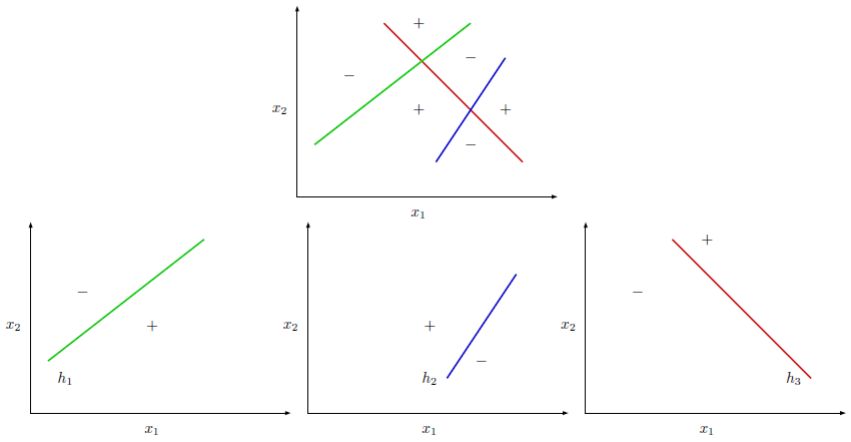
ECE421: Introduction to Machine Learning — Fall 2024

Worksheet 5: Multilayer Perceptron and Backward Propagation

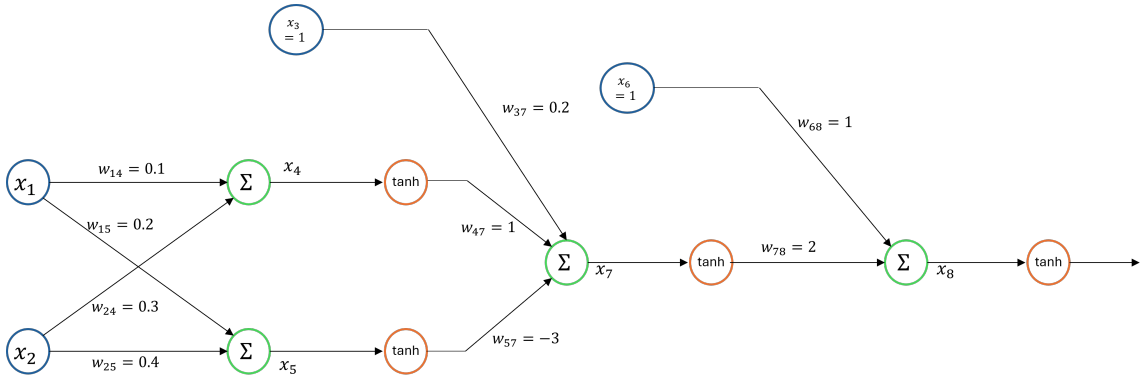
Q1 **(Exercise 7.1 from LFD)** Consider a target function f (top row) composed of three perceptron components h_1, h_2, and h_3. The $+$ and - regions of h_1, h_2, and h_3 are illustrated (from left to right in bottom row).



1.a Show that $f = \overline{h_1}h_2h_3 + h_1h_2\overline{h_3} + h_1\overline{h_2}h_3$.

1.b Is there a systematic way of going from a target function composed of perceptrons to a Boolean formula like in part (a)? [Hint: consider only the $+$ regions of the target function and use the disjunctive normal form (OR and ANDs).]

Q2 **(Forward and Backward Propagation)** Consider the following neural network:



Letting $x_1 = 1$, $x_2 = 2$, and $y = 1$, we would like to calculate the gradients. Note that x_3 and x_6 are set to 1. Clearly show the intermediate steps in calculations and perform one round of forward and backward propagation, and use the results to calculate the gradients. Specifically, fill in all the missing intermediate steps in the computation of x_4, x_5, x_7, x_8, and the partial derivatives, *i.e.*, $\frac{\partial E(W)}{\partial w_{i,j}}$, where $E(W) = (y - \theta(x_8))^2$ and $\theta(\cdot)$ denotes the *tanh* function.