CS 550: MACHINE LEARNING

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Learning

- In our lives, we take actions according to
  - What we observe in our environments
  - What we have previously learned
- Some daily life problems include
  - Face recognition
  - Handwritten character/digit recognition
  - Chess playing
  - Car driving
  - Stock price prediction

Learning

- In order to achieve a task, we should
  - Have relevant information representing the environment
  - Know the possible set of actions
  - Know the process to take an action based on the information
    - This process relies on our past experience

Handwritten letter recognition

- Obtain information representing the environment
  - Letter to be recognized
  - Preferably its adjacent letters
- Know the possible set of actions
  - Number of letters
  - Language
- Take an action, which is affected by whether or not
  - You have seen that letter before
  - You know the alphabet of that language
  - You understand the context of that language

Machine learning

- The goal of machine learning is
  - To design computer systems that automatically achieves tasks, with respect to some performance measures, using past experience
  - To have machines that automatically take actions similar to ours depending on the environment

Machine learning

- Design systems that
  - Automatically take actions (output) similar to ours
  - Depending on the environment (input)
  - Based on their past experience (training samples)

Machine learning

- We reduce the input measuring its certain properties (features), which can be numerical or non-numerical
  - Mileage (e.g., 34187)
  - Condition (e.g., poor, average, excellent)
- The output can be discrete or continuous
  - A, C, Z for letter recognition (**classification**)
  - Ali, Ayse, Cigdem for face recognition (**classification**)
  - 25999 TL for car price prediction (**regression**)
  - 3.7° by which a wheel is turned at each time (**regression**)

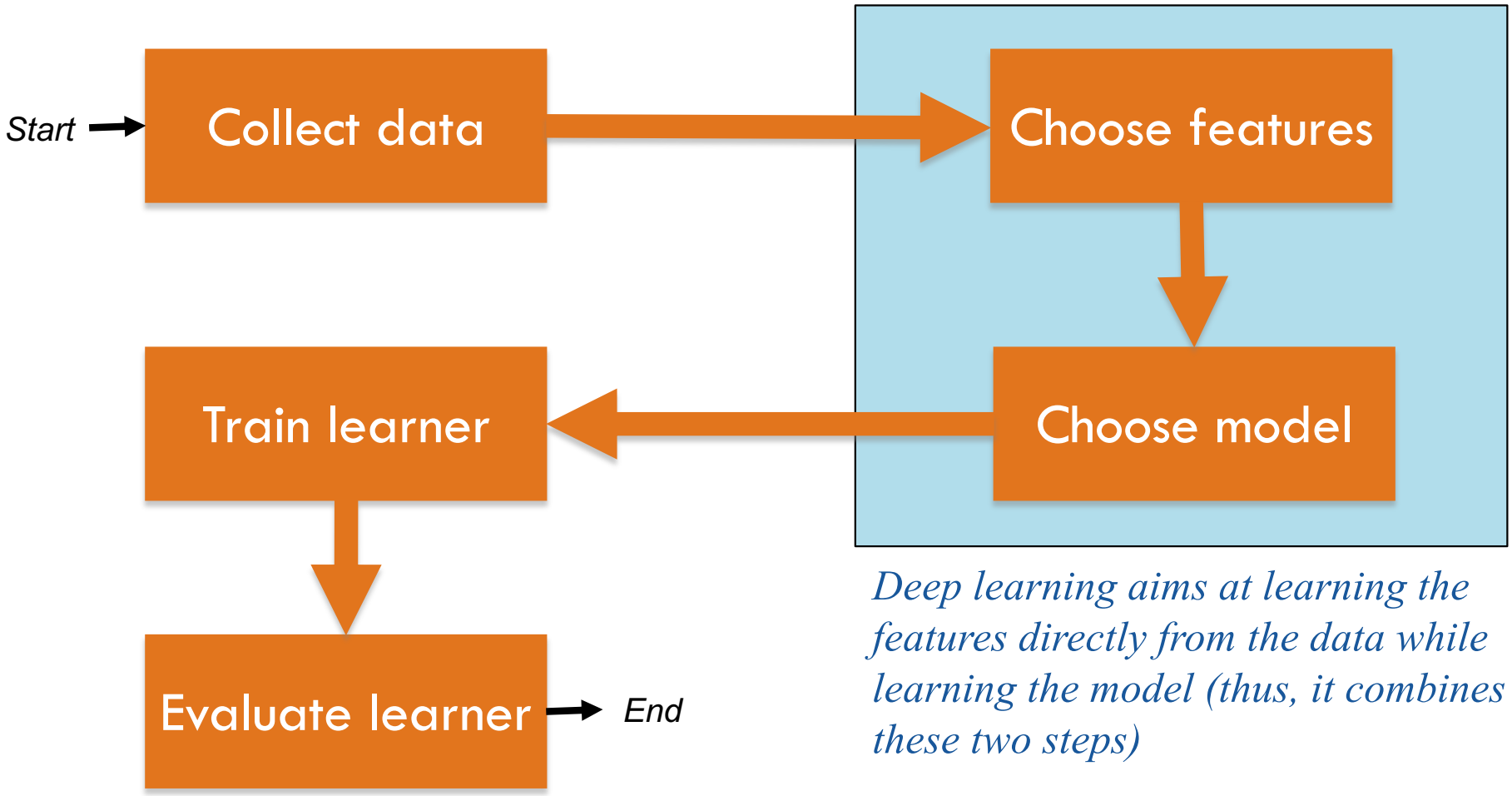
Machine learning

- We believe that there is a process underlying training samples (past experience)
  - We may not identify this process completely
  - But we can construct a model approximating the process
    - A function that distinguishes discrete outputs (**classification**)
    - A functional description of output in terms of inputs (**regression**)
  - **Machine learning mainly focuses on constructing such models**

Machine learning

- The goodness of the model depends on
  - How well your approximation is
    - No model fits all problems
    - Different models have different assumptions
  - How well training samples represent the distribution in the real-world
    - There may exist noise and exceptions in the samples
    - Some parts may not be covered by the samples

How to design a learning system



Deep learning aims at learning the features directly from the data while learning the model (thus, it combines these two steps)

Unsupervised learning

- So far, we have talked about **SUPERVISED** learning
  - There is a teacher that provides a label (output) for each training sample
  - The task is to map an input space to an output space

- In **UNSUPERVISED** learning
  - There is not explicit teacher that provides outputs
  - The task is to find regularities (clusters) in the input space
    - e.g., cluster customers based on their demographic information and past transactions for developing marketing strategies
    - e.g., cluster pixels based on their colors for image compression

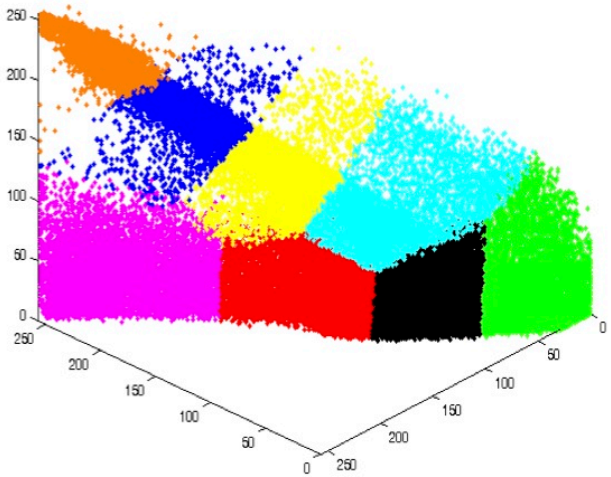
An example: Image compression

Image compression to reduce the number of bits to be transferred

RGB color space
→24 bits for each pixel

8 (= 2^3) clusters (colors)
→3 bits for each pixel

32 (= 2^5) clusters (colors)
→5 bits for each pixel



Reinforcement learning

- **REINFORCEMENT** learning is an approach to control learning that accommodates indirect or delayed feedback
  - Training experience is in the form of indirect information consisting of action sequences and final outcome
  - There are no input/output pairs as in the case of supervised learning
  - The environment could be dynamic such that it could be influenced by the selected action

An example: Chess playing

- The system should learn
  - How to choose a sequence of correct actions (*moves*)
  - In a dynamic environment (*chess board*)
  - Using past experience (*move sequences and final outcomes of various games played*)
  - To reach a goal (win chess)