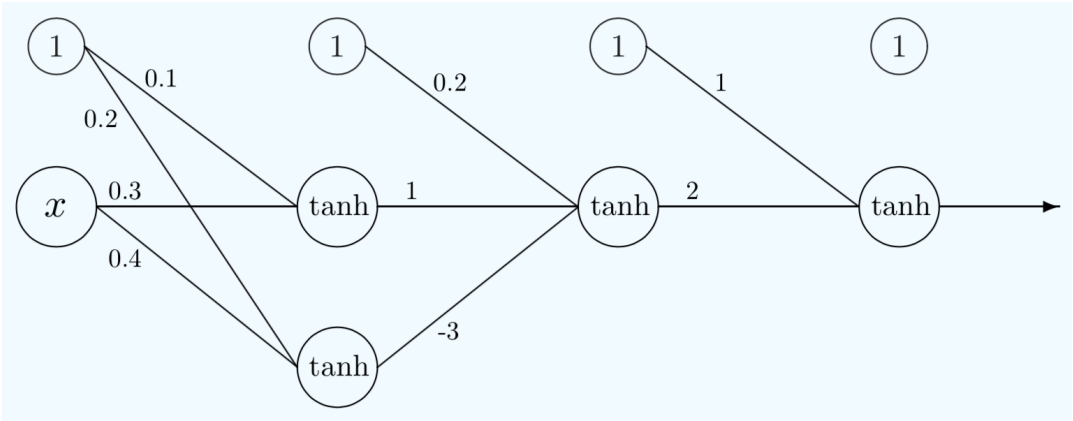
National Taiwan University **Introduction to Machine Learning and Deep Learning**
Department of Civil Engineering Instructor: C.-S. CHEN

Homework 5
Essay, Due 21:00, Wednesday, December 15, 2021

Late submission within 24 hours: score*0.9;
Late submission before post of solution: score*0.8 (the solution will usually be posted within a week); no late submission after the post of solution)

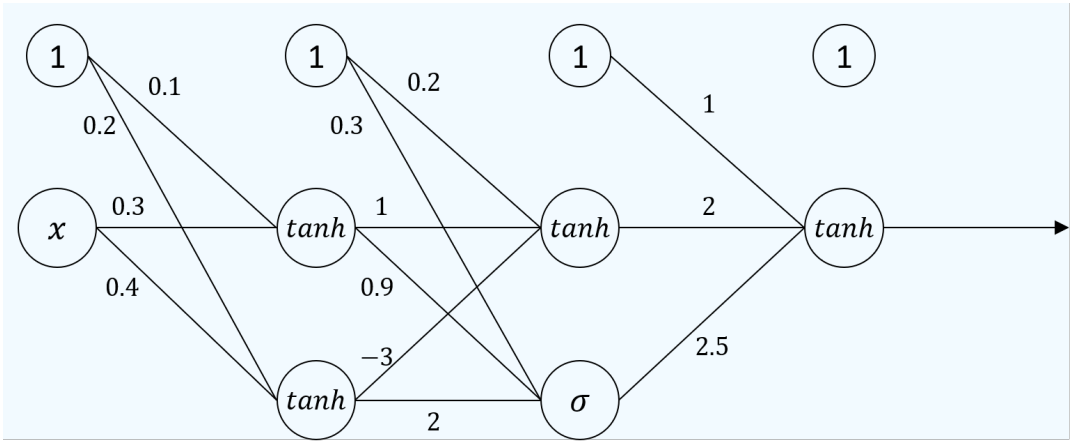
Total 70%

1. **(40%)** Name your file HW5_Prob1.pdf. Consider the simple network example with a single input $x = 2$ and a single output $y = 1$ shown below, as we have discussed in lecture.



   (a) (10%) Using the **half** of the sum square as our error function, derive and compute $\boldsymbol{\delta}^{(3)}$, $\boldsymbol{\delta}^{(2)}$, $\boldsymbol{\delta}^{(1)}$.
   (b) (10%) Compute $\frac{\partial e}{\partial \mathbf{W}^{(1)}}$, $\frac{\partial e}{\partial \mathbf{W}^{(2)}}$, $\frac{\partial e}{\partial \mathbf{W}^{(3)}}$.
   (c) (20%) Update the weight matrices using this single datapoint with a learning rate $\eta = 0.5$, repeat the forward propagation and compute $\mathbf{s}^{(1)}$, $\mathbf{x}^{(1)}$, $\mathbf{s}^{(2)}$, $\mathbf{x}^{(2)}$, and $\mathbf{x}^{(3)}$.

2. **(30%)** Name your file HW5_Prob2.pdf . Consider the simple network example with a single input $x = 2$ and a single output $y = 1$ shown below.



$$\sigma = sigmoid(x) = \frac{1}{1 + e^{-x}}$$

(a) (10%) Derive and compute $\mathbf{s}^{(1)}$, $\mathbf{x}^{(1)}$, $\mathbf{s}^{(2)}$, $\mathbf{x}^{(2)}$, and $\mathbf{x}^{(3)}$.
(b) (10%) Using the sum square as our error function, derive and compute $\boldsymbol{\delta}^{(3)}$, $\boldsymbol{\delta}^{(2)}$, $\boldsymbol{\delta}^{(1)}$.
(c) (10%) Compute $\frac{\partial \mathrm{e}}{\partial \mathbf{W}^{(1)}}$, $\frac{\partial \mathrm{e}}{\partial \mathbf{W}^{(2)}}$, $\frac{\partial \mathrm{e}}{\partial \mathbf{W}^{(3)}}$.

- **Submission Format:** Please compress the .pdf files into `yourStudentId_hw5.zip`, then upload it to NTU COOL.