CS 189 Introduction to Machine Learning
Spring 2018 Note 1

1 Machine Learning Principles

Have you ever tailored your exam preparation, to optimize exam performance? It seems likely that you would, and in fact, those preparations may range from "taking one practice exam" to "wearing lucky underwear". The question we're implicitly answering is: which of these actually betters exam performance? This is where machine learning comes in. In machine learning, we strive to find patterns in data, then make predictions using those patterns, just as the average student would do to better exam scores. We start by structuring an approach to understanding machine learning.

1.1 Levels of Abstraction

We will take an example from astronomy, below. How exactly do we define the parameters of the problem, and how do we leverage the machine learning framework to help with this problem? See below, for a concrete outline of what to think about.

1. **Applications and Data**: What are you trying to do? What is your data like? Here, identify your problem and the nature of your observations. Your data may be Cartesian coordinates, an matrix of RGB values etc.

   Example: We have (x_1, y_1) coordinates. We want to compute each planet's orbit.

2. **Model**: What kind of pattern do you want to find? This could be a polynomial, a geometric figure, a set of dynamics governing a self-feedback loop etc.

   Example: An ellipse for an orbit.

3. **Optimization Problem**: Whatever problem you have, turn it into an optimization problem. We could minimize losses or maximize gains, but in either case, define an objective function that formally specifies what you care about.

   Example: $\min_{\mathbf{x}} \|\mathbf{A}\mathbf{x} - \mathbf{b}\|_2^2$

4. **Optimization Algorithm**: How do we minimize? Determine how exactly to solve the optimization problem that you've now proposed.

   Example: Solve $\mathbf{C}\mathbf{x} = \mathbf{d}$*, a system of linear equations.*

In this course, we will study both **models** and **optimization problems** extensively. Being able to compartmentalize each of these will make it easier for you to frame and understand machine learning.