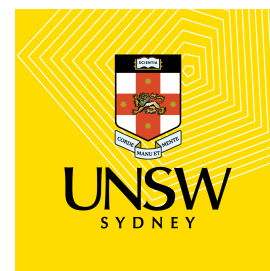


COMP9444

Neural Networks and Deep Learning

Term 2, 2024



Week 1 Tutorial: Perceptrons

1. Introduce yourselves, get to know your fellows and your tutor.

2. Perceptron Learning

- (a) Construct by hand a Perceptron which correctly classifies the following data; use your knowledge of plane geometry to choose appropriate values for the weights w_0 , w_1 , and w_2 .

Training Examples	x1	x2	Class
a.	0	1	-1
b.	2	0	-1
c.	1	1	+1

- (b) Demonstrate the Perceptron Learning Algorithm on the above data, using a learning rate of 1.0 and initial weight values of
 $w_0 = -1.5$
 $w_1 = 0$
 $w_2 = 2$

In your answer, you should clearly indicate the new weight values at the end of each training step. The first three steps are shown here:

Iteration	w_0	w_1	w_2	Training Example	x_1	x_2	Class	$s = w_0 + w_1x_1 + w_2x_2$	Action
1	-1.5	0	2	a.	0	1	-	+0.5	Subtract
2	-2.5	0	1	b.	2	0	-	-2.5	None
3	-2.5	0	1	c.	1	1	+	-1.5	Add

3. Computing any Logical Function with a 2-layer Network

Recall that any logical function can be converted to **Conjunctive Normal Form** (CNF), which means a conjunction of terms where each term is a disjunction of (possibly negated) literals. This is an example of an expression in CNF:

$$(A \vee B) \wedge (\neg B \vee C \vee \neg D) \wedge (D \vee \neg E)$$

Assuming False=0 and True=1, explain how each of the following could be constructed. You should include the bias for each node, as well as the values

of all the weights (input-to-output or input-to-hidden and hidden-to-output, as appropriate).

- (a) Perceptron to compute the OR function of m inputs,
- (b) Perceptron to compute the AND function of n inputs,
- (c) Two-layer Neural Network to compute the function
 $(A \vee B) \wedge (\neg B \vee C \vee \neg D) \wedge (D \vee \neg E)$

With reference to this example, explain how a two-layer neural network could be constructed to compute any (given) logical expression, assuming it is written in Conjunctive Normal Form.

Hint: first consider how to construct a Perceptron to compute the OR function of m inputs, with k of the m inputs negated.

4. XOR Network

Construct by hand a Neural Network (or Multi-Layer Perceptron) that computes the XOR function of two inputs. Make sure the connections, weights and biases of your network are clearly visible.

Challenge: Can you construct a Neural Network to compute XOR which has only one hidden unit, but also includes shortcut connections from the two inputs directly to the (one) output?

Hint: Start with a network that computes the inclusive OR, and then try to think of how it could be modified.

5. Implications of Deep Learning

What potential benefits and dangers might Deep Learning pose for education, entertainment, the economy, and society in general?