91258 Natural Language Processing

Lesson 11. "More than One" Neuron

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Previously

- The perceptron
- Intro to neural networks

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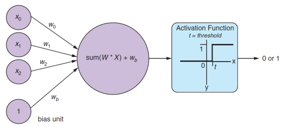
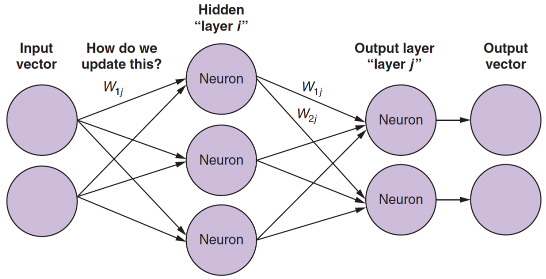
Backpropagation (brief)

Weight Updating

Learning in a “simple” perceptron[1] vs a fully-connected network

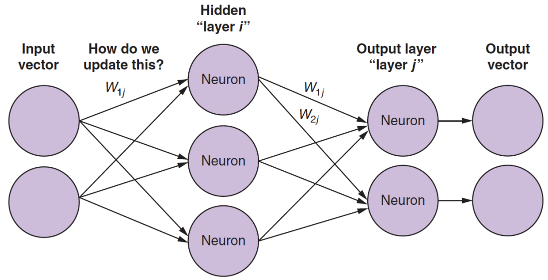




(Lane et al., 2019, p. 158, 168)

[1]Remember: aka linear regression

Backpropagation (of the errors)



- The error is computed on the output vector
- How much error did W_{1i} “contribute”?[2]
- “Path”: $W_{1i} \rightarrow [W_{1j}, W_{2j}] \rightarrow output$

[2]Notice that the first W_{1j} should be W_{1i}

Backpropagation (of the errors)

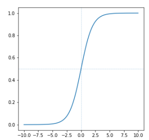
A better activation function

Step function: $f(\vec{x}) = \begin{cases} 1 & \text{if } \sum_{i=0}^{n} x_i w_i > threshold \\ 0 & \text{otherwise} \end{cases}$

Sigmoid function: non-linear[3] and continuously differentiable

$$S(x) = \frac{1}{1 + e^{-x}} \tag{1}$$

Let us see



Non-linear $\rightarrow$ model non-linear relationships

Continuously differentiable $\rightarrow$ partial derivatives wrt various variables to update the weights

[3]The change of the output is not proportional to the change of the input.

Backpropagation

Differentiating to adjust

Squared error[4]

$$SE = (y - f(x))^2 \tag{2}$$

Mean squared error

$$MSE = \frac{1}{n} \sum_{i=1}^{n} (y - f(x))^2 \tag{3}$$

Calculus chain rule

$$f(g(x))' = F'(x) = f'(g(x))\,g'(x) \tag{4}$$

With (4) we can find the derivative of the actfunct $\forall$ unit wrt its input.

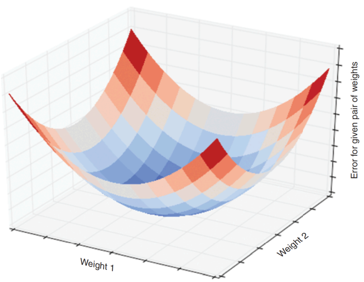
Plain words: find the contribution of a weight to the error and adjust it!

(no further math)

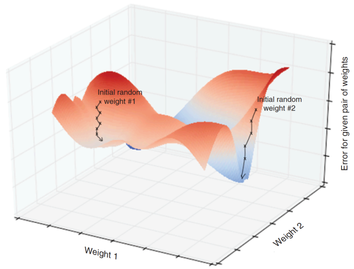
[4]In (Lane et al., 2019, p. 171) they say this is MSE; but there is no mean

Backpropagation (of the errors)

~Gradient descent: minimising the error



Convex error curve



Non-convex error curve

(Lane et al., 2019, p. 173–174)

Addressing Local minima

Batch learning

- Aggregate the error for the batch
- Update the weight at the end
- $\rightarrow$ hard to find global minimum

Stochastic gradient descent

- Look at the error for each single instance
- Update the weights right away
- $\rightarrow$ more likely to make it to the global minimum

Mini-batch

- Much smaller batch, combining the best of the two worlds
- $\rightarrow$ Fast as batch, resilient as stochastic gradient descent

Important parameter: learning rate α
A parameter to define at what extent should we "correct" the error

Keras

Some Popular Libraries

There are many high- and low-level libraries in multiple languages

- **PyTorch**
  Community-driven; `https://pytorch.org/`
- **Theano**
- **TensorFlow**
  Google Brain; `https://www.tensorflow.org/`
- **Others**

We will use **Keras**; `https://keras.io/`

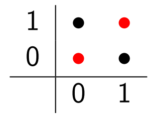
What is Keras

- High-level wrapper with an accessible API for Python
- Gives access to three alternative backends
  - TensorFlow
  - CNTK (MS)

Keras

Logical exclusive OR (XOR) in Keras

input		output
0	0	0
0	1	1
1	0	1
1	1	0



Let us see

First dense layer

- 2 inputs, 10 units
- 30 parameters
- $2 \times 10 \rightarrow 20$
- But we also have the bias! (10 more weights)

Second dense layer

- 10 inputs, 1 unit
- 11 parameters

Now we can compile the model

Let us see

Some Guidelines

Design Decisions

Activation functions

Sigmoid

ReLU Rectified linear unit (and variations)

tanh Hyperbolic tangent

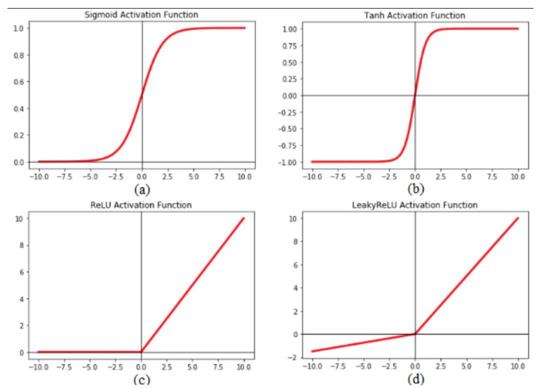


Figure source: (Kandel and Castelli, 2020)

Design Decisions

Activation functions

- Sigmoid
- ReLU (rectified linear unit)
- tanh (hyperbolic tangent)

Learning rate

- Choosing one in advance
- Use **momentum** to perform dynamic adjustments

Dropout

- Ignore randomly-chosen weights in a training pass to prevent overfitting

Regularisation

- Dampen a weight from growing/shrinking too far from the rest to prevent overfitting

Normalisation

Example House classification.

Input number of bedrooms, last selling price

Output Likelihood of selling

Vector `input_vec = [4, 12000]`

All input dimensions should have comparable values

Ideally, all features should be in the range $[-1, 1]$ or $[0, 1]$

Typical normalisation: mean normalisation, feature scaling, coefficient of variation

NLP typically uses TF–IDF, one-hot encoding, word2vec (already normalised)

References

Kandel, I. and M. Castelli
2020. Transfer learning with convolutional neural networks for diabetic retinopathy image classification. a review. *Applied Sciences*, 10(6).

Lane, H., C. Howard, and H. Hapkem
2019. *Natural Language Processing in Action*. Shelter Island, NY: Manning Publication Co.