Neural Networks

Pranay Patil

1 Introduction

This document introduces neural networks and is intended for readers with no prior knowledge of these types of networks.

You are free to distribute this document as you wish. Please report any mistakes to patilpranay@berkeley.edu.

Contents

2 Notation

Notation	Meaning
$\mathbb{R}$	the set of real numbers

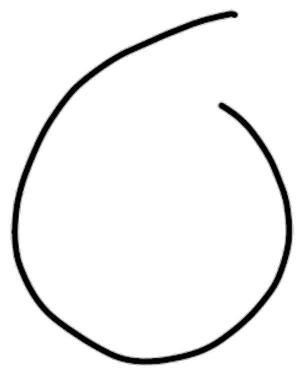
2.1 Other Notes

- Some of the entries in the table shown above may not make complete sense to the reader as of yet. These entries are intended to be a reference for the reader after they have first been introduced to the reader in the following sections of this document.

3 Motivation

Before discussing neural nets, let us take a step back and discuss the broader field of **machine learning**.

There are lots of problems, such as recognizing handwritten digits or identifying spam, for which it is too difficult to write an explicit computer program that always outputs the correct answer. This is primarily due to the variability of the data, as there are no specific rules that dictate whether the following digit is a zero or a six or if an email should be tagged as spam or not.



For this reason, we build models that learn by looking at lots and lots of examples and their correct answers. Then, when the model comes across a particular example that it has not seen before, it uses what it has learned to output a prediction for this new example.

The field of machine learning is concerned with the study of these types of models and what strategies and algorithms to use to build the best model, i.e., one that minimizes the number of incorrect predictions for unseen examples.

3.1 Formulation

We can formally state the problem described above as follows.

Given $\{x_i, y_i\}$ for $i = 1 \ldots n$, we want to build a model f such that we minimize $\displaystyle\sum_{i=1}^{n} \|y_i - f(x_i)\|^2$.

Let us break down this statement and understand what it is saying. $\{x_i, y_i\}$ indicates a set of n **training examples**, where the x_i are the examples and the y_i are the labels (or correct answers) of these examples.

f represents a model (which can be thought of as a function) that, given an input x_i, outputs a prediction $f(x_i)$.

Since we don't know the correct answers to any unseen data, the only way we can judge how well our model works is to compare the predictions output by the model against the correct answers to the training examples. We want the difference between the correct answer and the predicted answer to be as small as possible, i.e., we want to minimize $y_i - f(x_i)$. We take the squared l_2 norm of this value to discard the effect of negatives, resulting in $\|y_i - f(x_i)\|^2$. This as known as the **error** of the model for example x_i.

Since we want to measure how well the model predicts against all of the training examples, we calculate the error of the model for all the examples and sum up the results, giving us

$$\sum_{i=1}^{n} \|y_i - f(x_i)\|^2.$$

This is known as the **squared error loss** and is one way to measure the quality of a model.

4 Neural Networks

5 Ties to the Brain

In order to understand the rise of neural networks and how they work, it is helpful to look towards the brain. The brain consists of around 10^{11} neurons and each neuron has approximately 10^{4} connections to other neurons.