CSCI567 Machine Learning (Fall 2024)

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Introduction

About

- Modern machine learning methods used in real-world AI applications.

- Focus on conceptual understanding of these methods.

Objectives

- Develop skills to grasp abstract ML concepts and think critically.

- Practice with hands on programming tasks.

- Preparation for studying advanced machine learning topics.

Prerequisites

- Undergraduate level training in probability and statistics, linear algebra, multivariate calculus.
  Important: attend today's discussion session to see if you have the required background.

- Programming in Python
  Not an intro-level CS course, no training of basic programming skills.

Logistics

- Lectures: Fridays 2-4.20pm (SGM 123)

- Discussions: Fridays 4.30-5.20pm

- Course website: https://usc-tamagotchi.github.io/csci-567/24f/

- TAs: Yavuz Faruk Bakman, Robby Costales, Xiao Fu, Isabelle Lee, Sajjad Shahabi, Xinyan Yu

- No required textbook, lecture slides will be posted before class. Mathematics for Machine Learning https://mml-book.github.io/ Deep Learning https://www.deeplearningbook.org/

Grade

- Quiz 1 (10/4): 40%

- Quiz 2 (12/6): 40%

- Project report: 20%

Initial cut-offs

B- = [70, 75), B = [75, 80), B+ = [80, 86)
A- = [86, 92), A = [92, 100)

Final cut-offs will not be released

Course Project

An implementation focused project to assess real world machine learning skills done in a group of four.

- Choose a popular benchmark that is approved by at least two TAs (5 points).

- Implement a top performing baseline method *from scratch* that achieves comparable performance to the original implementation (10 points).

- Improve on the baseline (5 points).

- Write an intelligible report to present your results (5 points).

What is machine learning?

It is the fuel that powers state-of-the-art AI models.

AI is a civilization-altering technology that is going to transform the way we live.

Consumer products. speech-to-speech chatbot, search engine, stock price prediction, wearable devices.

Scientific applications. protein structure prediction, nuclear fusion, social network analysis.

The frontier of AI

- Pseudo artificial general intelligence.

- Chatbots that passed the Turing test.

- Realistic image generation.

- Short video generation.

Why study ML today?

Acquire the knowledge to apply state-of-the-art methods to solve real-world problems.

Analyze how existing models work to understand how to control them better.

Make progress towards superintelligence.

Foundations of Modern Machine Learning

- Data

- Model

- Loss function (objective function)

- Evaluation metric

Outline

What is machine learning?

One possible definition (cf. Murphy's book)
a set of methods that can automatically *detect patterns* in data, and then use the uncovered patterns to *predict future data*, or to perform other kinds of *decision making under uncertainty*
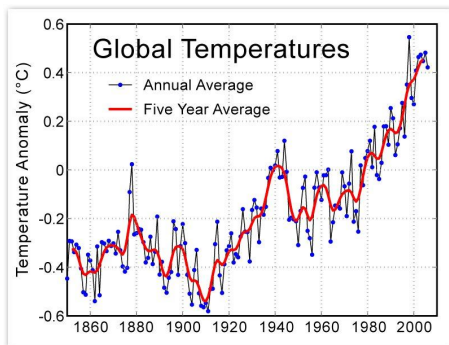
Example: detect patterns

How the temperature has been changing?
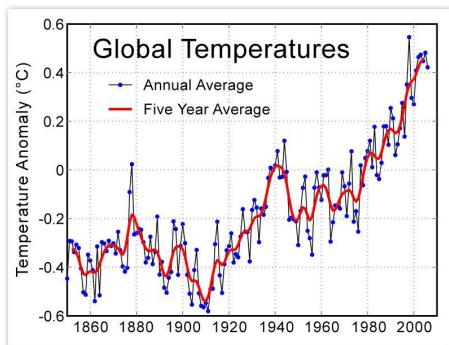
Example: detect patterns

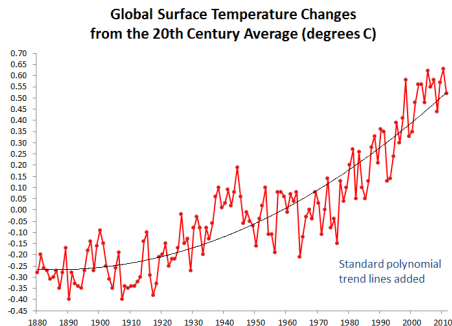**How the temperature has been changing?**

Patterns

- Seems going up
- Repeated periods of going up and down.

How do we describe the pattern?

Build a model: fit the data with a polynomial function

Global Surface Temperature Changes
from the 20th Century Average (degrees C)

- The model is not accurate for individual years
- But collectively, the model captures the major trend

Predicting future

What is temperature of 2030?

Global Surface Temperature Changes
from the 20th Century Average (degrees C)
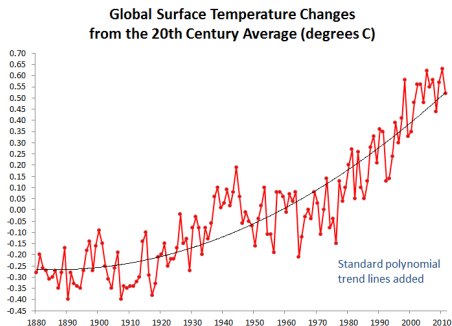
- Again, the model is probably inaccurate for that specific year
- But then, it might be close enough

What we have learned from this example?

Key ingredients in machine learning

- Data
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- Prediction
  apply the model to forecast what is going to happen in future

A rich history of applying statistical learning methods

Recognizing flowers (by R. Fisher, 1936)
Types of Iris: setosa, versicolor, and virginica

Huge success 30 years ago

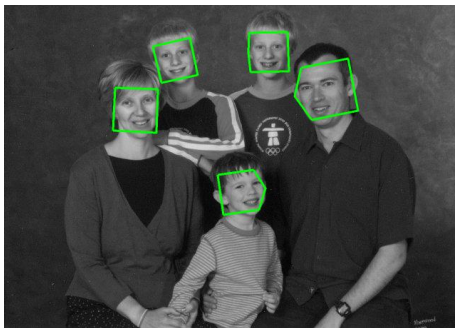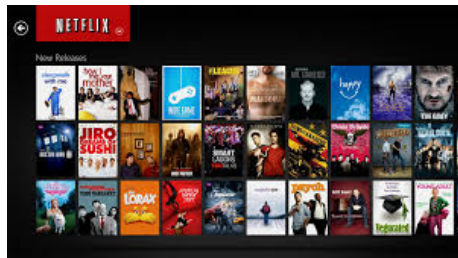**Recognizing handwritten zipcodes (AT&T Labs, late 1990s)**

More modern ones, in your social life

Recognizing your friends on Facebook

It might know more about you than yourself

Recommending what you might like

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  Aim to predict (as in previous examples)
- Unsupervised learning
  Aim to discover hidden and latent patterns and explore data
- Decision making (e.g. reinforcement learning)
  Aim to act optimally under uncertainty
- Many other paradigms