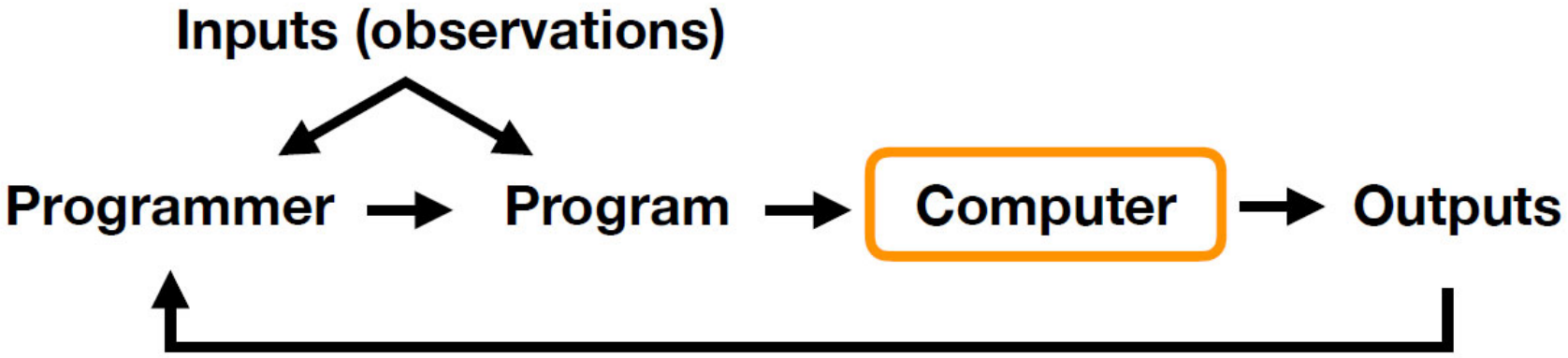
Introduction

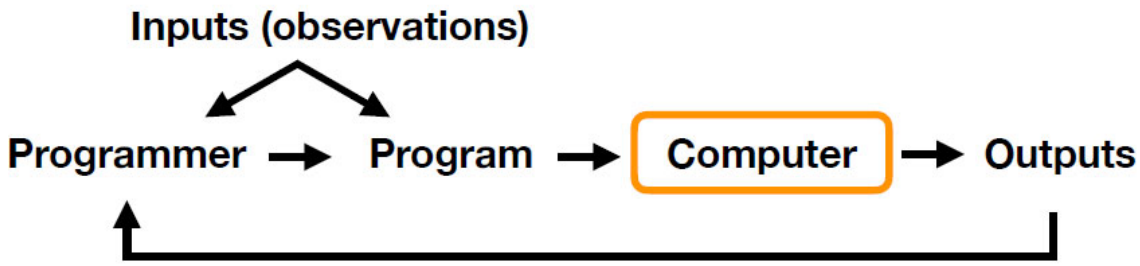
Fatemeh Mansoori

This slide are based the slides by Sebastian Raschka for intro. to machine learning course

What is machine learning

The traditional Programming Paradigm





Machine learning is the field of study that gives computers the ability to learn without being explicitly programmed

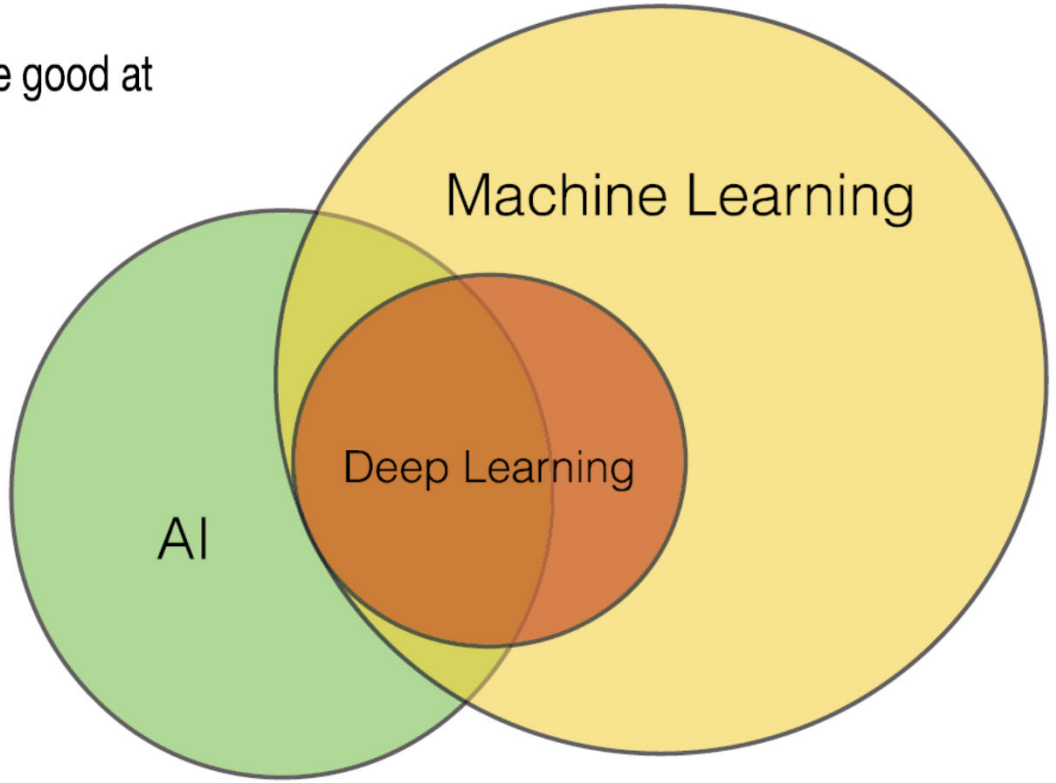
— *Arthur Samuel (1959)*

The Connection between fields

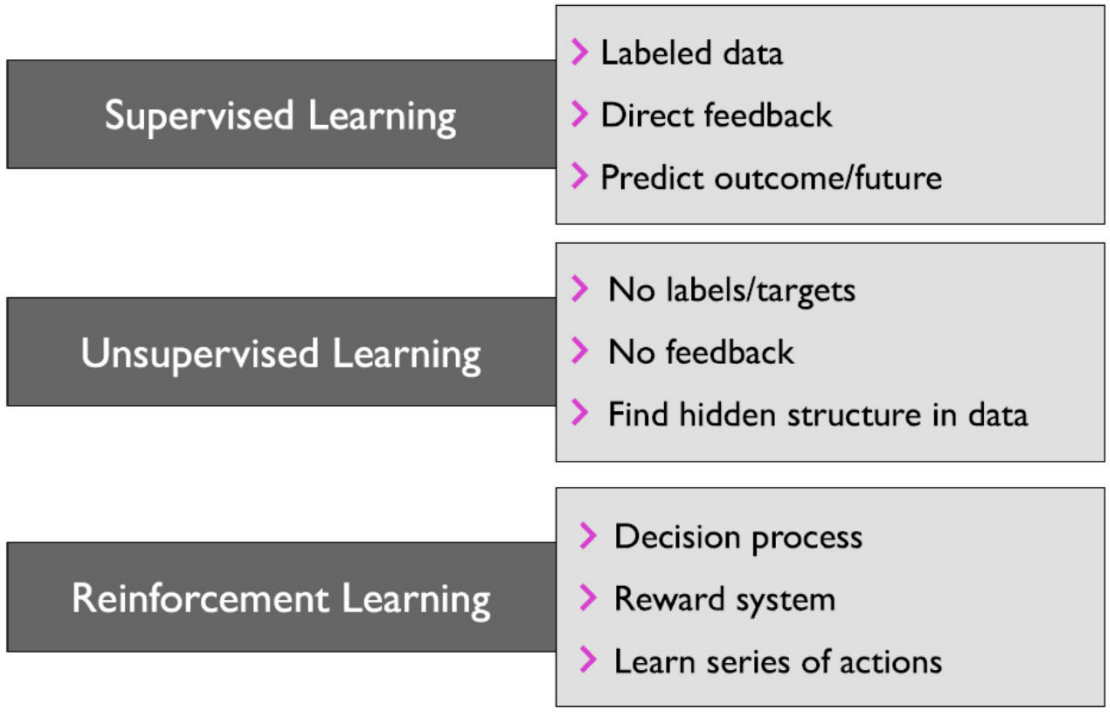
Artificial Intelligence (AI):
orig. subfield of computer science, solving tasks humans are good at

Narrow AI:
solving a particular task (playing a game, driving a car, ...)

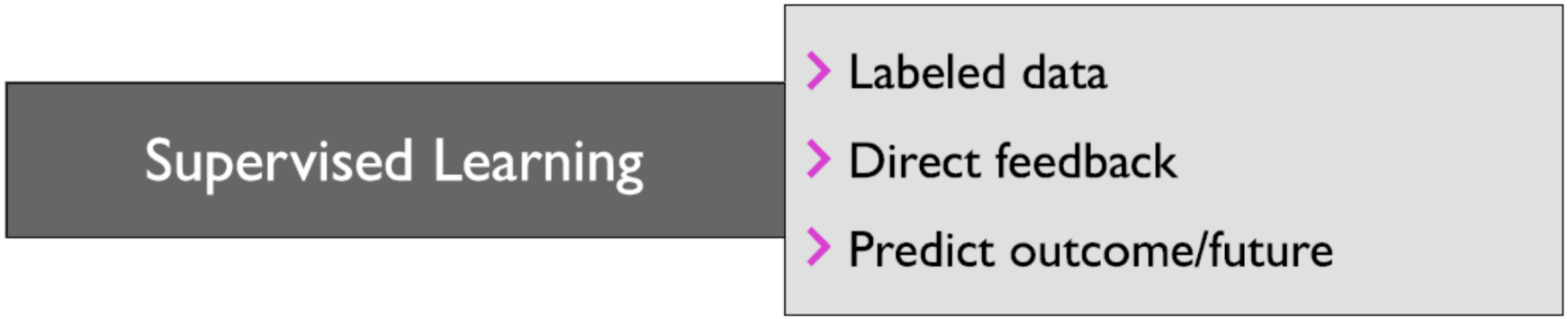
Artificial General Intelligence (AGI):
multi-purpose AI mimicking human intelligence across tasks



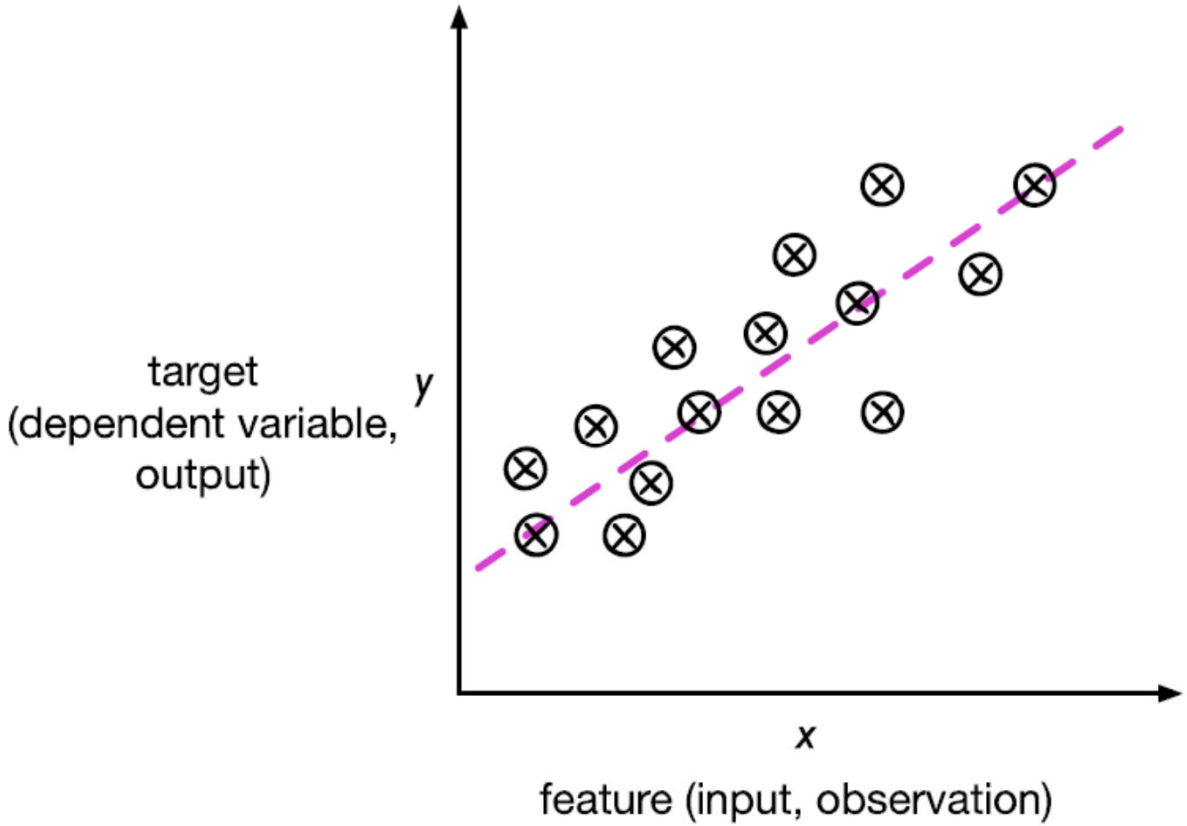
Categories of Machine Learning



Supervised Learning Is The Largest Subcategory



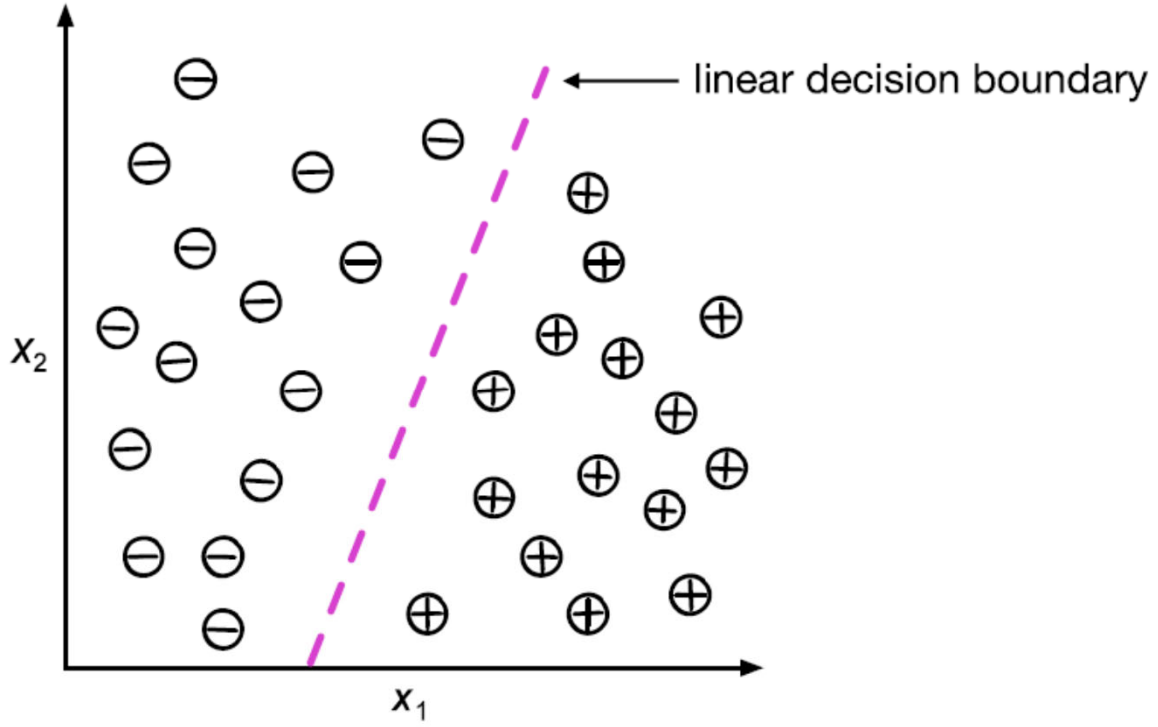
Supervised Learning 1: Regression



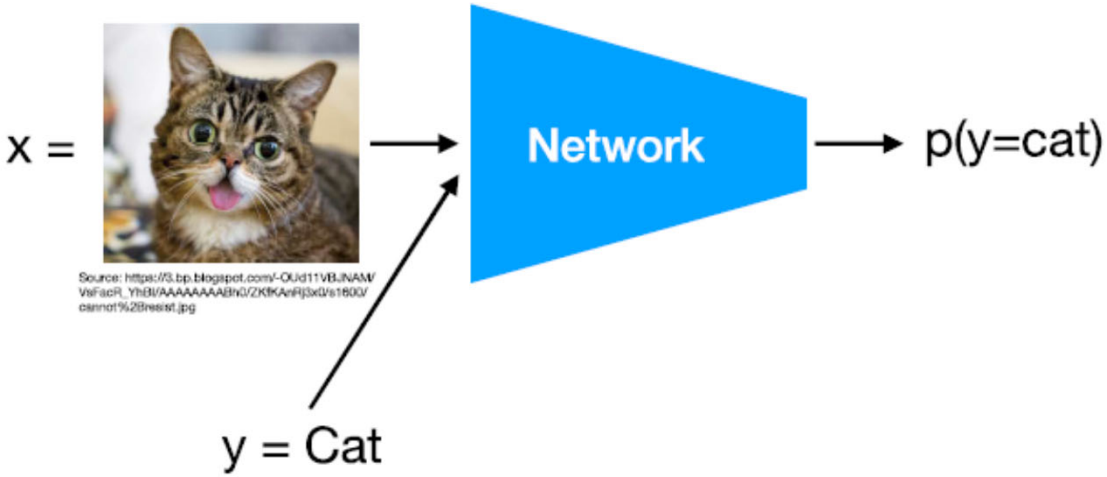
Supervised Learning 2: Classification

Binary classification example with two *features* ("independent" variables, predictors)

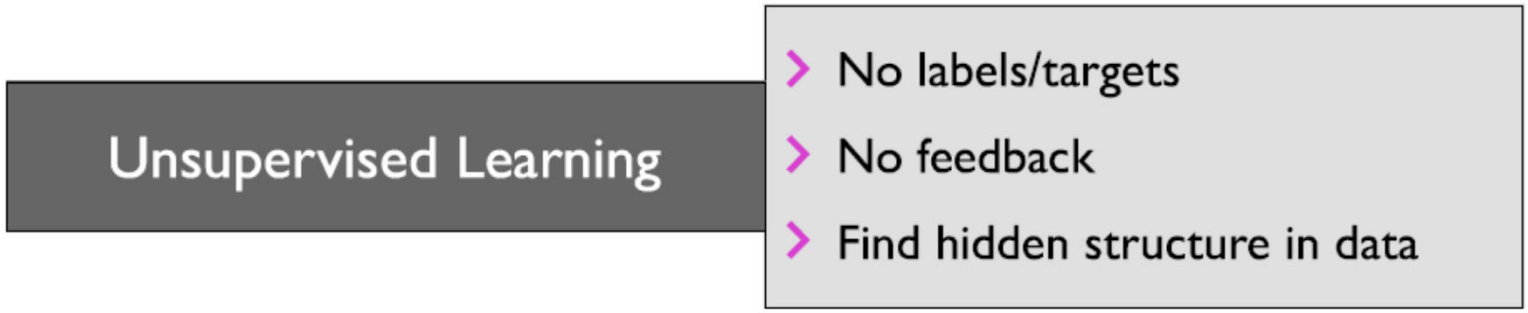
What are the class labels (y's)?



Classification works like this

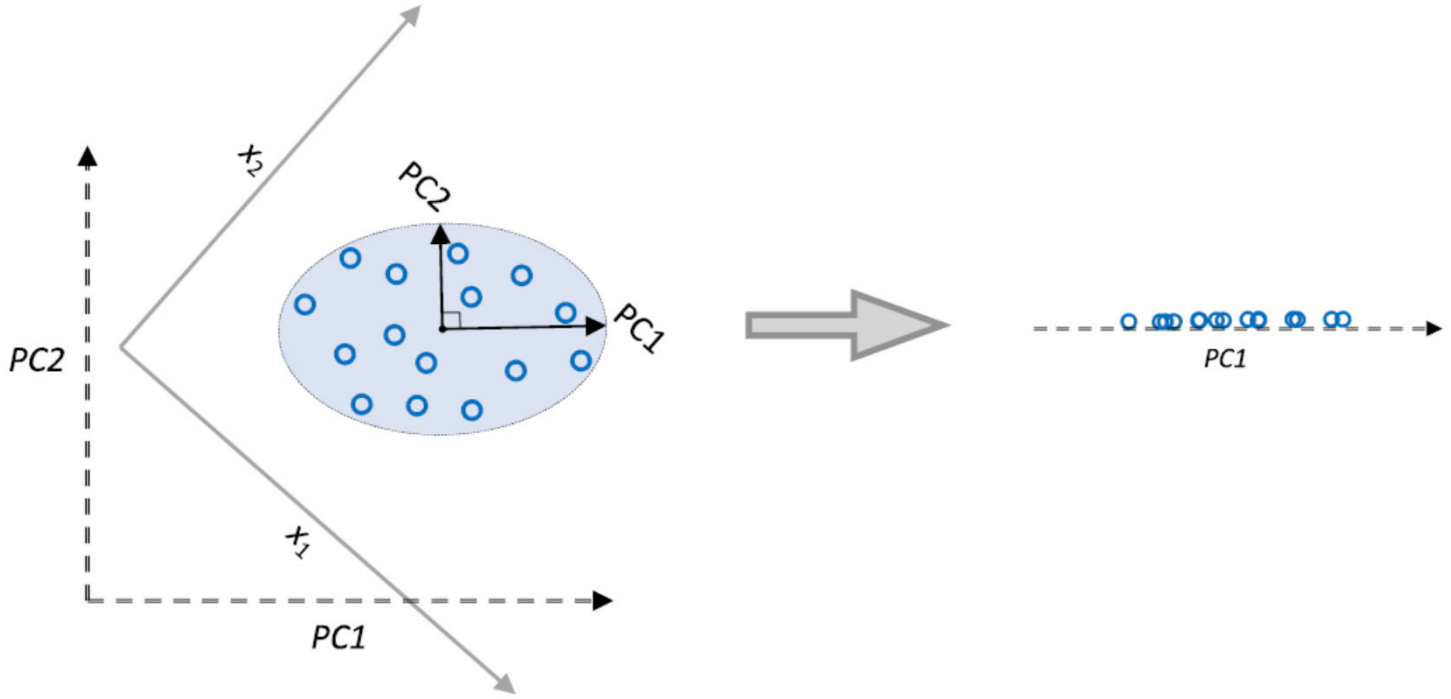


The 2nd Subcategory Of ML (And DL)

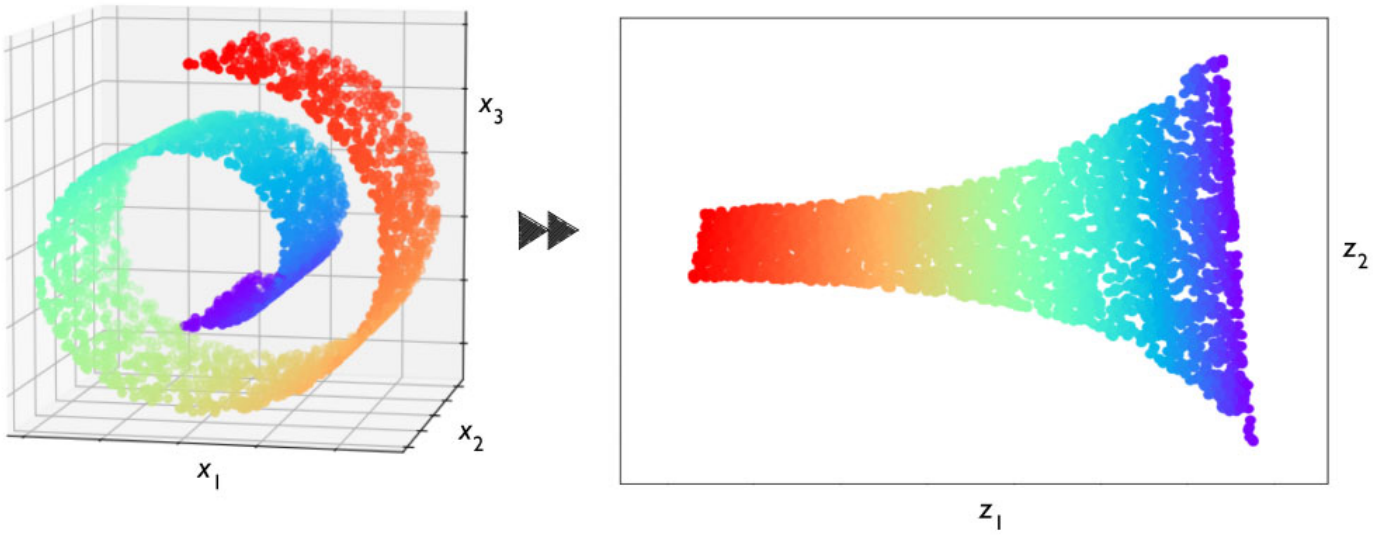


Unsupervised Learning 1:
Representation Learning/Dimensionality Reduction

E.g., Principal Component Analysis (PCA)

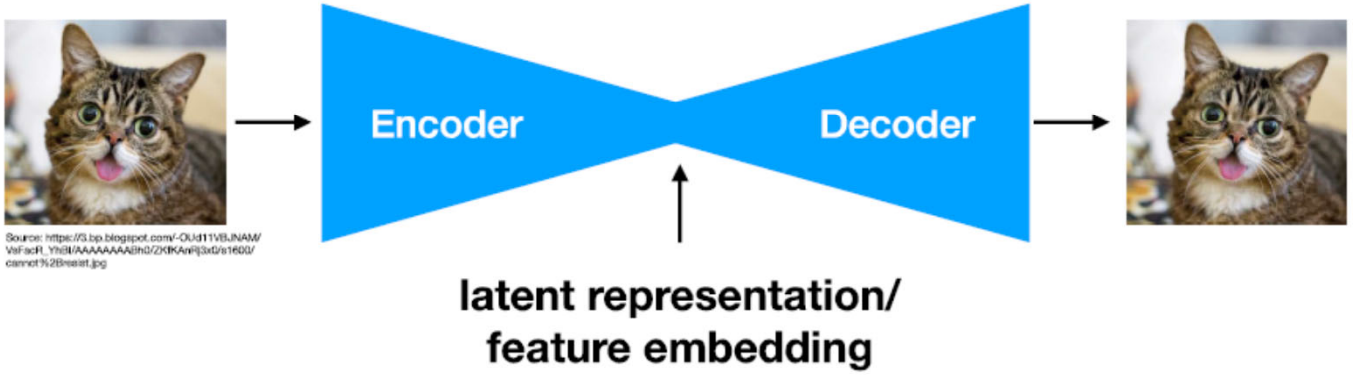


Unsupervised Learning--Dimensionality Reduction



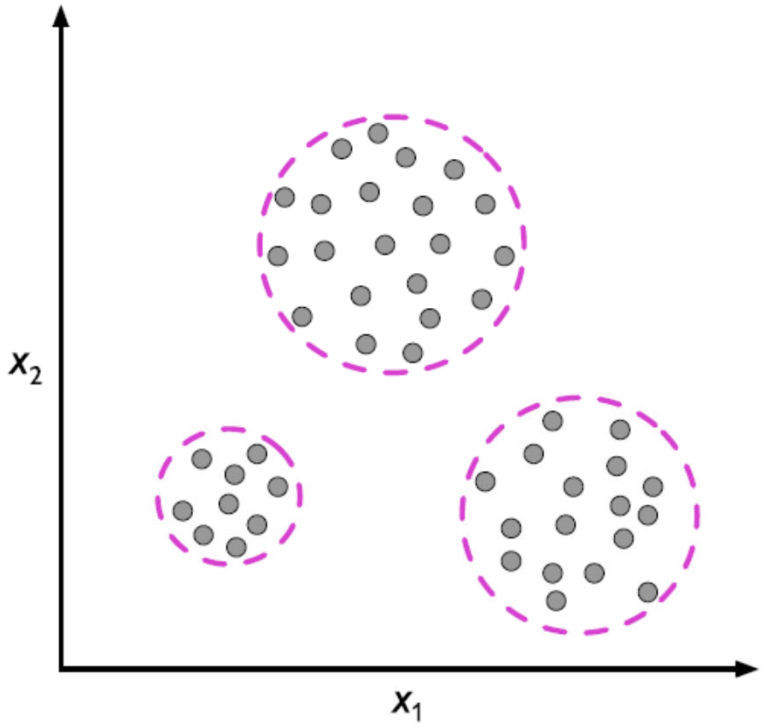
Unsupervised Learning 1:
Representation Learning/Dimensionality Reduction

E.g., Autoencoders

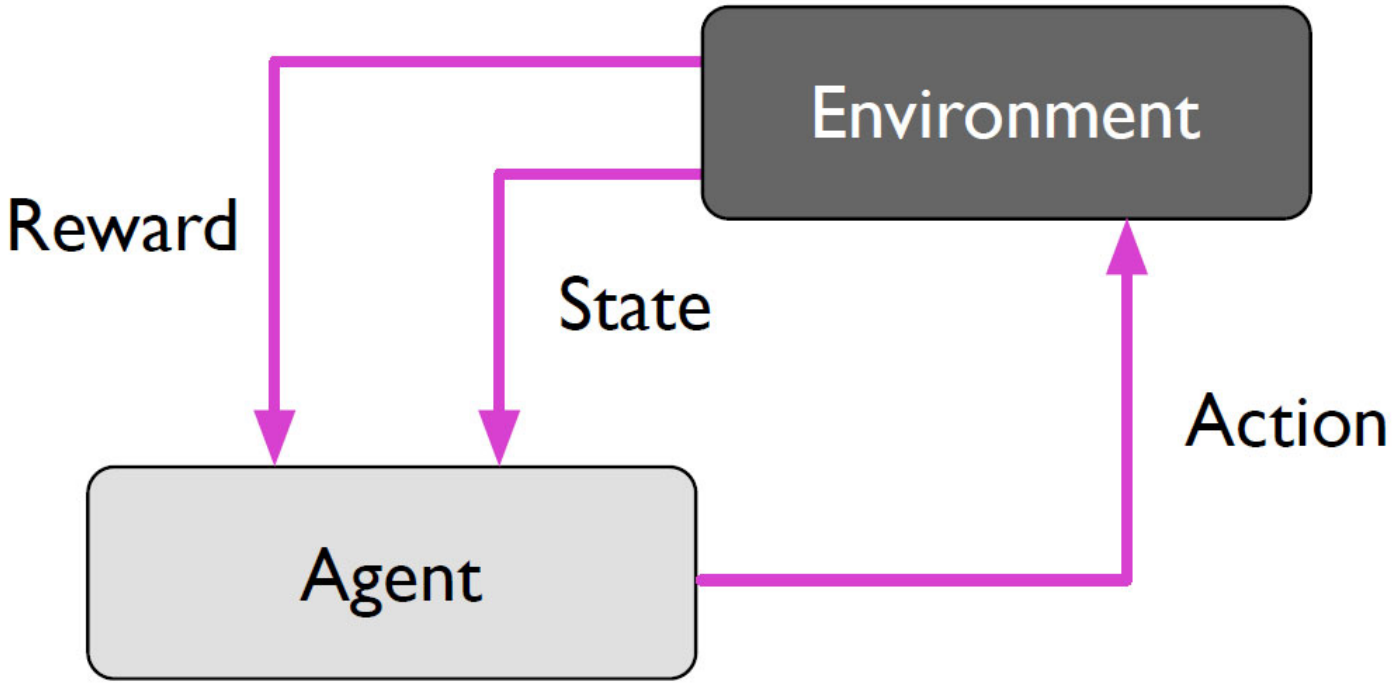


Unsupervised Learning 2: Clustering

Assigning group memberships to unlabelled examples (instances, data points)



Reinforcement Learning



Semi-Supervised Learning

- mix between supervised and unsupervised learning
- some training examples contain outputs, but some do not
- use the labeled training subset to label the unlabeled portion of the training set, which we then also utilize for model training

Semi-Supervised Learning

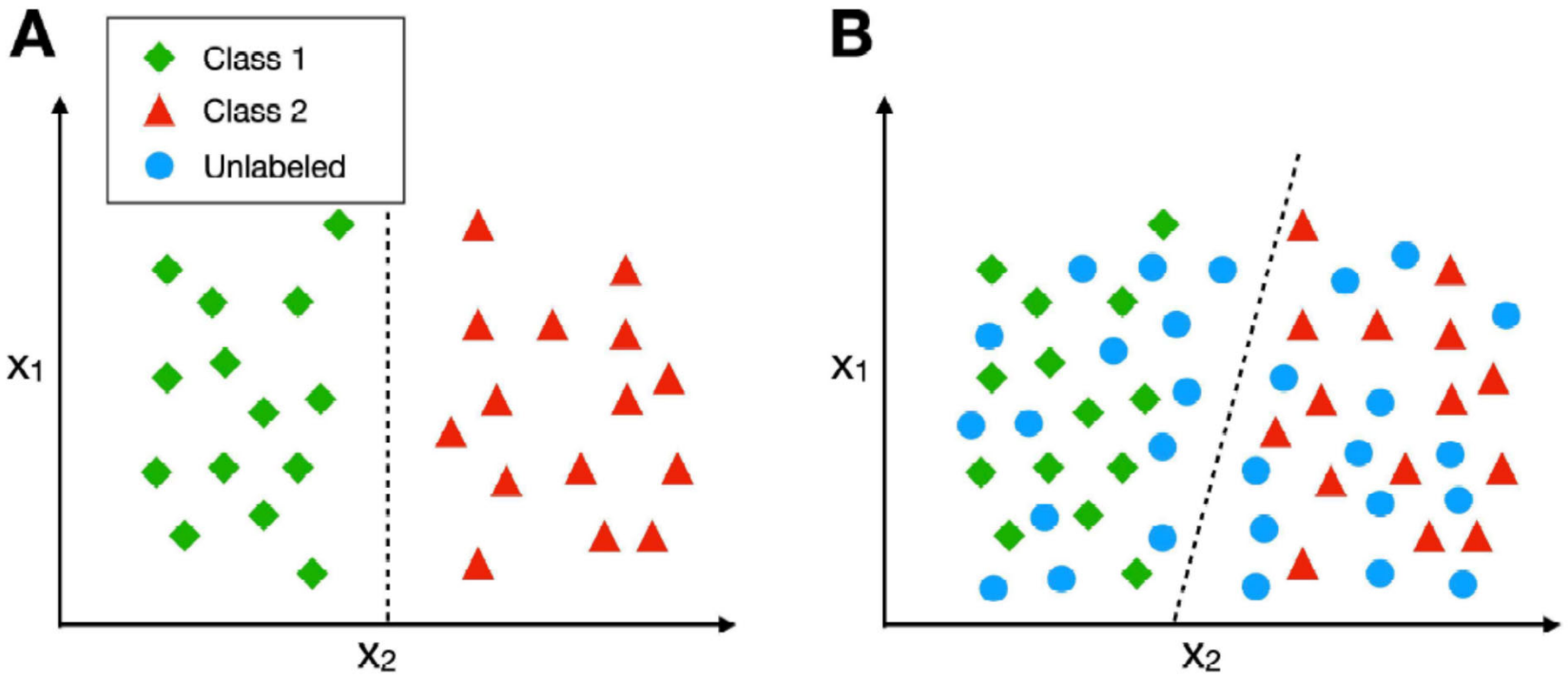
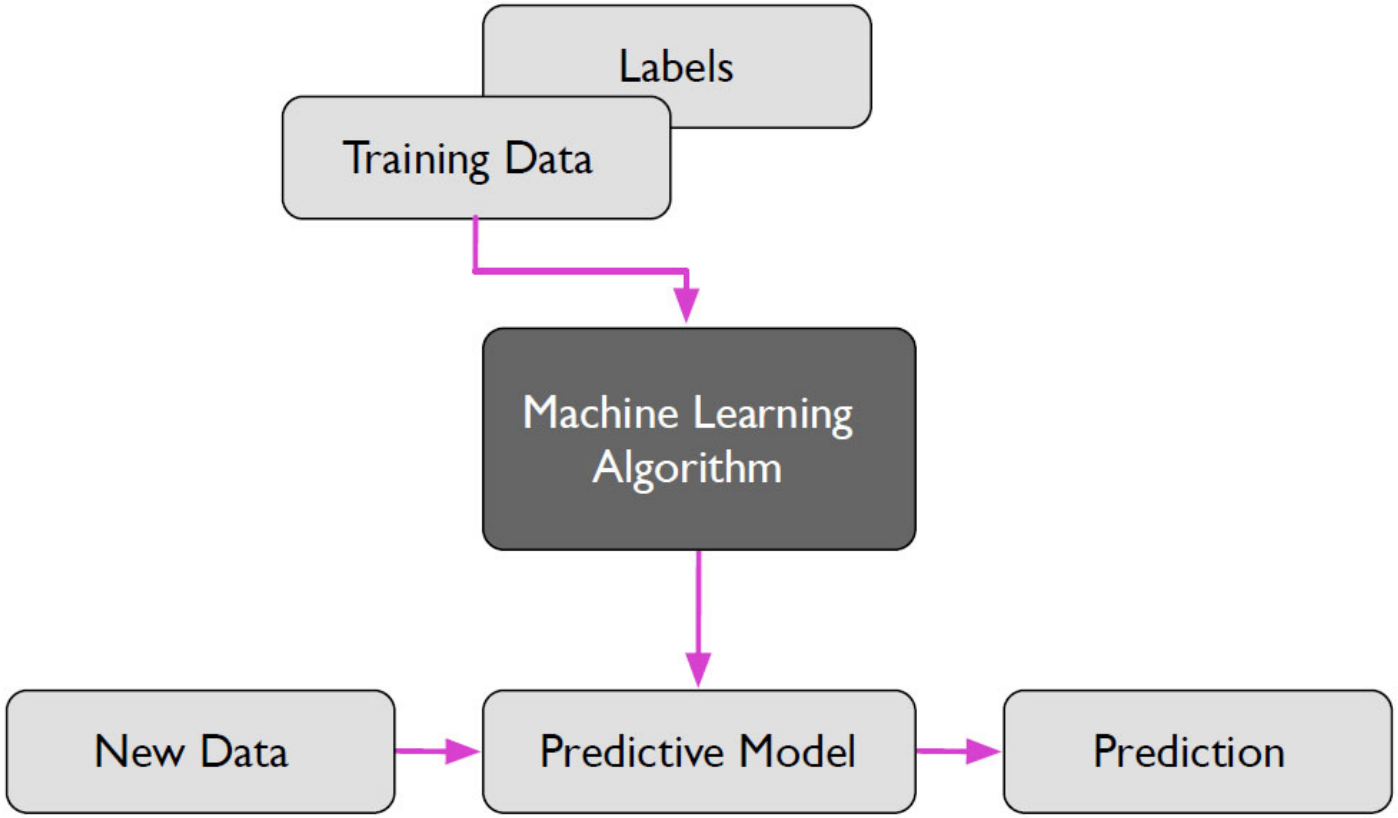


Illustration of semi-supervised learning incorporating unlabeled examples. (A) A decision boundary derived from the labeled training examples only. (B) A decision boundary based on both labeled and unlabeled examples.

Supervised Learning Workflow -- Overview



Structured vs Unstructured Data

A

Feature vector of the 1st training example

Class label

Index	Sepal length	Sepal width	Petal length	Petal width	Species
1	5.1	3.5	1.4	0.2	Iris-setosa
2	4.9	3	1.4	0.2	Iris-setosa
3	4.7	3.2	1.3	0.2	Iris-setosa
...	...	...	...	...	...
150	5.9	3	5.1	1.8	Iris-virginica

B

Machine Learning vs Deep Learning

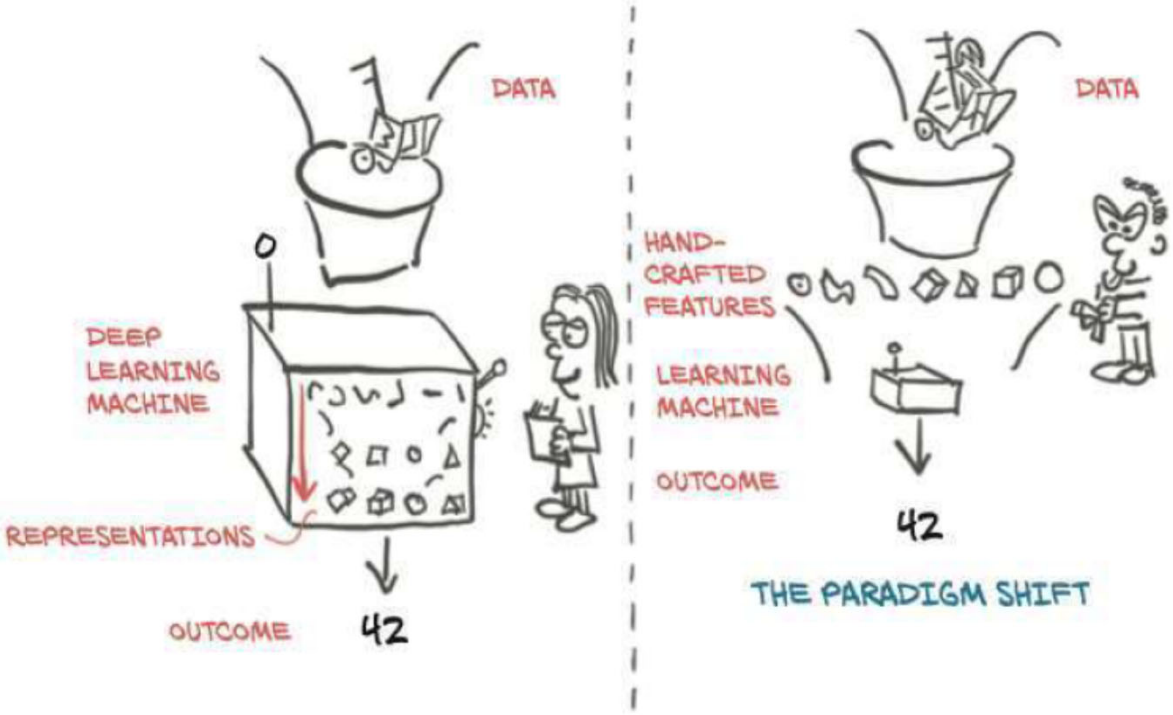


Image source: Stevens et al., *Deep Learning with PyTorch.* Manning, *2020*

Supervised Learning Notation

Training set: $\mathscr{D} = \{\langle \mathbf{x}^{[i]}, y^{[i]} \rangle, i = 1, \ldots, n\},$

Unknown function: $f(\mathbf{x}) = y$

Hypothesis: $h(\mathbf{x}) = \hat{y}$

Classification **Regression**

$h : \mathbb{R}^m \rightarrow \_\_$ $h : \mathbb{R}^m \rightarrow \_\_$

Data Representation

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{bmatrix} \qquad \mathbf{X} = \begin{bmatrix} \mathbf{x}_1^T \\ \mathbf{x}_2^T \\ \vdots \\ \mathbf{x}_n^T \end{bmatrix} \qquad \mathbf{X} = \begin{bmatrix} x_1^{[1]} & x_2^{[1]} & \cdots & x_m^{[1]} \\ x_1^{[2]} & x_2^{[2]} & \cdots & x_m^{[2]} \\ \vdots & \vdots & \ddots & \vdots \\ x_1^{[n]} & x_2^{[n]} & \cdots & x_m^{[n]} \end{bmatrix}$$

Feature vector

Data Representation

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{bmatrix} \qquad \mathbf{y} = \begin{bmatrix} y^{[1]} \\ y^{[2]} \\ \vdots \\ y^{[n]} \end{bmatrix}$$

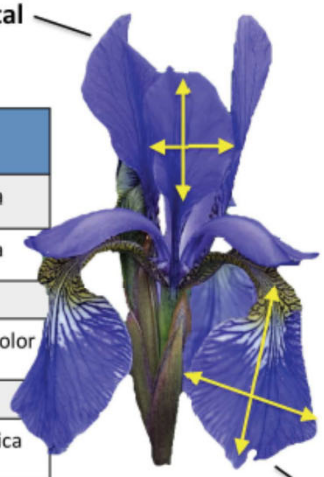
Input features

Data Representation (structured data)

$m =$ ____

$n =$ ____

	Sepal length	Sepal width	Petal length	Petal width	
1	5.1	3.5	1.4	0.2	Setosa
2	4.9	3.0	1.4	0.2	Setosa
			...		
50	6.4	3.5	4.5	1.2	Versicolor
			...		
150	5.9	3.0	5.0	1.8	Virginica



Data Representation (unstructured data; images)

"traditional methods"

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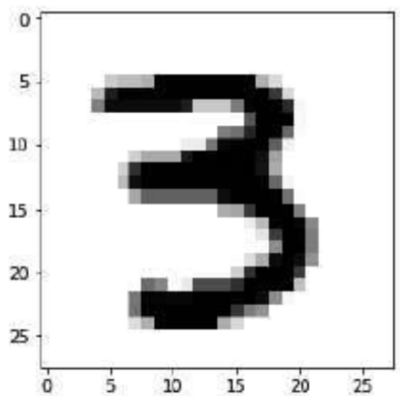


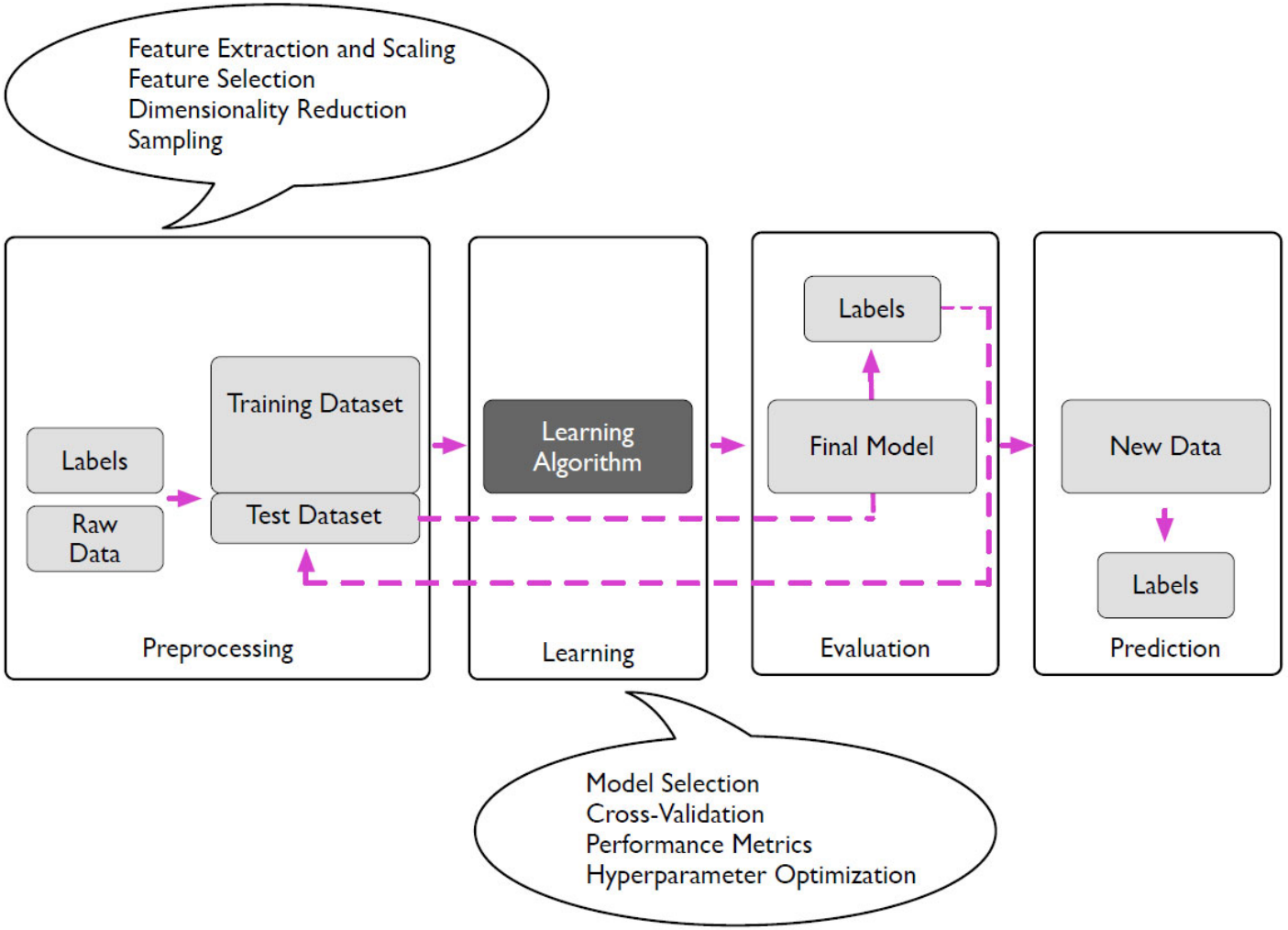
ML Terminology (Part 1)

- **Training example**: A row in the table representing the dataset. Synonymous to an observation, training record, training instance, training sample (in some contexts, sample refers to a collection of training examples)

- **Feature**: a column in the table representing the dataset. Synonymous to predictor, variable, input, attribute, covariate.

- **Targets**: What we want to predict. Synonymous to outcome, output, ground truth, response variable, dependent variable, (class) label (in classification).

- **Output / prediction**: use this to distinguish from targets; here, means output from the model.


Feature Extraction and Scaling
Feature Selection
Dimensionality Reduction
Sampling
Labels
Raw Data
Training Dataset
Test Dataset
Preprocessing
Learning Algorithm
Learning
Labels
Final Model
Evaluation
New Data
Labels
Prediction
Model Selection
Cross-Validation
Performance Metrics
Hyperparameter Optimization