COMP9444
Neural Networks and Deep Learning
Term 2, 2023

Week 2 Tutorial: Perceptrons

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1. **Introduce yourselves, get to know 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 Example	x_1	x_2	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

   Continue the table until all items are correctly classified.

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

   Recall that any logical function can be converted into 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 $\text{False}=0$ and $\text{True}=1$, 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?
