Chapter One

Introduction to Machine Learning

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Outline

- Introduction
- What is machine learning?
- History of machine learning.
- Applications of machine learning.
- Types of machine learning.

What is machine learning?

- Learning is any process by which a system improves performance from experience.
- Machine Learning is the study of algorithms that:
  - ✓ improve their performance P
  - ✓ at some task T
  - ✓ with experience E.
- A well-defined learning task is given by <P, T, E>
- Machine learning is field of study that focuses on computer system that can learn from data.

Example

- Handwriting recognition learning problem
  - ✓ Task T: Recognizing and classifying handwritten words within images.
  - ✓ Performance P: Percent of words correctly classified.
  - ✓ Training experience E: A dataset of handwritten words with given classifications.
- A chess learning problem
  - ✓ Task T: Playing chess.
  - ✓ Performance measure P: Percent of games won against opponents.
  - ✓ Training experience E: Playing practice games against itself.
- A computer program which learns from experience is called a machine learning program or simply a learning program.

Machine learning vs traditional programs

- Traditional programs are being explicit programmed to perform specific task.
- Machine learning system is often called model that can learn to perform a specific task by analyzing many examples for a particular problem.
- For example, machine learning system can learn to recognize an image of a dog by being shown many images of a dog.
- The machine learning program learns to recognize the image of dog without being explicitly programmed.

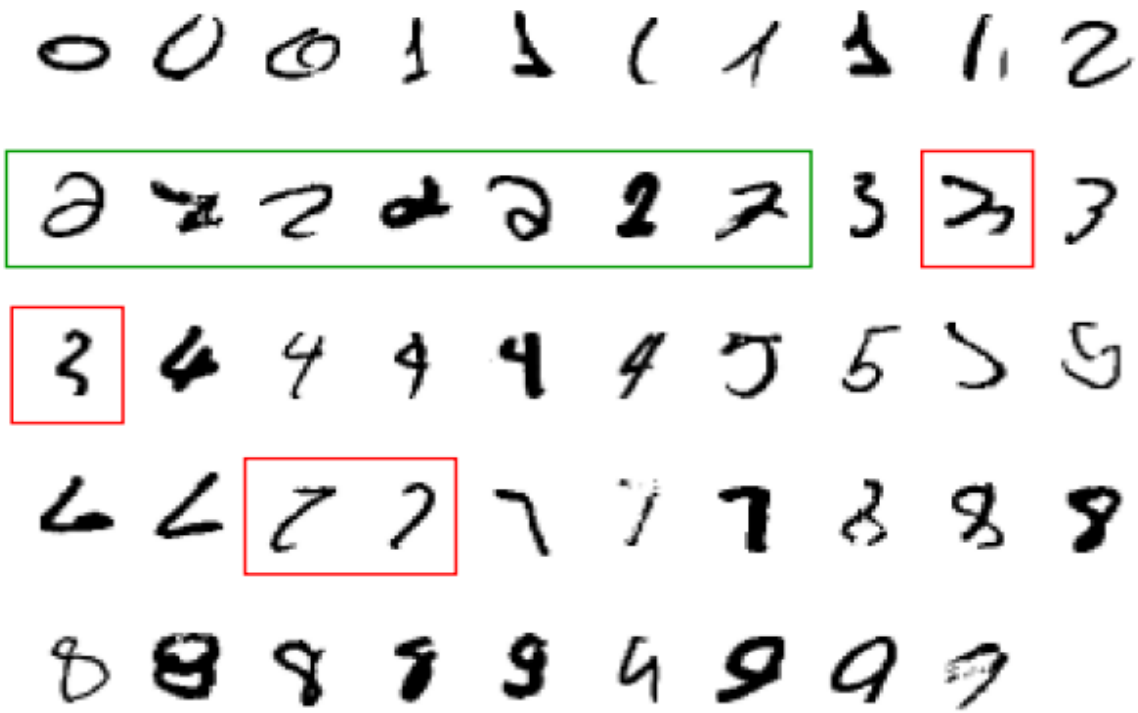
When do we use machine learning?

ML is used when:

- Human expertise does not exist (navigating on Mars)
- Humans can’t explain their expertise (speech recognition)
- Models must be customized (personalized medicine)
- Models are based on huge amounts of data (genomics)

Applications of machine learning

- A classic example of a task that requires machine learning:
- It is very hard to say what makes a 2.



Cont.

- Recognizing patterns:
  - ✓Facial identities or facial expressions.
  - ✓Handwritten or spoken words, and Medical images.
- Generating patterns:
  - ✓Generating images or motion sequences.
- Recognizing anomalies:
  - ✓Unusual credit card transactions.
  - ✓Unusual patterns of sensor readings in a nuclear power plant.
- Prediction: Future stock prices or currency exchange rates.

Sample applications

- Web search
- Face detection
- Recommendation system
- E-commerce
- Space exploration
- Robotics
- Fraud detection
- Social networks

Types of machine learning techniques

In general machine learning algorithms can be classified into three types.

1) Supervised learning: A set of examples with the correct responses (targets) is provided and, based on this set, the algorithm generalizes to respond correctly to all possible inputs.

- Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs.
- In the optimal case, the function will correctly determine the class labels for unseen instances.

Supervised learning

- In supervised learning we have dataset with set of features and our goal is to predict where the object will fall given the set of features.
- We are given a dataset and we already know what the correct output should look like, having the idea that there is a relationship between the input and output.
- *Example: predicting a car price:* car price depends on features like consumption of diesel, model, and so on, and these are the features and we try to predict price based on these features.
- *Example: predicting house price:* the house price can be predicted based on certain features such as number of bed rooms, lot size, square foot. *Classification* and *regression* are some of the techniques used.

Cont.

2) Unsupervised learning: Correct responses are not provided, instead the algorithm tries to identify similarities between the inputs and categorizes together.

- Unsupervised learning is used to draw inferences from datasets consisting of input data without labeled responses.
- Since the examples given to the learner are unlabeled, the accuracy of the structure that is output by the algorithm cannot be evaluated.
- The most common unsupervised learning method is cluster analysis, which is used for exploratory data analysis to find hidden patterns or grouping in data.

Unsupervised learning continued.

- No learning of data features.
- We will be discovering data features given the data.
- Finds similarity between objects.
- In unsupervised learning approaches, we have little or no idea about what the result should look like.
- Data is presented and the algorithm analyzes and comes up with similarities by clustering together similar data features.
- By analyzing the data, unsupervised learning tries to find some structures of the presented data. *K-means clustering*, and *nearest neighbors* are some of the techniques used.

Examples of unsupervised learning

- Identifying areas of similar topology (example, Deseret, forest, grass).
- Determining different groups of weather patterns.
- Discovering crime hot spots.
- Recommending items based on purchase history.

Cont.

- *Reinforcement learning:* This is somewhere between supervised and unsupervised learning.
- The algorithm gets told when the answer is wrong, but does not get told how to correct it.
- It has to explore and try out different possibilities until it works out how to get the answer right.
- Reinforcement learning is sometime called learning with a critic because of this monitor that scores the answer, but does not suggest improvements.
- Reinforcement learning is the problem of getting an agent to act in the world so as to maximize its rewards.

Review questions

1) Define machine learning.

2) Mention different techniques of machine learning.

3) Differentiate between supervised and unsupervised learning.

4) Describe some applications of machine learning.

5) What is the difference between traditional programming and machine learning?

6) Compare and contrast the challenges of creating algorithms that learn from their experience to improve their performance.