MTK DLP
Lab1 - Backpropagation

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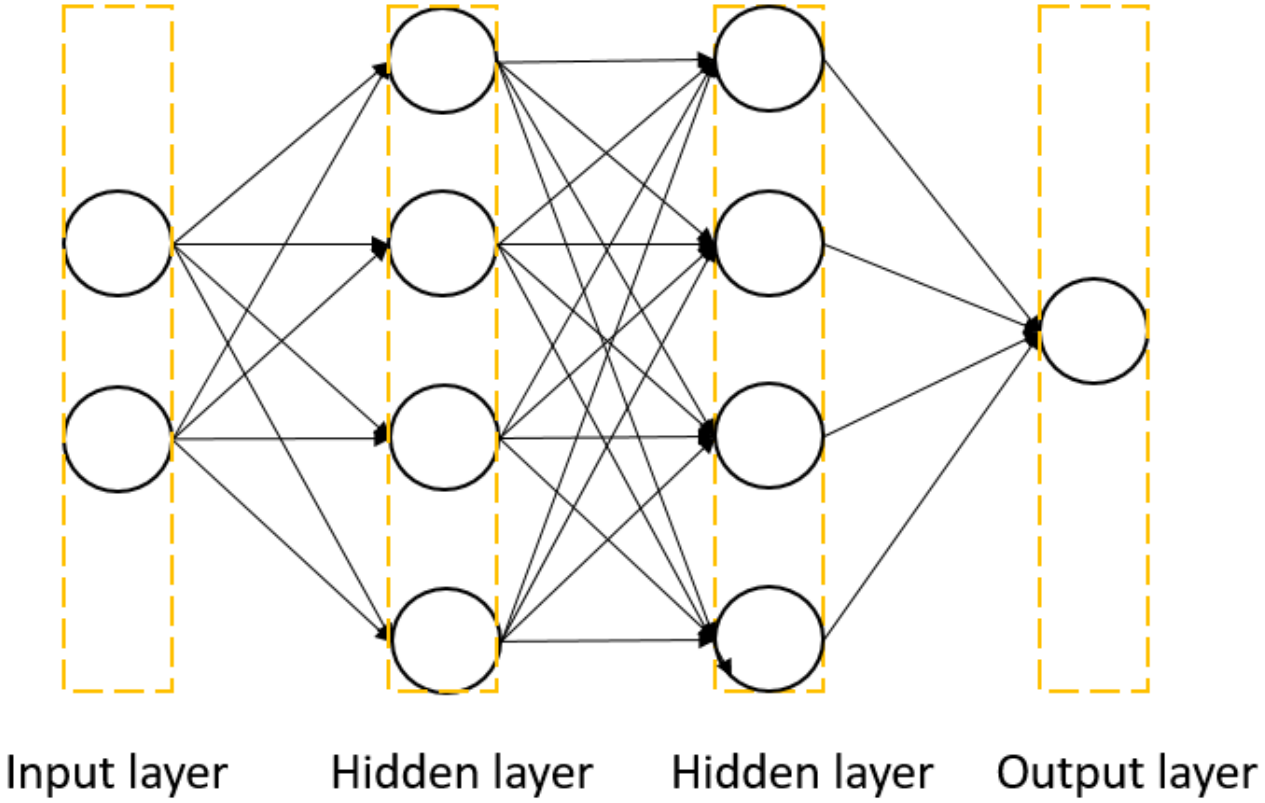
Aug 12, 2020

Outline

- Lab Objective
- Important Date
- Lab Description
- Scoring Criteria

Lab Objective

- In this lab, you will need to understand and implement a simple neural network with forward and backward pass using two hidden layers



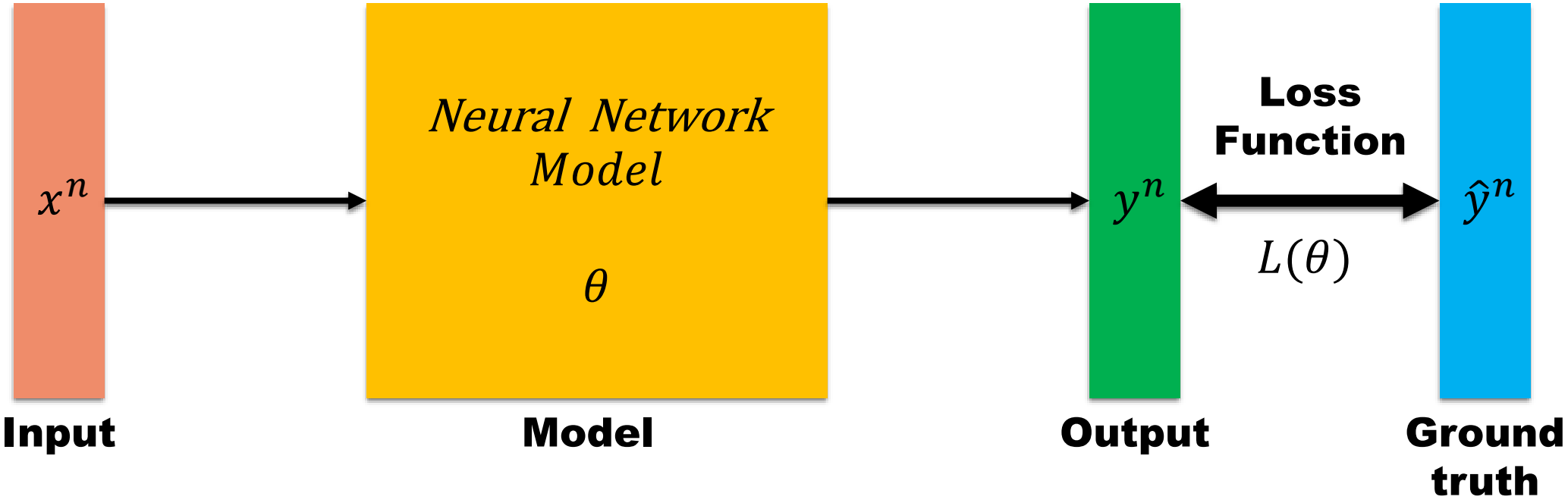
Important Date

- Report Submission Deadline: 8/26 (Wed) 11:59 a.m
- Demo date: 8/26 (Wed)
- Zip all files in one file
  - Report (.pdf)
  - Source code
- name it like「DLP_LAB1_yourID_name.zip」
  - ex:「DLP_LAB1_0756172_鍾嘉峻.zip」

Lab Description

- Implement a simple neural network with two hidden layers
- You can only use Numpy and other python standard libraries.
- Plot your comparison figure showing the predictions and ground truth.
- Plot your learning curve (loss, epoch).
- Print the accuracy of your prediction.

Lab Description



$$\theta = \{w_1, w_2, w_3, w_4, \cdots\}$$

$$\boldsymbol{\nabla L(\theta)} = \begin{bmatrix} \partial L(\theta)/\partial w_1 \\ \partial L(\theta)/\partial w_2 \\ \partial L(\theta)/\partial w_3 \\ \vdots \\ \vdots \end{bmatrix}$$

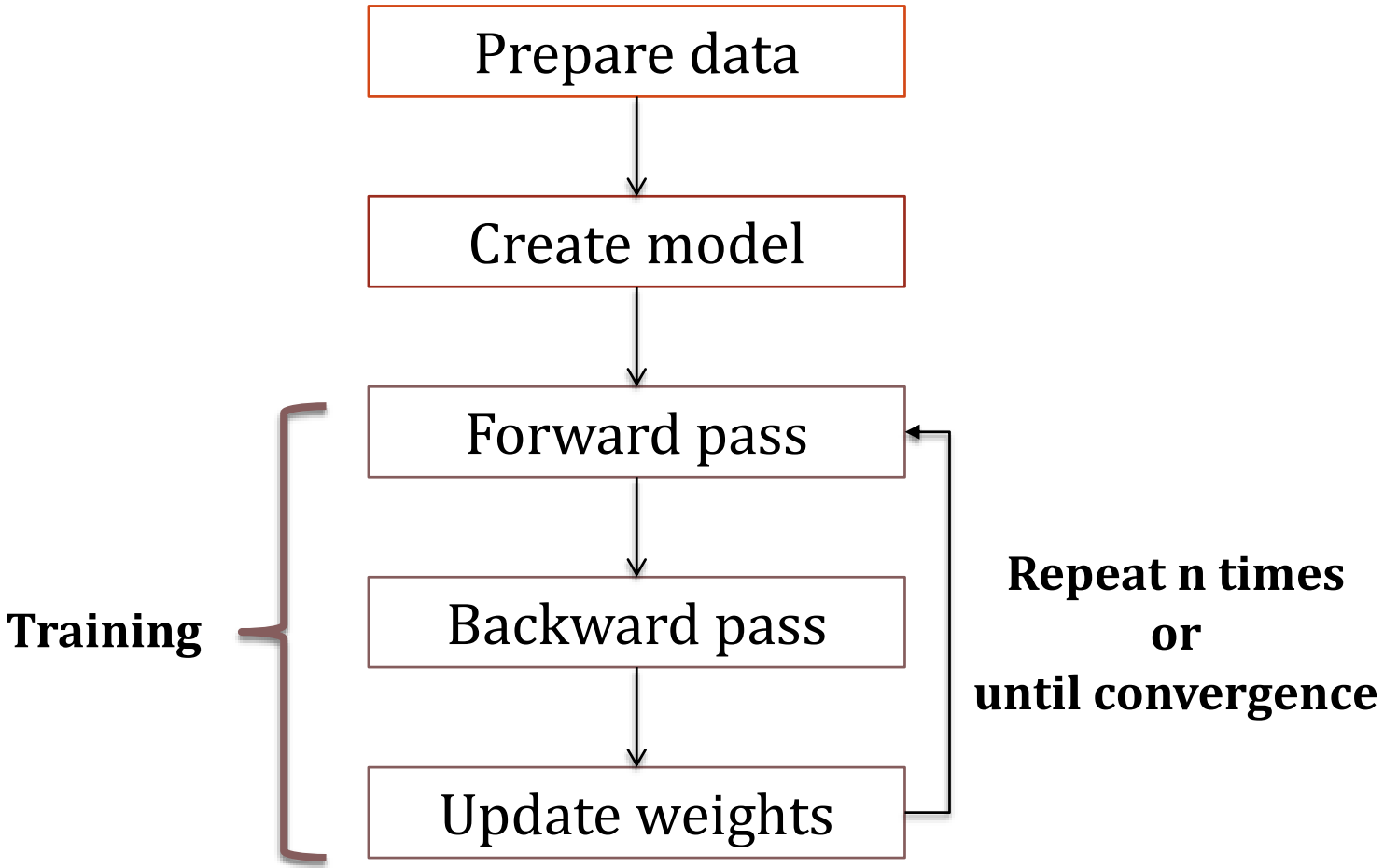
Compute $\nabla L(\theta^0)$ $\quad \theta^1 = \theta^0 - \rho \nabla L(\theta^0)$

Compute $\nabla L(\theta^1)$ $\quad \theta^2 = \theta^0 - \rho \nabla L(\theta^1)$

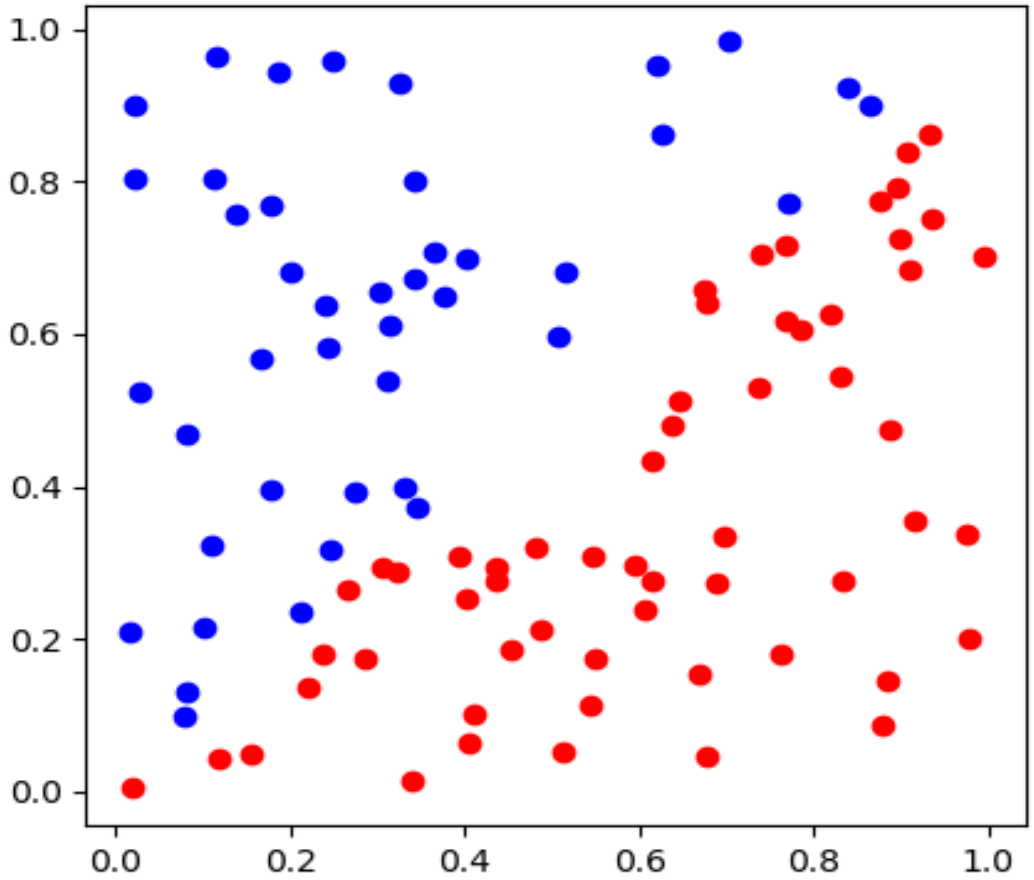
Compute $\nabla L(\theta^2)$ $\quad \theta^3 = \theta^0 - \rho \nabla L(\theta^2)$

ρ : Learning rate

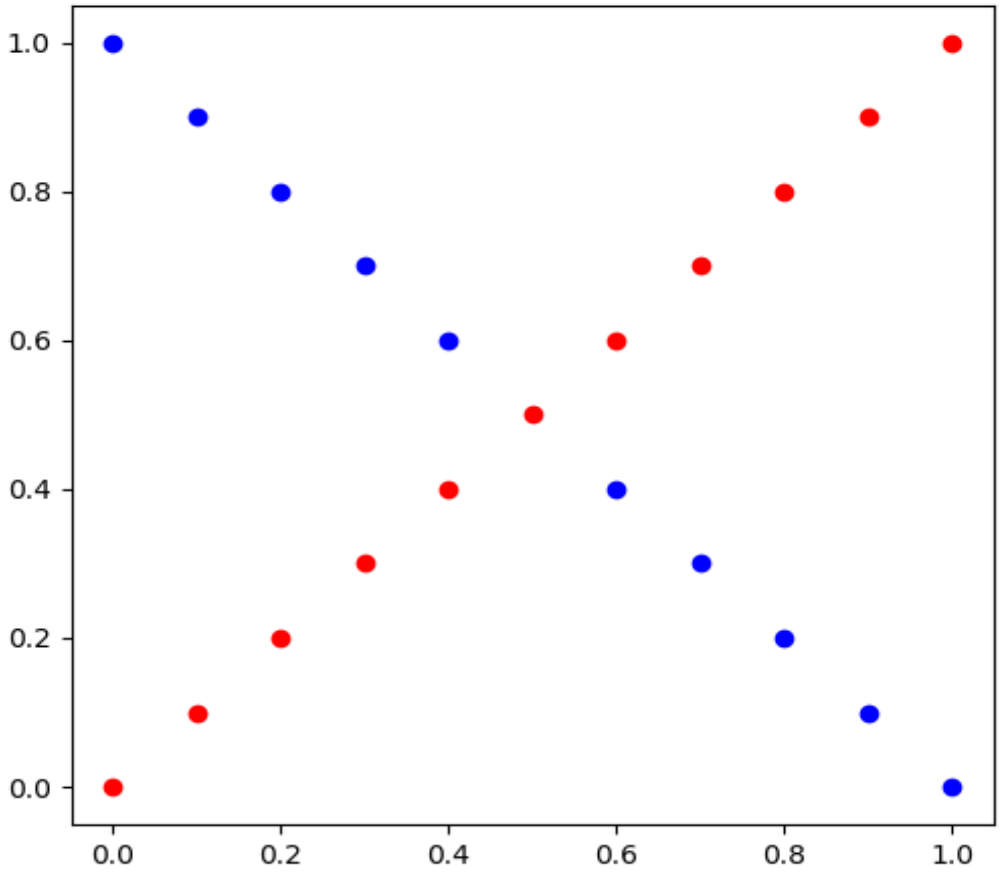
Lab Description – Flowchart



Lab Description - Data

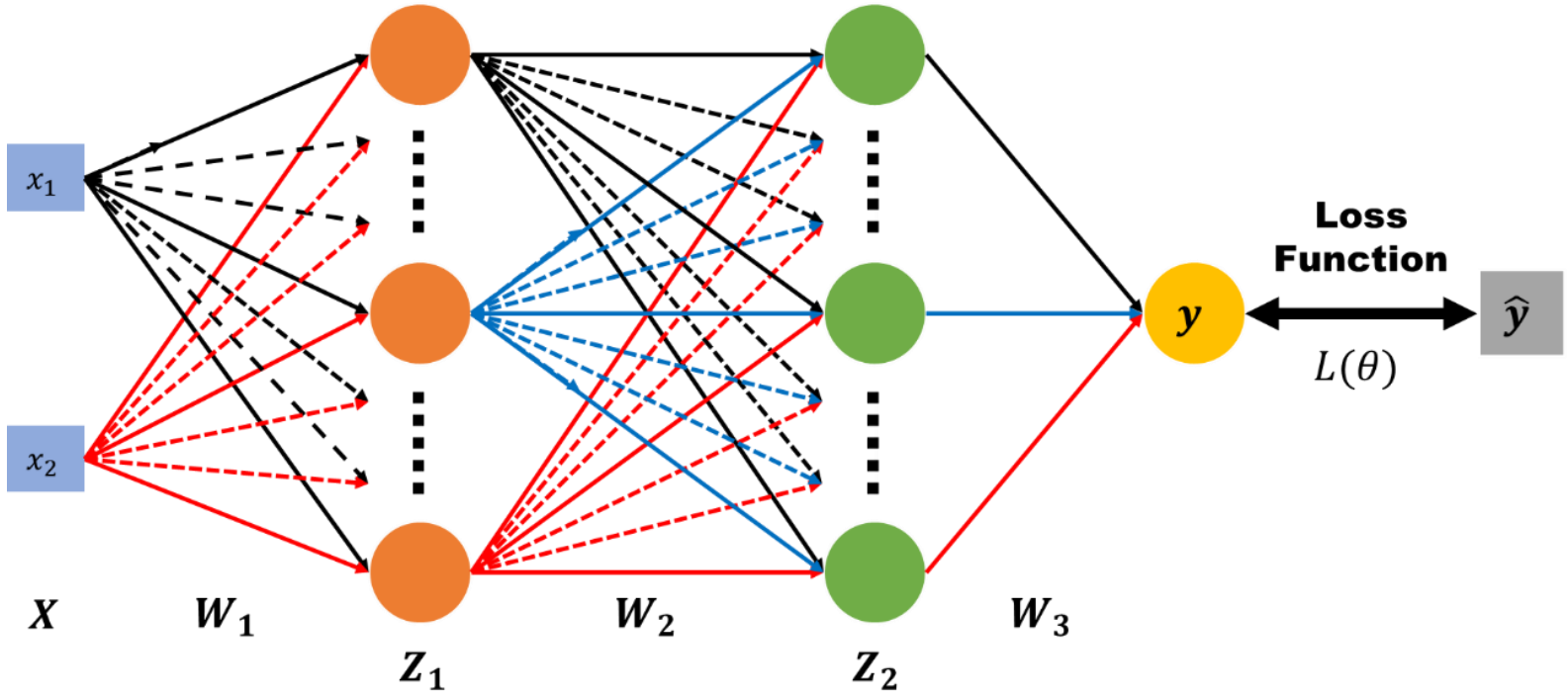


generate_linear()



generate_XOR_easy()

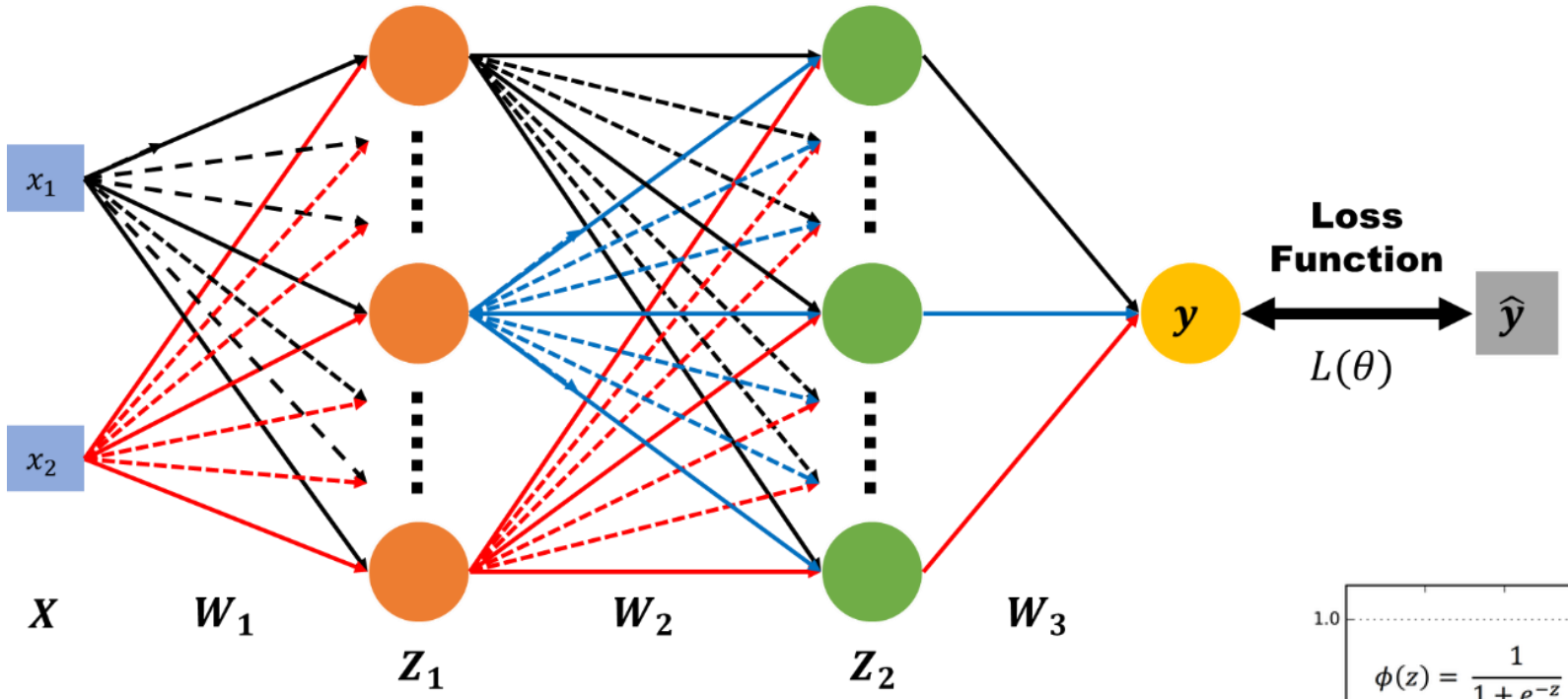
Lab Description – Architecture



$X : [x_1, x_2]$ $y :$ *outputs* $\hat{y} :$ *ground truth*

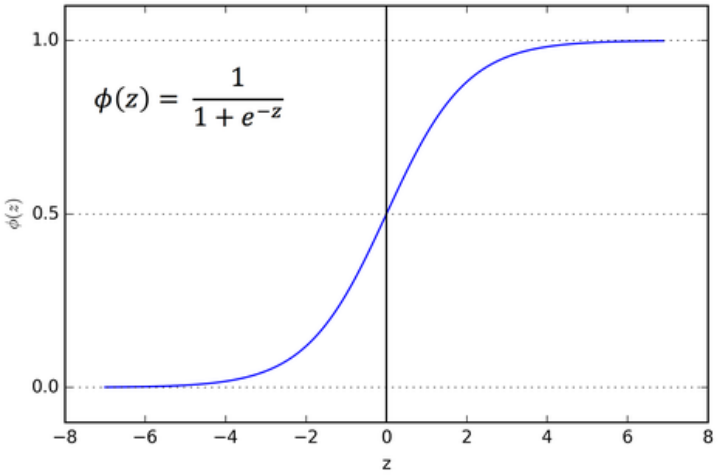
W_1, W_2, W_3 : *weight matrix of network layers*

Lab Description – Forward

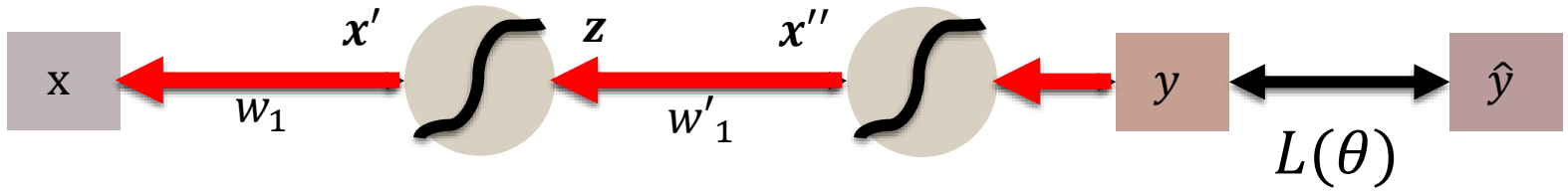


$$Z_1 = \sigma(XW_1) \qquad Z_2 = \sigma(Z_1W_2) \qquad y = \sigma(Z_2W_3)$$

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



Lab Description – Backward



$x' = xw_1$ $z = \sigma(x')$ $x'' = zw'_1$ $y = \sigma(x'')$

Chain rule

$y = g(x)$ $z = h(y)$

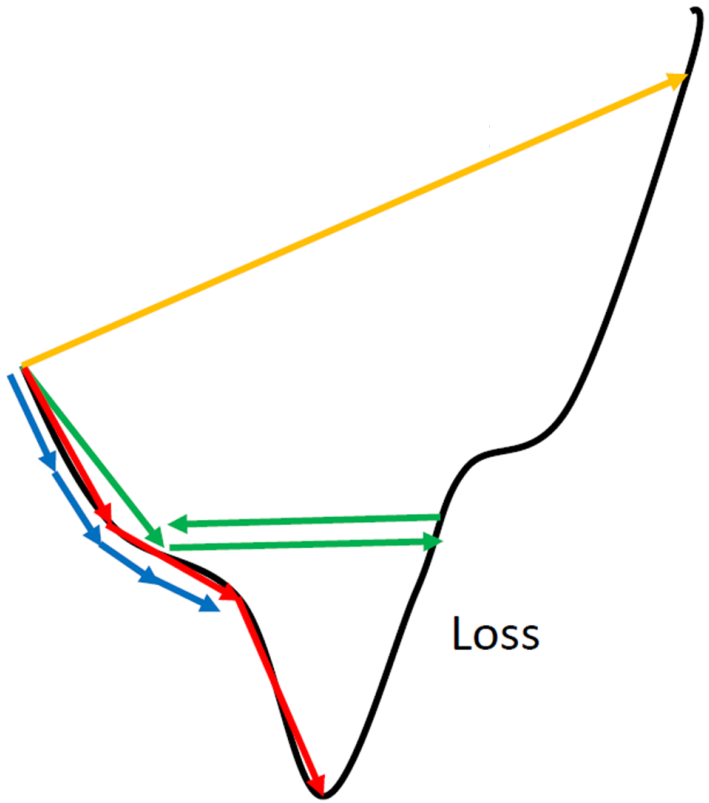
$\mathbf{x} \xrightarrow{\mathbf{g}()} \boldsymbol{y} \xrightarrow{\boldsymbol{h}()} \boldsymbol{z}$

$$\frac{dz}{dx} = \frac{dz}{\cancel{dy}}\frac{\cancel{dy}}{dx}$$

$$\frac{\partial L(\theta)}{\partial w_1} = \frac{\partial y}{\partial w_1}\frac{\partial L(\theta)}{\partial y}$$
$$= \frac{\partial x''}{\partial w_1}\frac{\partial y}{\partial x''}\frac{\partial L(\theta)}{\partial y}$$
$$= \frac{\partial z}{\partial w_1}\frac{\partial x''}{\partial z}\frac{\partial y}{\partial x''}\frac{\partial L(\theta)}{\partial y}$$
$$= \frac{\partial x'}{\partial w_1}\frac{\partial z}{\partial x'}\frac{\partial x''}{\partial z}\frac{\partial y}{\partial x''}\frac{\partial L(\theta)}{\partial y}$$

Lab Description – Gradient descent

Network Parameters $\theta = \{w_1, w_2, w_3, w_4, \cdots\}$

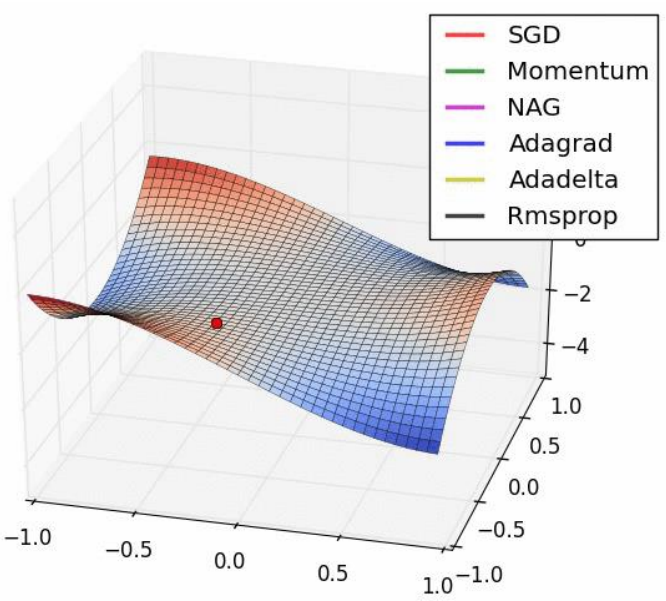


$$\theta^1 = \theta^0 - \rho \nabla L(\theta^0)$$

$$\theta^2 = \theta^0 - \rho \nabla L(\theta^1)$$

$$\theta^3 = \theta^0 - \rho \nabla L(\theta^2)$$

ρ ：Learning rate



http://www.denizyuret.com/2015/03/alec-radfords-animations-for.html

Lab Description - Prediction

- In the training, you need to print loss

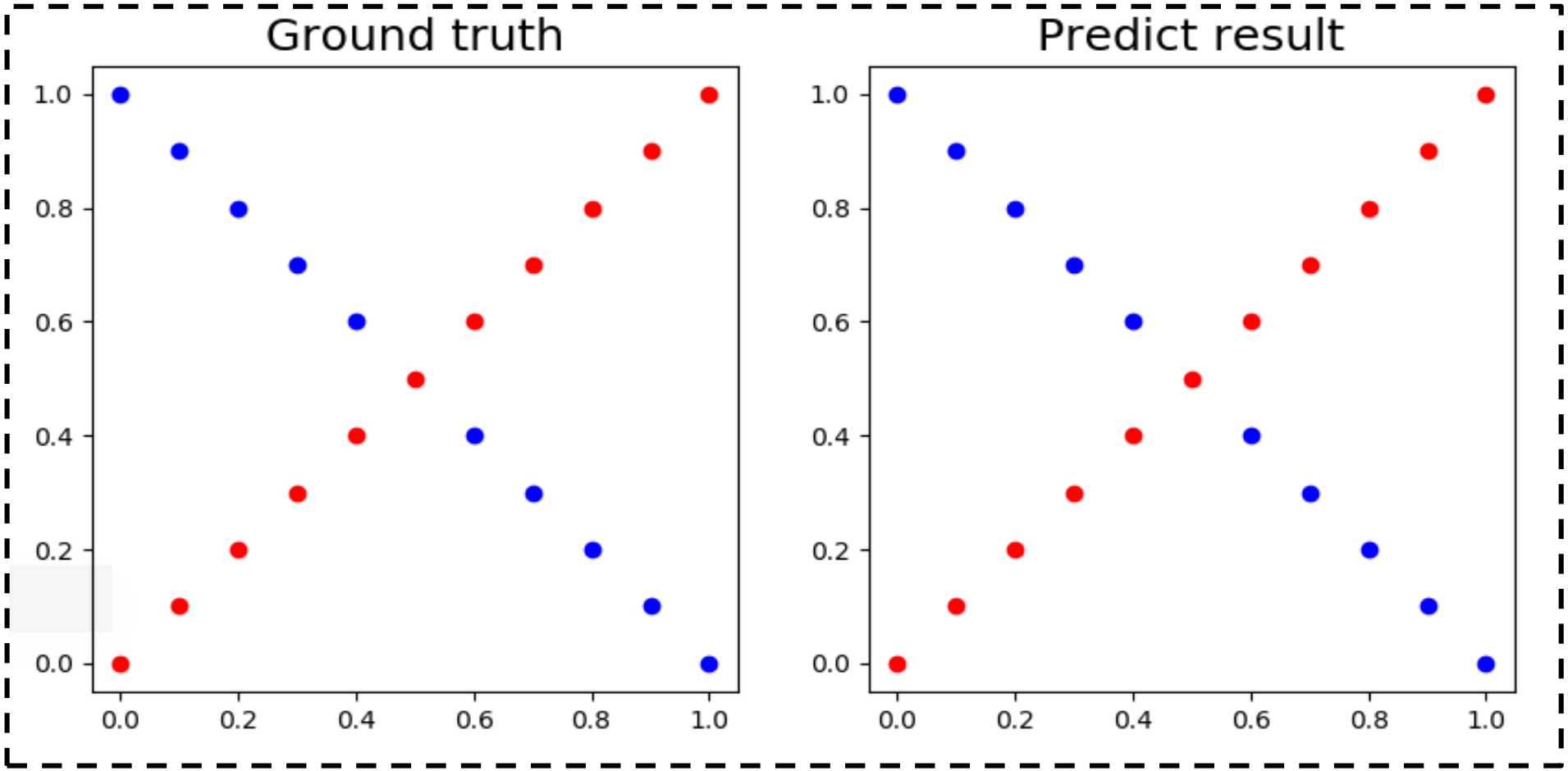
```
epoch 10000 loss : 0.16234523253277644
epoch 15000 loss : 0.252433663417614
epoch 20000 loss : 0.159078304754092
epoch 25000 loss : 0.22099447030234853
epoch 30000 loss : 0.3292173477217561
epoch 35000 loss : 0.40406233282426085
epoch 40000 loss : 0.43052897480298924
epoch 45000 loss : 0.4207525735586605
epoch 50000 loss : 0.3934759509342479
epoch 55000 loss : 0.361500837210692l
epoch 60000 loss : 0.33077879872648525
epoch 65000 loss : 0.30333537090819584
epoch 70000 loss : 0.279485808974l792
epoch 75000 loss : 0.25892812312991587
epoch 80000 loss : 0.24119780823897027
epoch 85000 loss : 0.22583656353511342
epoch 90000 loss : 0.21244497028971704
epoch 95000 loss : 0.2006912468389013
```

- In the testing, you need to show your predictions, also the accuracy

```
[[0.01025062]
 [0.99730607]
 [0.02141321]
 [0.99722154]
 [0.03578171]
 [0.99701922]
 [0.04397049]
 [0.99574117]
 [0.04162245]
 [0.92902792]
 [0.03348791]
 [0.02511045]
 [0.94093942]
 [0.01870069]
 [0.99622948]
 [0.01431959]
 [0.99434455]
 [0.01143039]
 [0.98992477]
 [0.00952752]
 [0.98385905]]
```

Lab Description - Prediction

- Visualize the predictions and ground truth at the end of the training process



Scoring Criteria

- Report (40%)
- Demo(60%)
  - Experimental results (40%)
  - Questions (20%)
- Late report or demo
  - Score *0.8

Reference

1. *http://www.denizyuret.com/2015/03/alec-radfords-animations-for.html*
2. *http://speech.ee.ntu.edu.tw/~tlkagk/courses_ML17_2.html*