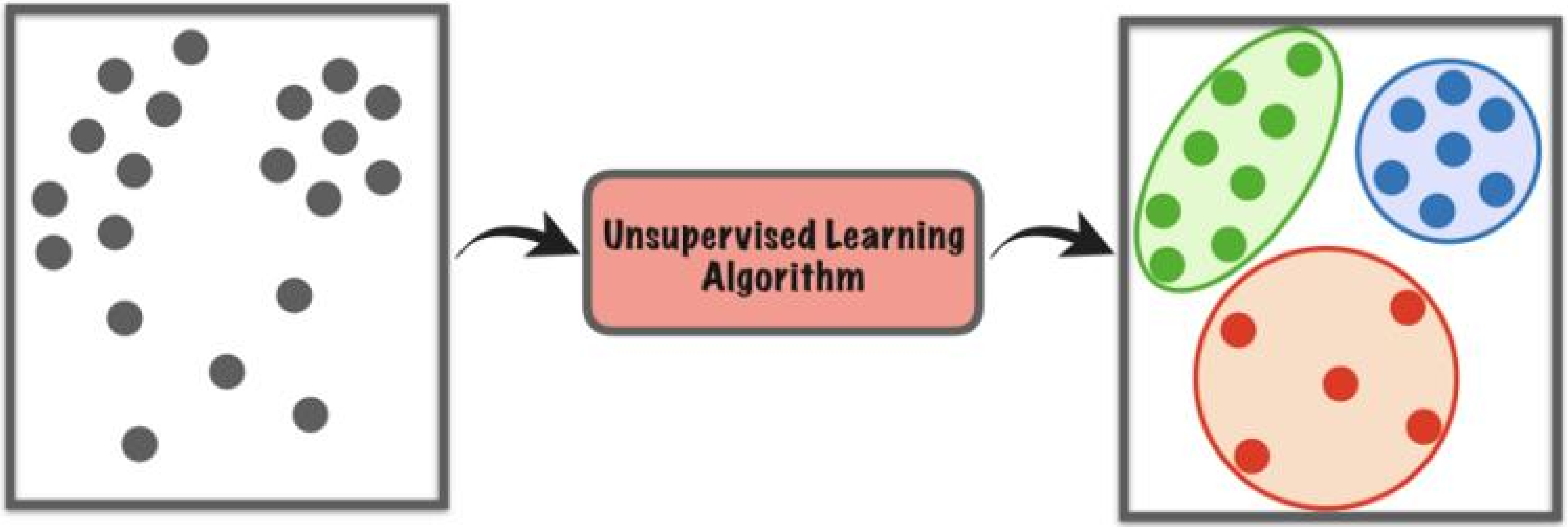
Unsupervised Learning:

In unsupervised learning, as you might guess, **the training data is unlabeled**. The system tries to learn without a teacher.

$$\mathcal{D} = \{x^{(1)}, x^{(2)}, \cdots, x^{(n)}\}$$

No labels are given to the learning algorithm, leaving it on its own to explore or find structure in the data.

Types of Machine Learning Systems



An unlabeled training set for unsupervised learning.

Types of Machine Learning Systems

Here are some of the most important unsupervised learning algorithms:

- Clustering
- Visualization and dimensionality reduction

Types of Machine Learning Systems

Semi-Supervised Learning :

Some algorithms can deal with **partially labeled training data**, usually a lot of **unlabeled data** and a little bit of **labeled data**. This is called semi-supervised learning.

Most semi-supervised learning algorithms are **combinations of unsupervised and supervised algorithms**.

Types of Machine Learning Systems

Reinforcement Learning :

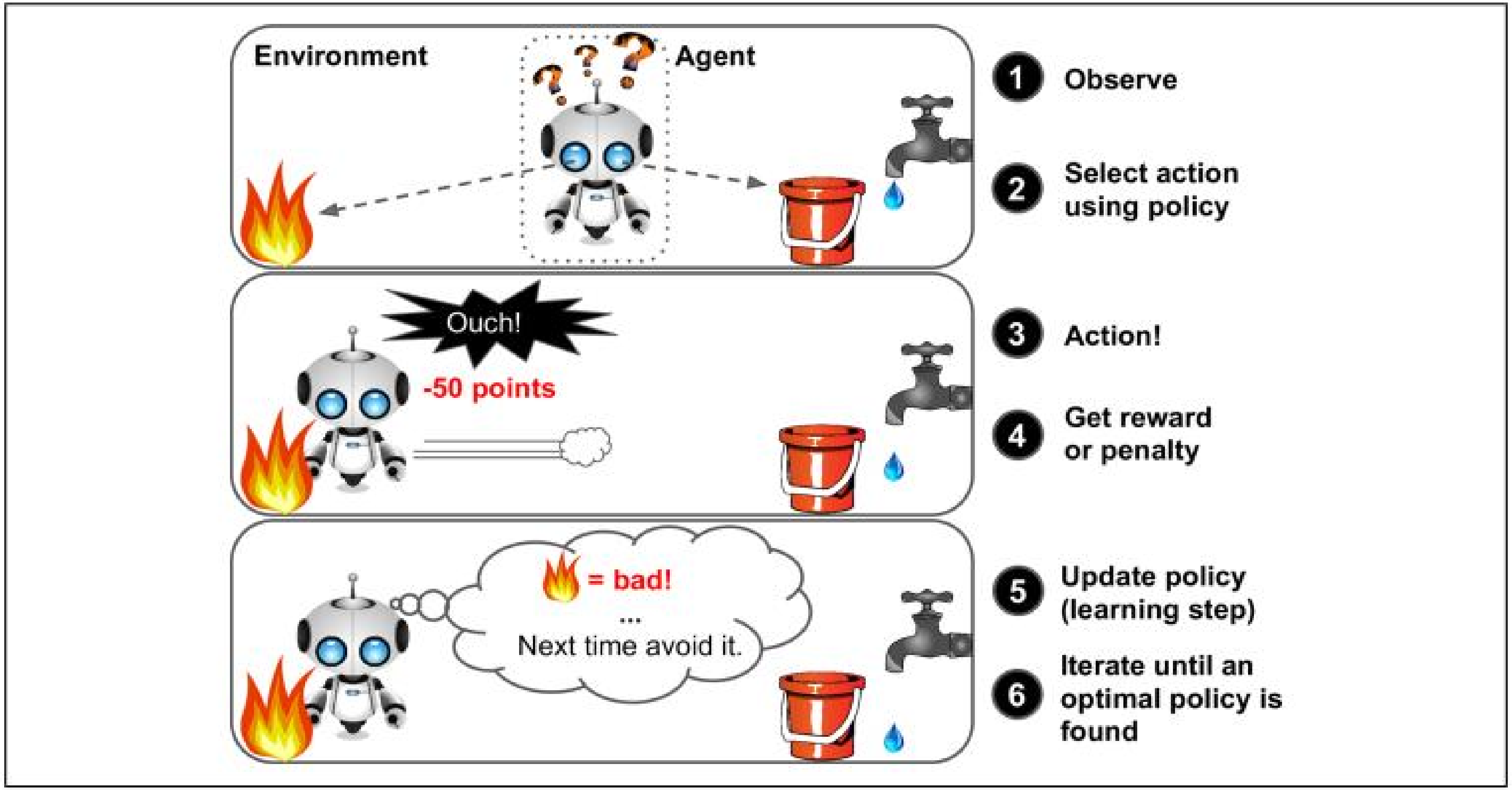
- The learning system called an **agent** in this context.

- Can **observe** the environment, **select and perform actions**, and **get rewards** in return (or penalties in the form of negative rewards).

- It must then learn by itself what is **the best strategy**, called a **policy**, to get the most reward over time.

- **A policy defines what action the agent should choose** when it is in a given situation.

Types of Machine Learning Systems



Reinforcement Learning

Types of Machine Learning Systems

Batch learning:

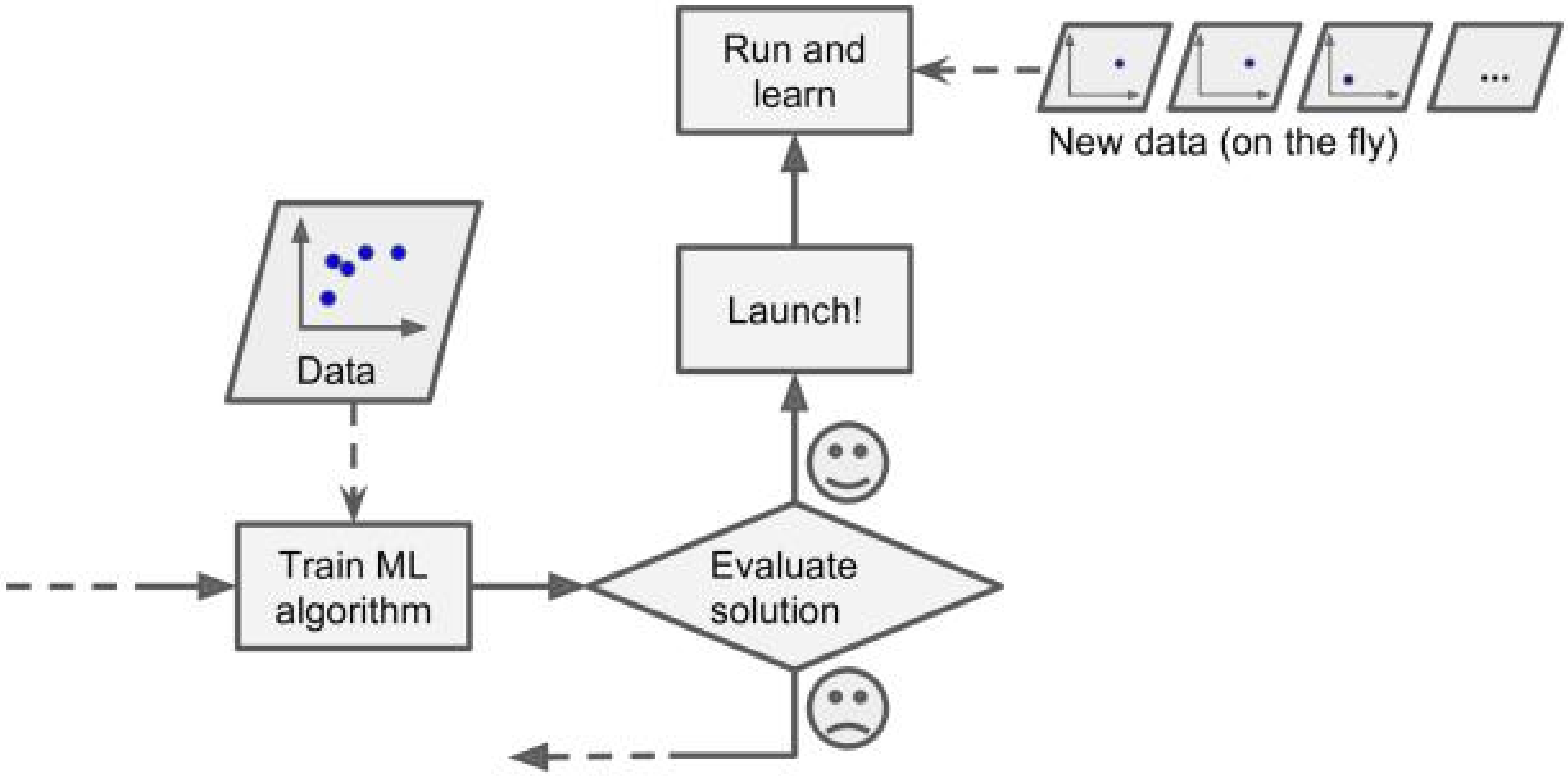
In batch learning, the system is incapable of learning incrementally: **it must be trained using all the available data.** This will generally take a lot of time and computing resources, so it is typically **done offline**. First, the system is trained, and then it is launched into production and runs without learning anymore; it just applies what it has learned. This is called offline learning.

Types of Machine Learning Systems

On-line learning:

In online learning, **you train the system incrementally by feeding it data instances sequentially**, either individually or by small groups called mini batches. Each learning step is fast and cheap, so **the system can learn about new data on the fly**, as it arrives.

Types of Machine Learning Systems

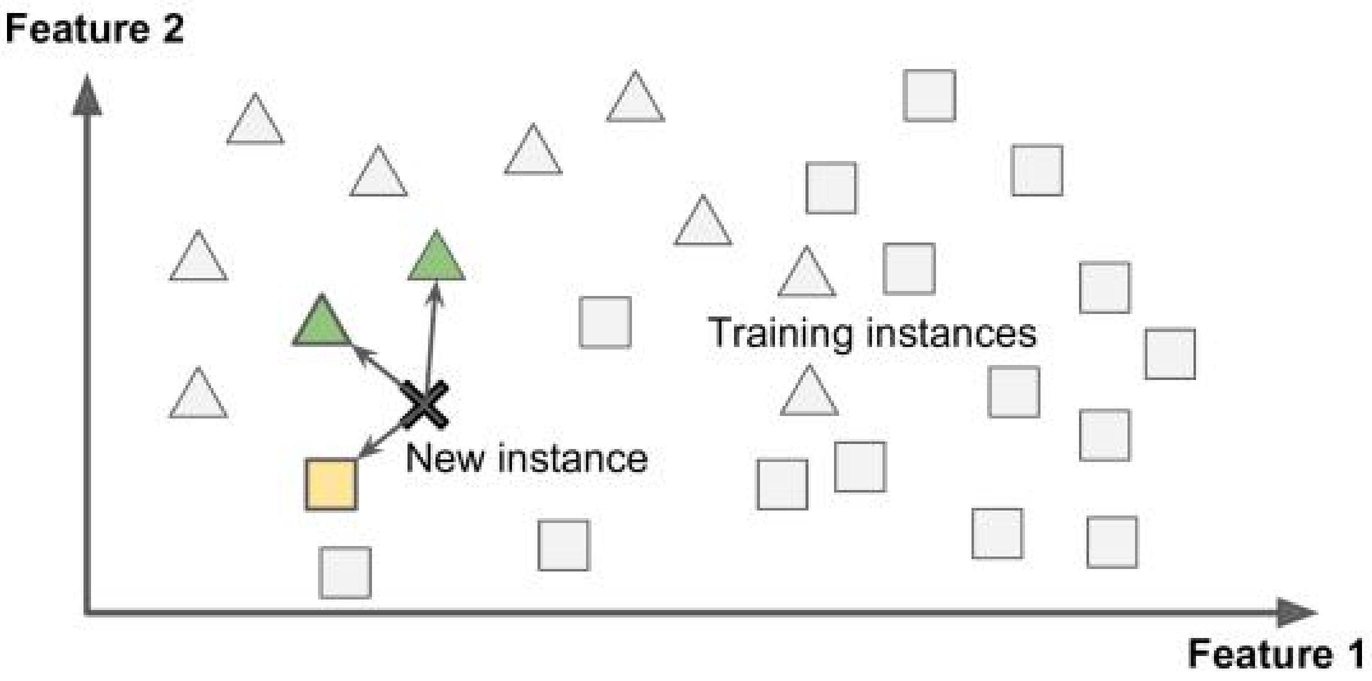


Online learning

Instance-Based VS Model-Based Learning

Instance-based learning:

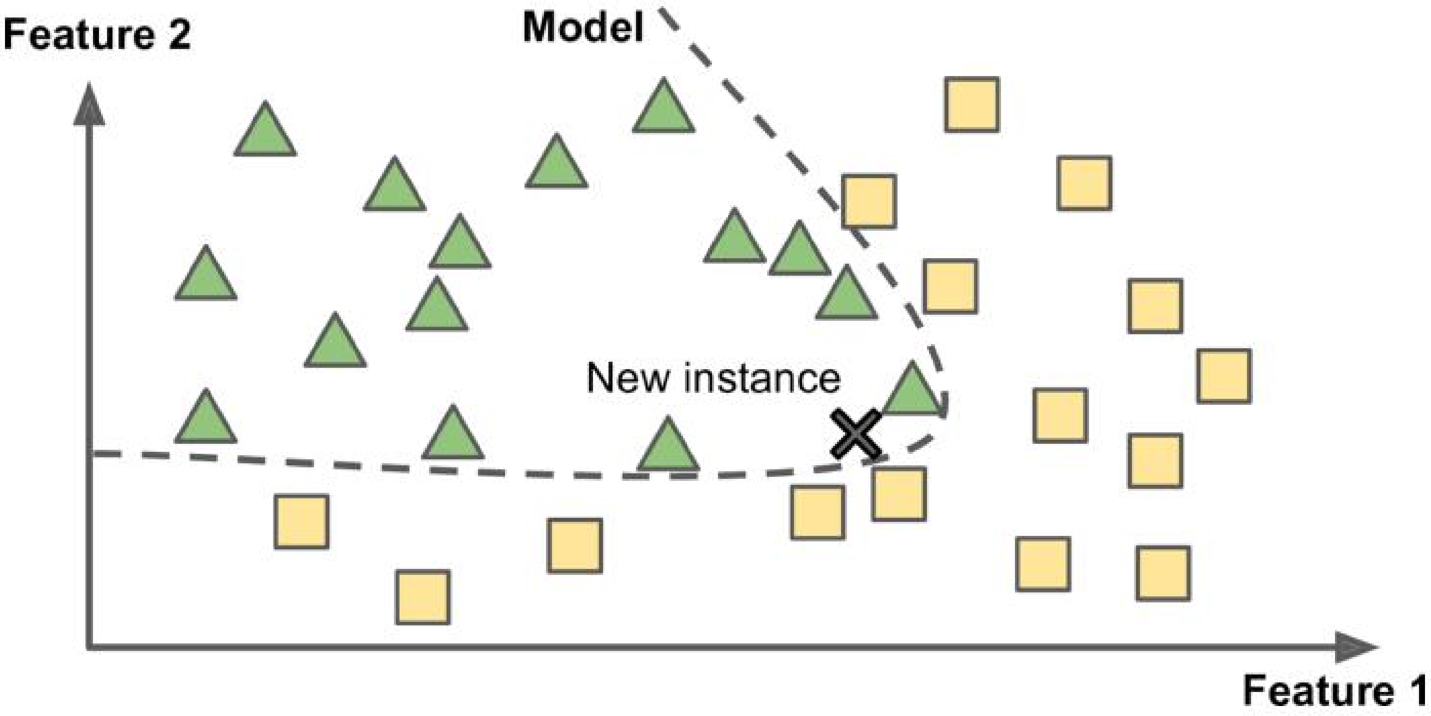
The system learns the examples by heart, then generalizes to new cases using a similarity measure.



Instance-Based VS Model-Based Learning

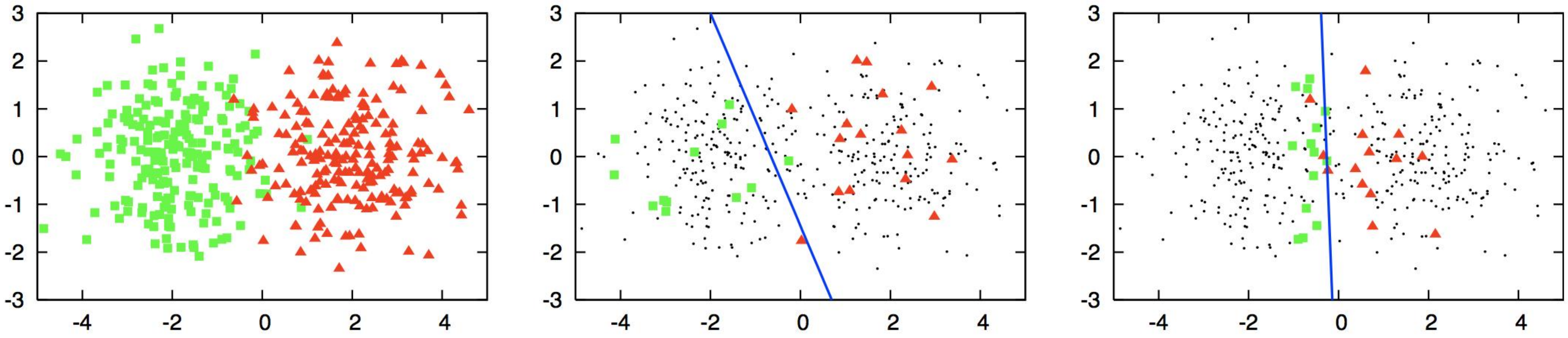
Model-based learning:

Build a model of these examples, then use that model to make predictions.



Active Learning vs Transfer Learning

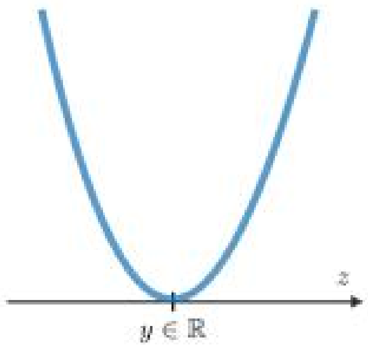
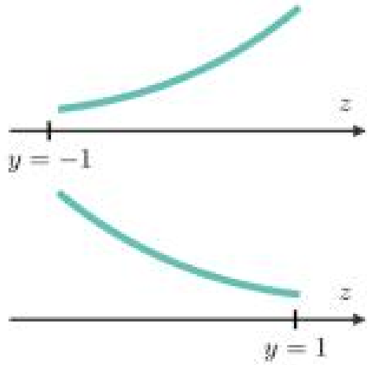
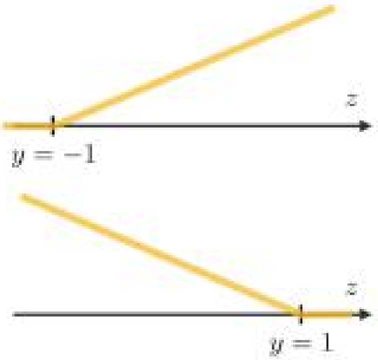
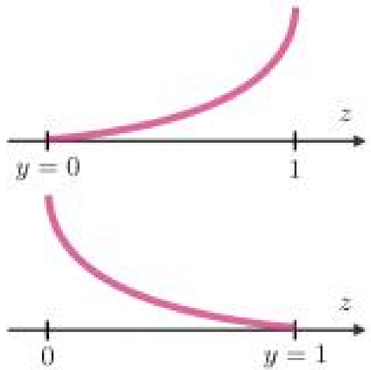
- **Active Learning** is a case of semi-supervised machine learning.
- For **classification**, you would want to sample a small subset of examples and **find those labels** and use these labeled examples as your training data for a classifier.



Active Learning vs Transfer Learning

Transfer learning (TL) is a research problem in ML that focuses on storing knowledge gained while solving one problem and applying it to a different but related problem. **For example**, knowledge gained while learning to recognize Cats could apply when trying to recognize Tigers.

Loss Function

Least squared	Logistic	Hinge	Cross-entropy
$\frac{1}{2}(y-z)^2$	$\log(1+\exp(-yz))$	$\max(0,1-yz)$	$-\left[y\log(z)+(1-y)\log(1-z)\right]$
			
Linear regression	Logistic regression	SVM	Neural Network

The loss function computes the error for a **single training example**, while **the cost function** is the average of the loss functions of the entire training set.

Machine Learning Vocabulary 3

- **Hyperparameters :** are configuration variables that are external to the model and whose values cannot be estimated from data. That is to say, they can not be learned directly from the data in standard model training. They are almost always specified by the machine learning engineer prior to training.

- **Regression:** this is the problem of predicting a real value for each item. Examples of regression include prediction of stock values or that of variations of economic variables.

- **Classification:** this is the problem of assigning a category to each item.

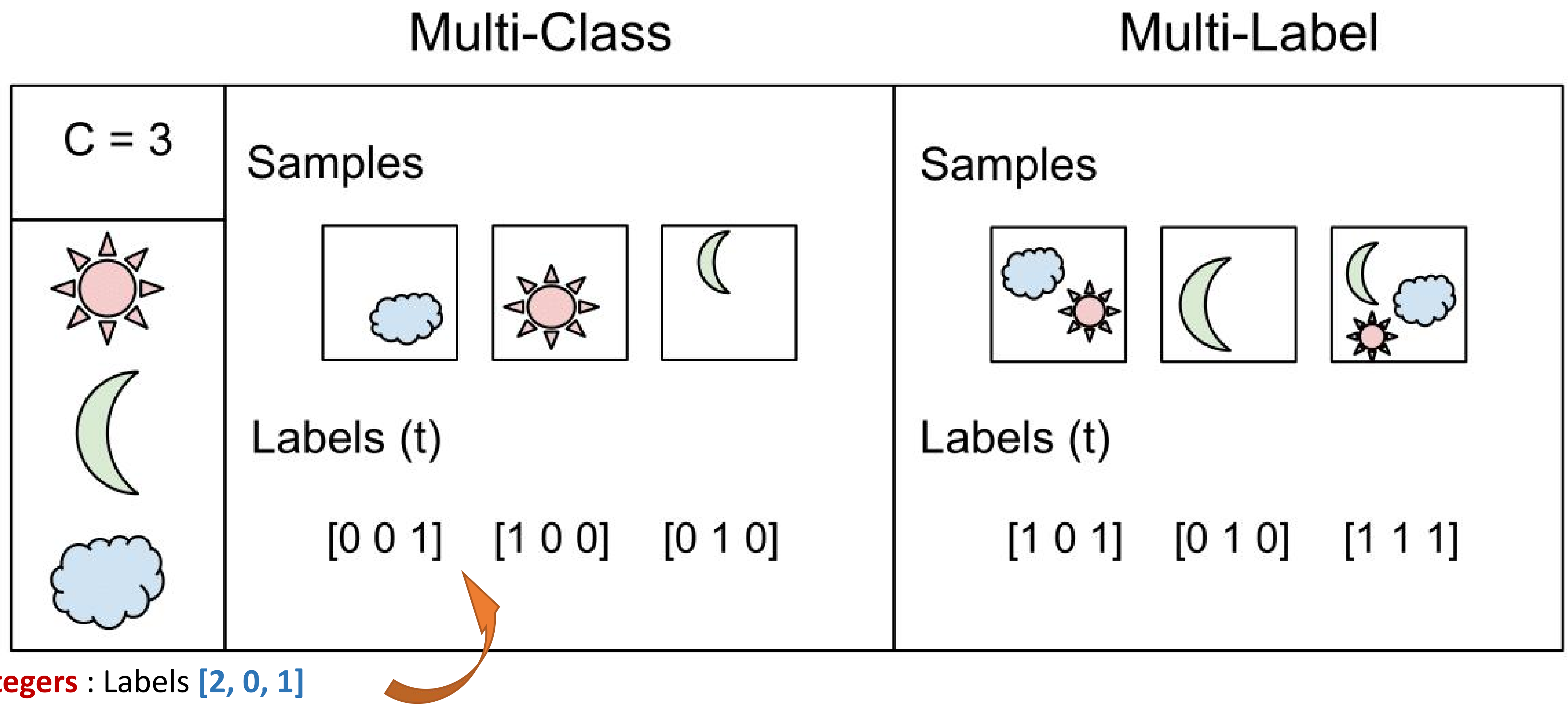
- **Clustering:** this is the problem of partitioning a set of items into homogeneous subsets.

Machine Learning Vocabulary 3

Simple Regression: If you want to **predict a single value** (e.g., the price of a house, given many of its features). The output is the predicted value.

Multivariate Regression (i.e., to **predict multiple values at once**). For example, to locate the center of an object in an image, you need to predict 2D coordinates.

Machine Learning Vocabulary 3



Integers : Labels **[2, 0, 1]**
one-hot : Labels **[[0 0 1], [1 0 0], [0 1 0]]**

In Summary

1) You studied the data.

2) You selected a model.

3) You trained it on the training data.

4) Finally, you applied the model to make predictions on new cases.

Thank you for your attention

Hichem Felouat …