

CSE 4553

Machine Learning

Lecture 1: Introduction to Machine Learning

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Contents

- Introduction
- What is Machine Learning?
- Types of machine learning
- Machine Learning applications

Introduction

“Data is abundant and cheap but knowledge is scarce and expensive.”

- Machine = computer, computer program
- Learning = improving performance on a given task, based on experience / examples

What is machine learning?

- **Arthur Samuel** (1959). Machine Learning:
 - *Field of study that gives computers the ability to learn without being explicitly programmed.*
- **Tom Mitchell** (1998). Well-posed Learning Problem:
 - *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 .*

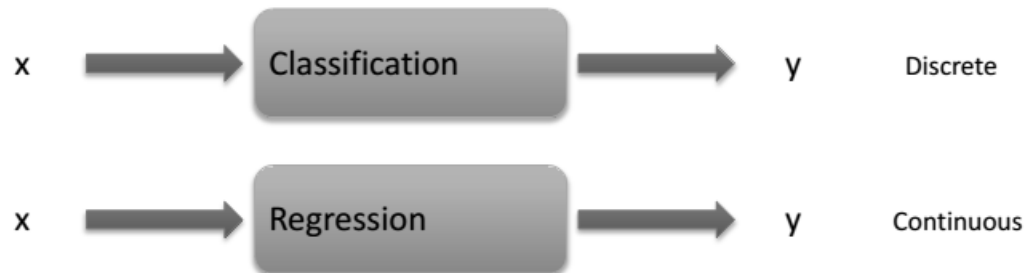
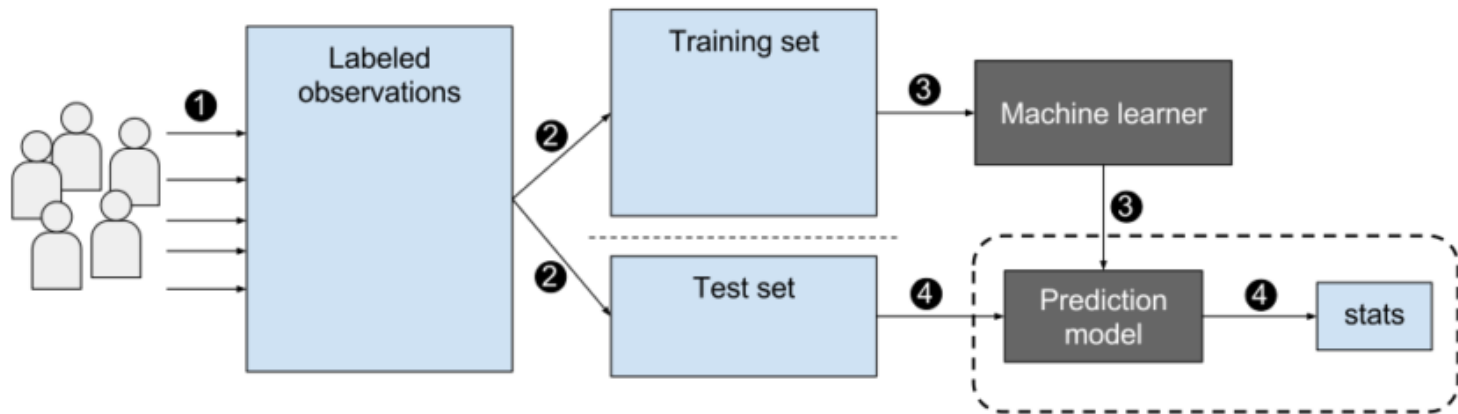
What is machine learning?...

- Improving some measure of performance P when executing some task T through some type of training experience E
- E.g. 1
 - So if you want your program to predict, for example, traffic patterns at a busy intersection (task T), you can run it through a machine learning algorithm with data about past traffic patterns (experience E) and, if it has successfully “learned”, it will then do better at predicting future traffic patterns (performance measure P).
- E.g. 2
 - Task T : Assign label of fraud or not fraud to credit card transaction
 - Performance measure P : Accuracy of fraud classifier with higher penalty when fraud is labeled as not fraud
 - Training experience E : Historical credit card transactions labeled as fraud or not

Types of learning

- **Supervised** (inductive) learning
 - Training data includes desired outputs
- **Unsupervised** learning
 - Training data does not include desired outputs
- **Semi-supervised** learning
 - Training data includes a few desired outputs
- **Reinforcement** learning
 - Rewards from sequence of actions

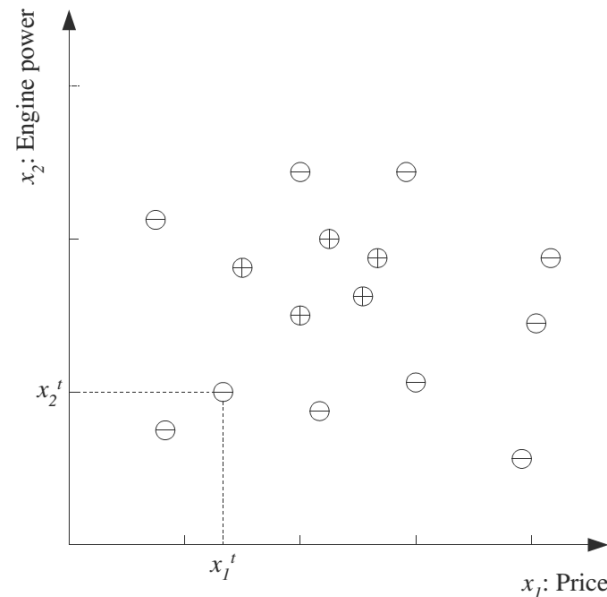
Supervised learning



Some examples for supervised algorithms include Linear Regression, Decision Trees, Random Forest, k-nearest neighbours, SVM, Neural Network etc.

Supervised learning...

- Given a set of data points $\{x^{(1)}, x^{(2)}, \dots, x^{(m)}\}$ associated to a set of outcomes, $\{y^{(1)}, y^{(2)}, \dots, y^{(m)}\}$ we want to build a classifier that learns how to predict y from x .

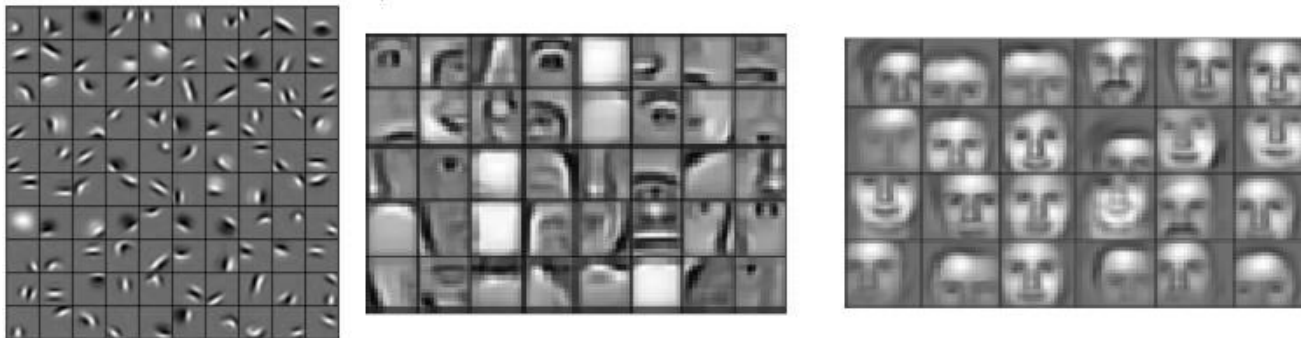


- Training
- Testing
- Hypothesis
- Loss function
- Cost estimation

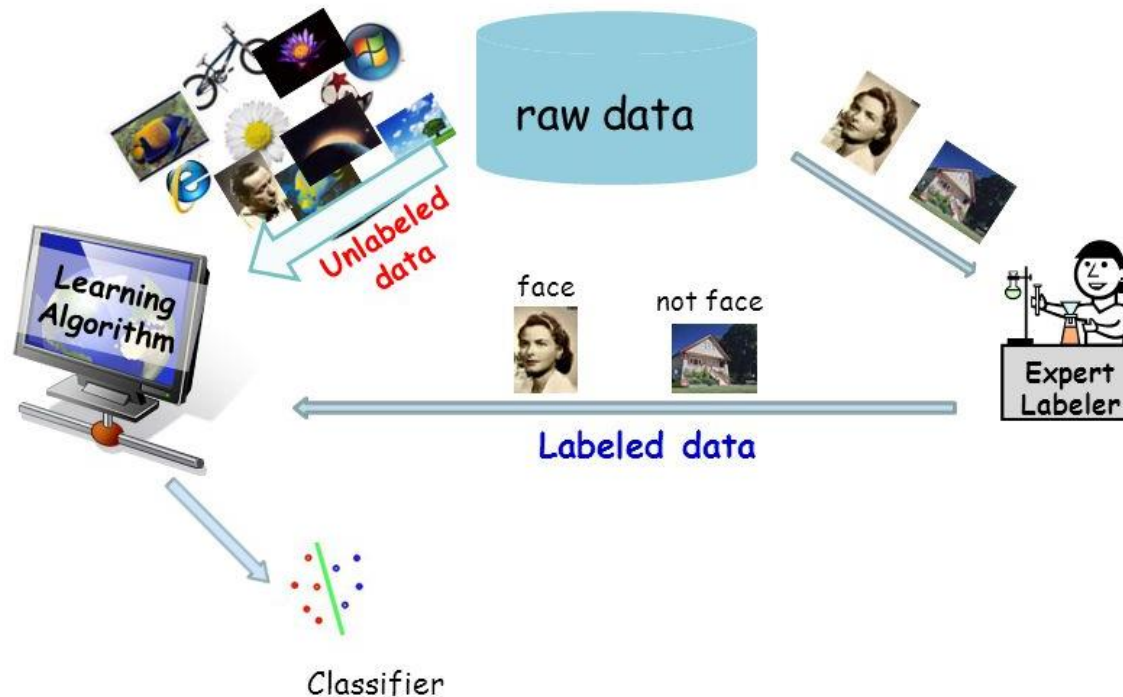
- We want estimate the prediction function h , by minimizing prediction error, $\sum (y^{(i)} - h(x^{(i)}))^2$

Unsupervised Learning

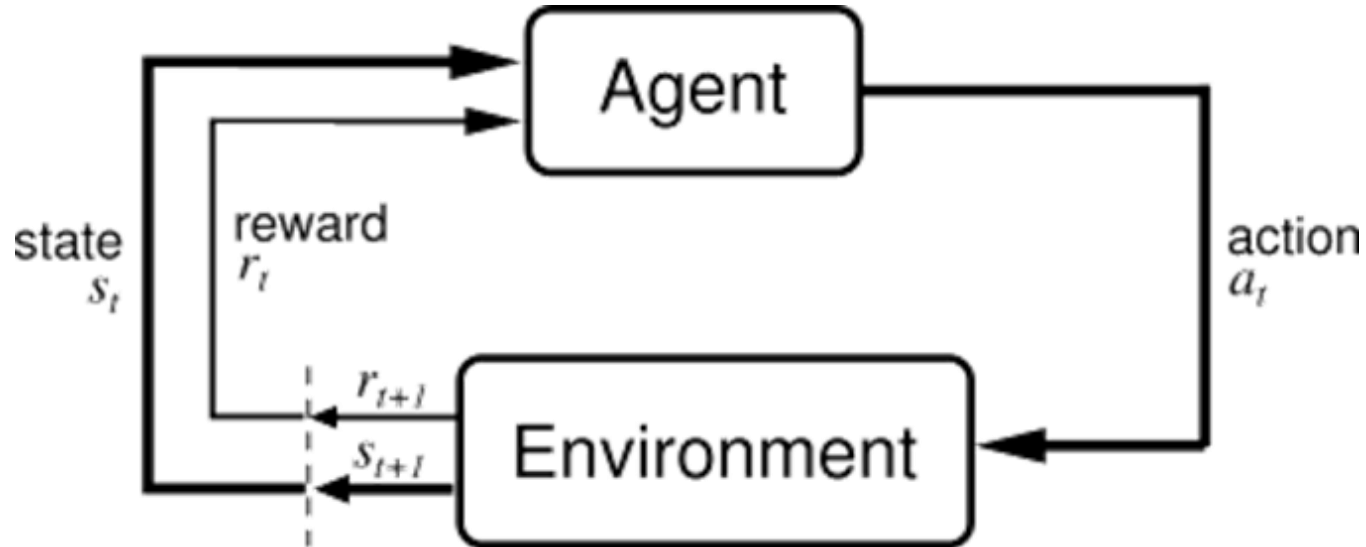
- The goal of unsupervised learning is to find hidden patterns in unlabeled data, $\{x^{(1)}, x^{(2)}, \dots, x^{(m)}\}$



Semi supervised learning

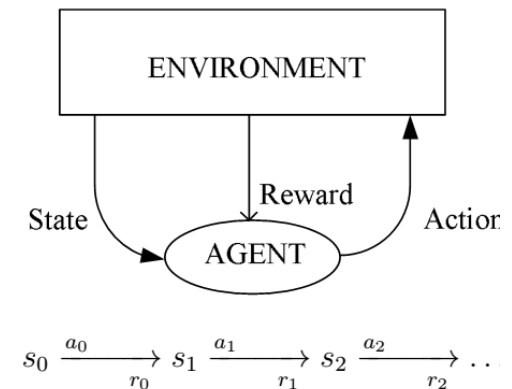


Reinforcement Learning

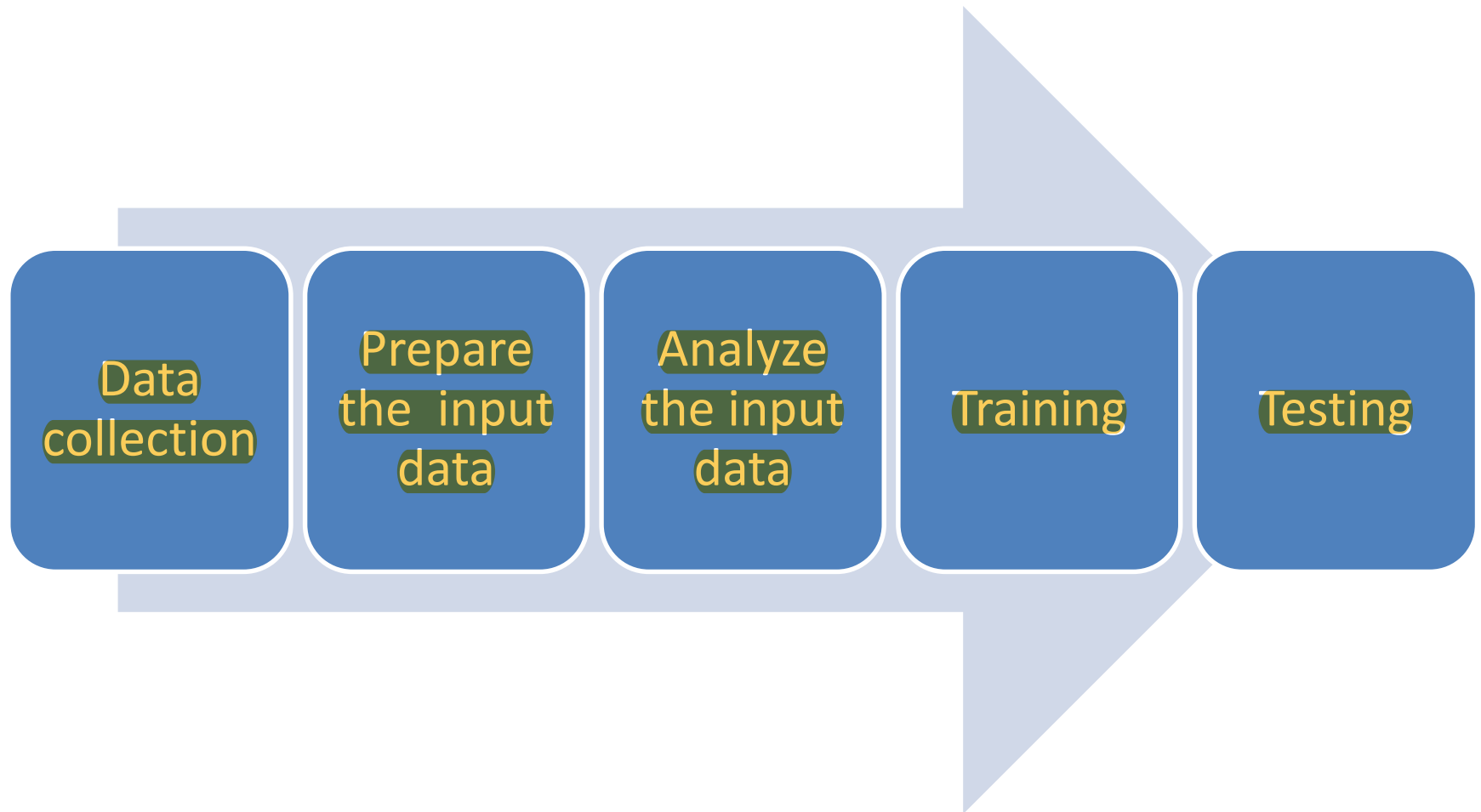


Reinforcement learning...

- Basic elements of a reinforcement learning problem:
 - *Agent*: the decision maker (e.g. game player, robot). It has *sensors* to observe the environment (e.g. robot camera).
 - *Environment* (e.g. board, maze). At any time t , the environment is in a certain *state* s_t that is one of a set of possible states \mathcal{S} (e.g. board state, robot position). Often, there is an initial state and a goal state.
 - A set \mathcal{A} of possible *actions* a_t (e.g. legal chess movements, possible robot steps). The state changes after an action: $s_{t+1} = \delta(s_t, a_t)$. The solution requires a sequence of actions.
 - *Reward* $r_t = r(s_t, a_t) \in \mathbb{R}$: the feedback we receive, usually at the end of the game. It helps to learn the policy.
 - *Policy* $\pi: \mathcal{S} \rightarrow \mathcal{A}$: a control strategy for choosing actions that achieve a goal.



Steps developing a machine learning application



References

- Chapter 2: Introduction to Machine learning by Ethem Alpydin.