Chapter - 1
Learning from Data

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1 Introduction

Artificial **I**ntelligence refers to the ability of a machine to mimic human cognitive abilities such as perception, reasoning, learning, vision and language. **M**achine **L**earning is a major subset of AI that focuses on developing algorithms that can learn patterns from data without requiring explicit programming. The title of the first chapter, **learning from data** thus faithfully describes what the subject is about.

2 Pre-requisites for Machine Learning

If you find these three components in a problem from your field, then machine learning is ready as an application tool.

2.1 A pattern exists

A pattern refers to any repetition or regularity in an arrangement or design. As such, the elements of a pattern repeat in a predictable manner.
This condition makes sense because, if there is no pattern, just unpredictable randomness, then there is nothing to learn really.

2.2 It is unfeasible to pin it down mathematically

If the nature of problem is such that you can program it precisely and easily in mathematical terms, for example dividing two numbers, then you don't require learning from data.
However, for instance when trying to determine a user's movie preferences, it is easy to see that writing an exact mathematical formula for it is unfeasible. Applying machine learning and thereby learning from data, makes more sense in such scenarios.

2.3 We have the data

As discussed, we are learning from data. So we first and foremost need to have the relevant data points. Otherwise, machine learning is not applicable.

3 The Machine Learning Process

Let us understand and formalize the process of machine learning through an example from the financial domain. Consider a customer who applies for a credit card. The Bank needs to decide whether it is a good idea to extend the credit card or not, as the bank wants to maximize its profits.

Naturally, the bank doesn't have a magic formula to decide whether a customer is credit worthy or not. Instead, they are going to rely on the historical records of previous customers and how their credit behavior turned out to be in hindsight. The idea is to look for patterns in those previous data points, in order to predict the credit worthiness of future customers. Let us look at the major components of the learning process to understand further :

3.1 Data

The data, which in this case is the historical record of customers, consists of two parts :

1. The **Input**, which is the customer application information such as age, salary, years in residence, current debt. Represented by a matrix $\mathbf{x}$.

2. The **Output**, which captures whether the customer was credit worthy or not in hindsight, from the bank's point of view. Represented by a binary y.

The historical data from say N previous customers is therefore represented as :

$$\mathbf{Data} : (\mathbf{x_1}, y_1), (\mathbf{x_2}, y_2), (\mathbf{x_3}, y_3)...(\mathbf{x}_N, y_N)$$

As discussed before, we use the above data points to discover an underlying pattern with respect to customer behavior and credit worthiness.

3.2 Target Function

This underlying pattern obviously, is not exactly known. Hence, we try to learn it approximately through the available data points. It is formally called the target function and denoted by :
$$f : X \rightarrow Y$$

Here, X is the domain of f, which is the set of all inputs $\mathbf{x}$ from the data above. Whereas, Y the codomain, is the set of all outputs y.

3.3 Hypothesis Function

The hypothesis function is the formal name for our approximation of the unknown target function f, learned through the available data points. It is denoted by :

$$g : X \rightarrow Y$$

The goal is that g approximates f well, that is $g \approx f$.

3.4 The Learning Model

The learning model is what connects the data-set to the hypothesis function. The data-set is fed into the learning model, which in turn comes out with the final hypothesis function. For instance, Let us look at a simple learning model, called the Perceptron next.

4 The Perceptron Learning Model

5 References

1. CalTech Machine Learning Course - CS156, Lecture 1.