92586 Computational Linguistics

9. “More than One” Neuron

Alberto Barrón-Cedeño

Alma Mater Studiorum-Università di Bologna
a.barron@unibo.it @_albarron_

16/04/2020

Previously

- The perceptron
- Intro to neural networks

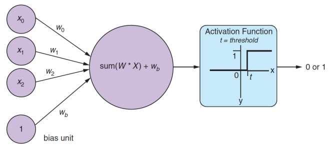
Table of Contents

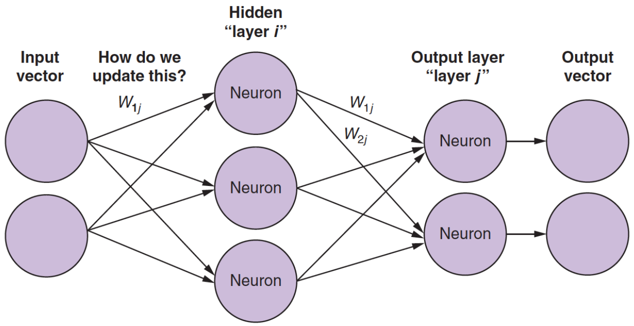
Chapter 5 of Lane et al. (2019)

Backpropagation (brief)

Weight Updating

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

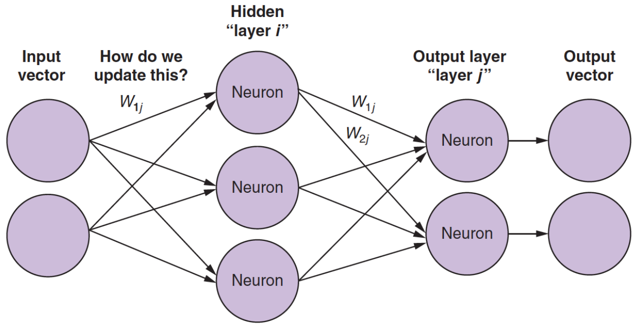




(Lane et al., 2019, p. 158, 168)

[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)

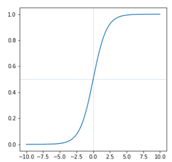
A better activation function

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 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

Backpropagation

Differentiating to adjust

Squared error (in (Lane et al., 2019, p. 171) they say this is MSE; wrong)

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

Mean squared error

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

Calculus chain rule

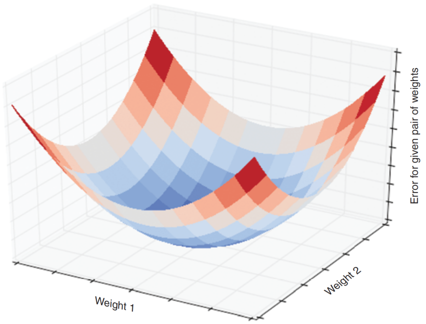
$$f(g(x))' = F'(x) = f'(g(x))\, g'(x) \tag{4}$$

With (4) we can find the derivative of the actfunct $\forall$ neuron wrt its input.
Plain words: find the contribution of a weight to the error and adjust it!

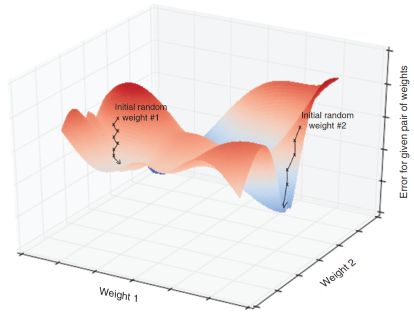
(no further math)

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
- → hard to find global minimum

Stochastic gradient descent

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

Mini-batch

- Much smaller batch, combining the best of the two worlds
- → 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 Available Libraries

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

- **PyTorch**
  Community-driven; `https://pytorch.org/`
- **Theano**
  MILA (UdeM); `www.deeplearning.net/software/theano/`[3]
- **TensorFlow**
  Google Brain; `https://www.tensorflow.org/`
- **Others**

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

[3] Non active

What is Keras

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

Keras

Logical exclusive OR 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 neurons
  - 30 parameters
  - $2 \times 10 \rightarrow 20$
  - But we also have the bias! That's 10 more weights
- Second dense layer
  - 10 inputs, 1 neuron
  - 11 parameters

Now we can compile the model

Let us see

Some Guidelines

"Design Decisions"

Activation functions

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

Learning rate

- Choosing one in advance
- Use alertmomentum 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 = [2, 90000]`

All input dimensions should have comparable values

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

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

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

References

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