Day 19 Perceptron

Nov. 19, 2020

Announcements

- **Homework 5** Working with Tensorflow. Due 12/4. This is the last homework assignment!
- **Projects** Rubric posted to D2L.
    - Due finals week
    - 8-10 minute video presentation + documented notebook on your analysis
    - 3 In-class work periods for the project

Calendar

This week

- Thursday: Day 19 Perceptron model

Thanksgiving week

- Tuesday 11/24: Project work day 1
- Thursday 11/26: No class

Week after Thanksgiving

- Tuesday 12/1: Day 20 Neural Networks 1
- Thursday 12/3: Day 21 Neural Networks 2

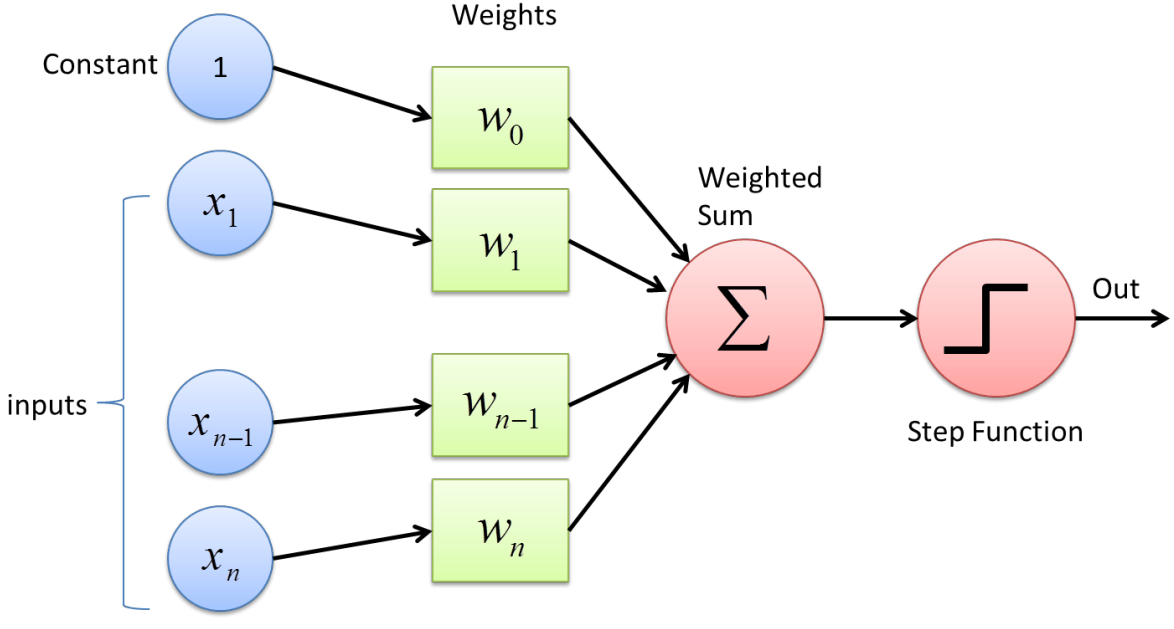
Last week of classes

- Tuesday 12/8: Project work day 2
- Thursday 12/10: Project work day 3

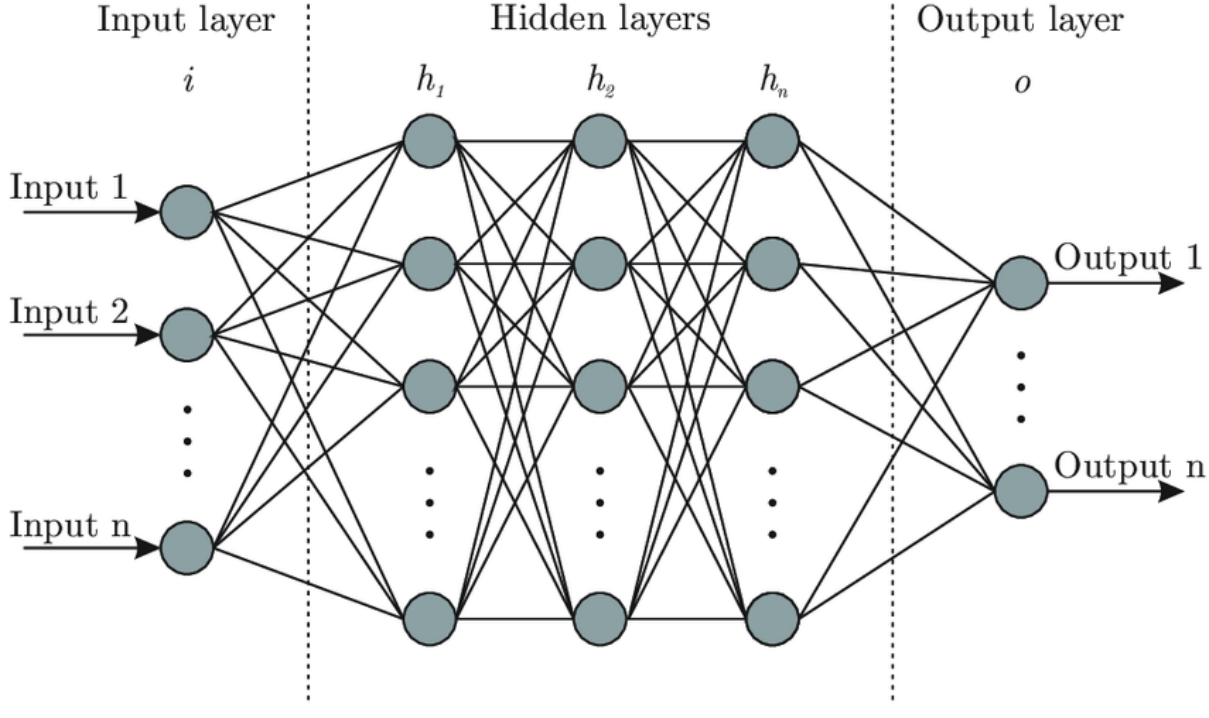
Pre-Class

- What is the perceptron model doing?
- How do we take the mathematics and make it into code?
- How is this different from a neural network?

Perceptron (single layer neural network)

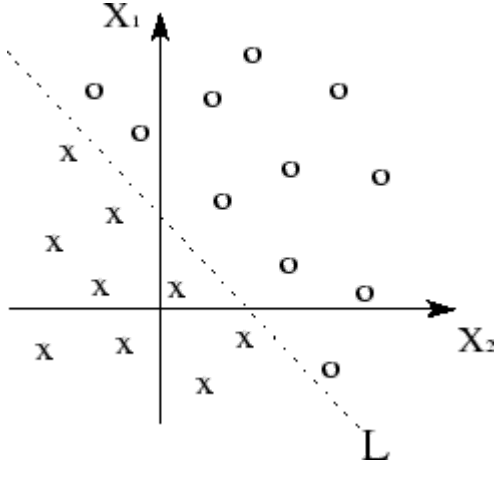


Neural Network ("multi layer perceptron")



How does a Perceptron model classify points?

2D example



- A perceptron model is trying to find a line to seperate the classes
- Each point in a 2D space has a location (x_1, x_2); basically `feature_1` and `feature_2`
- A line in that space would have the normal form $A + Bx_1 + Cx_2 = 0$ or $x_2 = -\frac{B}{C}x_1 - \frac{A}{C}$
- Using an iterative approach, a Perceptron model tries to find A, B, and C.

One prediction `predict()`

The perceptron model iteratively determines A, B, and C by looking at every point in the data it is trained on.

- Take the location of one data point plus a constant (the "bias"; e.g., 1) and take the dot product with an initial guess of the weights (e.g., $\vec{w} = (1, 1, 1)$).

$$result = \vec{x} \cdot \vec{w} = (x_1, x_2, 1) \cdot (1, 1, 1) = x_1 + x_2 + 1$$

- If $x_1 = 2$ and $x_2 = 3$, then the $result = (2 + 3 + 1) = 6$

Because this is greater than zero, we predict it to be in class 1

```
if result > 0:
    predict class 1 and return 1;
 else:
    predict class 2 and return -1
```

For our example, we return 1!

But we know the class (because we are using *supervised learning*)!

Compare to actual class and update weights

- Originally we guessed the weights $\vec{w} = (1, 1, 1)$, we can use the misclassifications to update the weights.

Let's assume we were wrong, so the data is actually in class 2.

That update uses this equation:

$$\vec{w}_{new} = \vec{w}_{old} + \eta * d * \vec{x}$$

where η is the learning rate and d = `actual_class_value - predicted_class_value` (as long as classes are 1 and -1)

Continuing example

We predicted class 1 (`class_label` =1), but the data is in class 2 (`class_label` =-1). So the update to the weights is:

$$update = \eta * d * \vec{x} = \eta * (-1 - (1)) * (2, 3, 1)$$
$$update = \eta * (-2) * (2, 3, 1) = (-4, -6, -2) * \eta$$

where we choose η, let's take it to be 0.01. So the update is:

$$update = (-4, -6, -2) * 0.01 = (-0.04, -0.06, -0.02)$$

We add this to the guessed weights:

$$\vec{w}_{new} = \vec{w}_{old} + update = (1, 1, 1) + (-0.04, -0.06, -0.02) = (0.96, 0.94, 0.98)$$

What is we guess correctly?

In that case, the predicted and known classes are the same, so the update is:

$$update = \eta * d * \vec{x} = \eta * (-1 - (-1)) * (2, 3, 1)$$
$$update = \eta * (0) * (2, 3, 1) = (-4, -6, -2) * \eta = 0$$

And there's no change to the weights because we did ok!

This means perceptrons don't find the "best line" just a line that separates the data.

So how do we fit the model? `fit()`

```
for the number of iterations we choose:
    for the data we have:
        predict the class
        update the weights
```

Questions, Comments, Concerns?