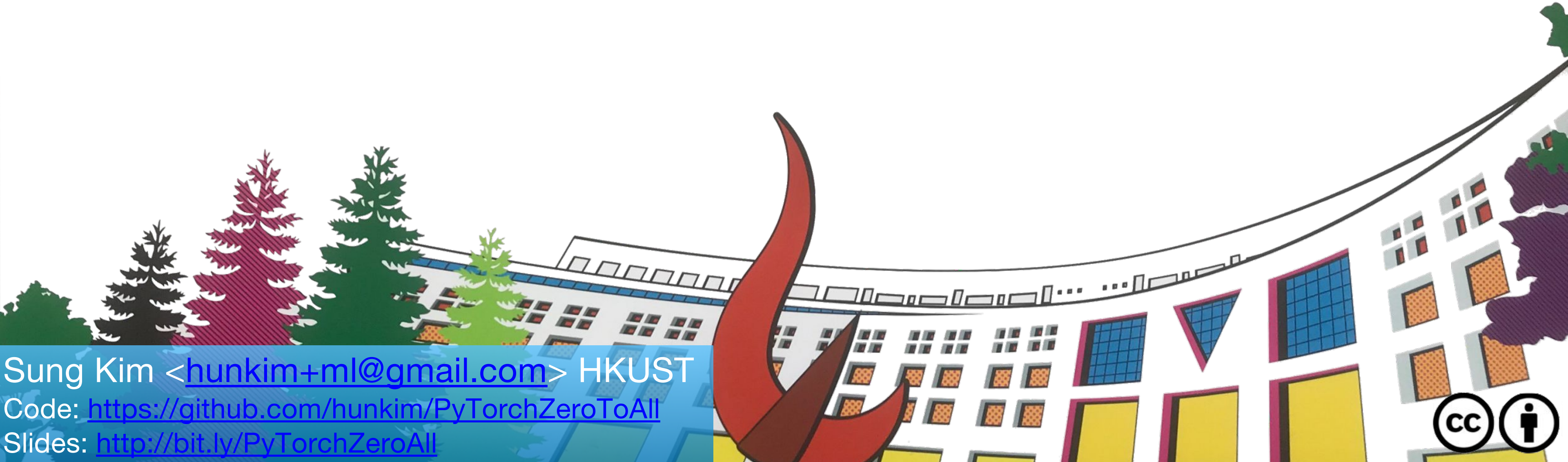
ML/DL for Everyone with PYTORCH

Lecture 2: Linear Model



Sung Kim <hunkim+ml@gmail.com> HKUST
Code: https://github.com/hunkim/PyTorchZeroToAll
Slides: http://bit.ly/PyTorchZeroAll

Call for Comments

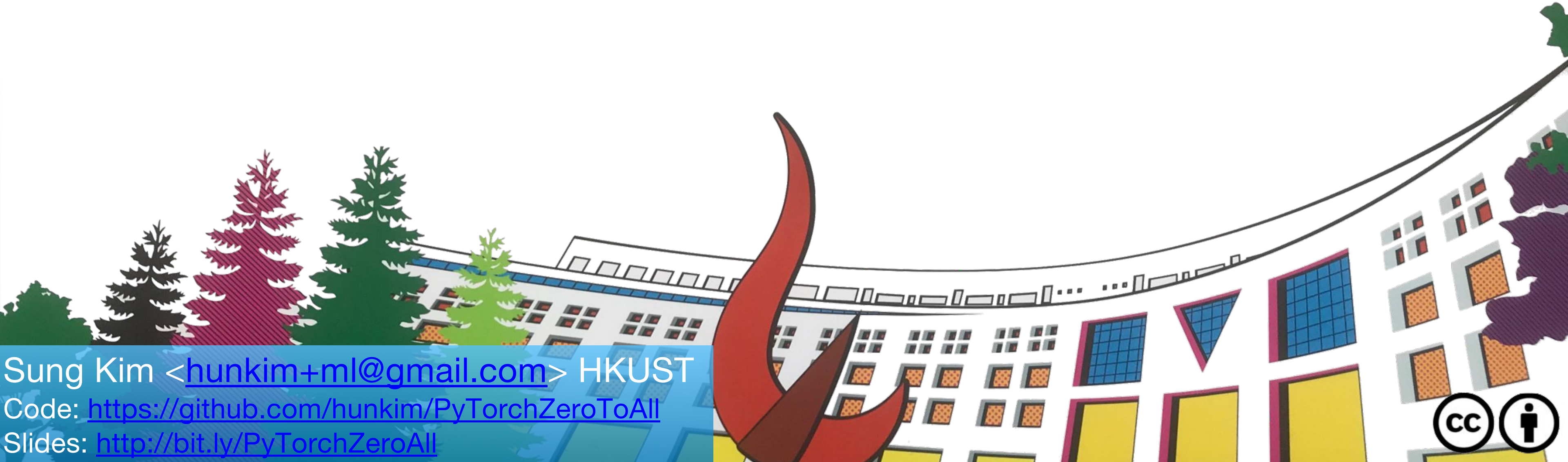
Please feel free to add comments directly on these slides.

Other slides: http://bit.ly/PyTorchZeroAll

Picture from http://www.tssablog.org/archives/3280

ML/DL for Everyone with PYTORCH

Lecture 2: Linear Model

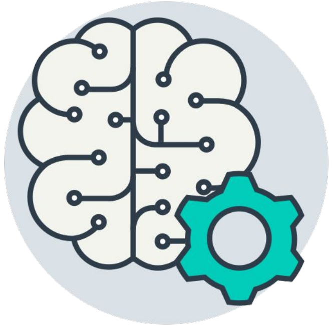


Sung Kim <hunkim+ml@gmail.com> HKUST
Code: https://github.com/hunkim/PyTorchZeroToAll
Slides: http://bit.ly/PyTorchZeroAll

Machine Learning

What would be the grade if I study 4 hours?

4
hours



?
points
Prediction

Hours (x)	Points (y)
1	2
2	4
3	6
4	?

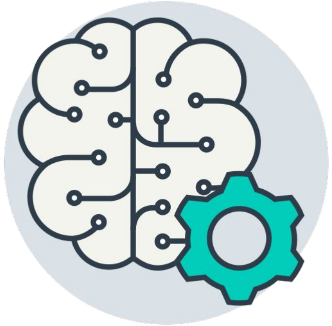
Training dataset

Test dataset

Machine Learning

What would be the grade if I study 4 hours?

4 hours



? points

Prediction

Hours (x)	Points (y)
1	2
2	4
3	6
4	?

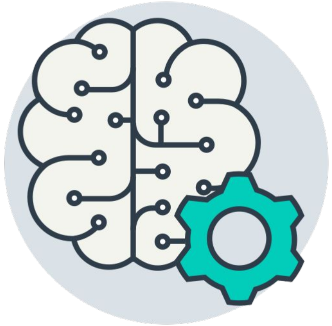
Training dataset } Supervised learning

Test dataset

Model design

What would be the best model for the data? Linear?

Hours (x)	Points (y)
1	2
2	4
3	6
4	?



$$\hat{y} = x * w + b$$

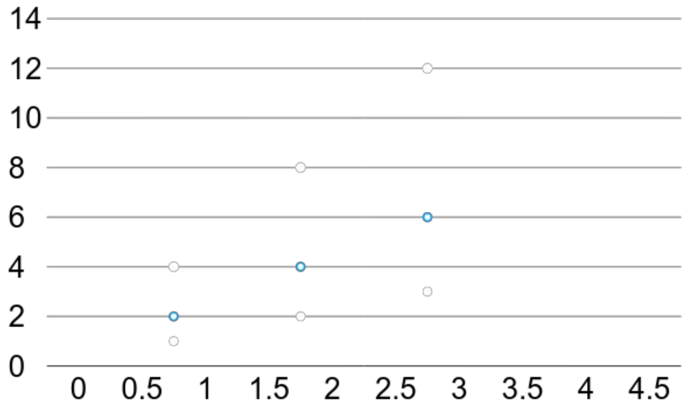
$$x \longrightarrow \boxed{\text{Linear}} \longrightarrow \hat{y}$$

Linear Regression

$$\hat{y} = x * w + b \qquad \hat{y} = x * w$$

* The machine starts with **a random guess**, w=random value

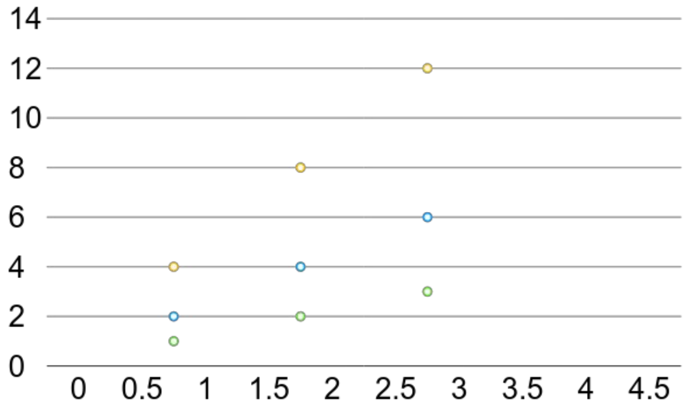
Hours (x)	Points (y)
1	2
2	4
3	6



Linear Regression error?

$$\hat{y} = x * w + b$$

Hours (x)	Points (y)
1	2
2	4
3	6



Training Loss (error)

$$loss = (\hat{y} - y)^2 = (x * w - y)^2$$

Hours, x	Points, y	Prediction, y^(w=3)	Loss (w=3)
1	2	3	1
2	4	6	4
3	6	9	9
			mean=14/3

Training Loss (error)

$$loss = (\hat{y} - y)^2 = (x * w - y)^2$$

Hours, x	Points, y	Prediction, y^(w=4)	Loss (w=4)
1	2	4	4
2	4	8	16
3	6	12	36
			mean=56/3

Training Loss (error)

$$loss = (\hat{y} - y)^2 = (x * w - y)^2$$

Hours, x	Points, y	Prediction, y^(w=0)	Loss (w=0)
1	2	0	4
2	4	0	16
3	6	0	36
			mean=56/3

Training Loss (error)

$$loss = (\hat{y} - y)^2 = (x * w - y)^2$$

Hours, x	Points, y	Prediction, y^(w=1)	Loss (w=1)
1	2	1	1
2	4	2	4
3	6	3	9
			mean=14/3

Training Loss (error)

$$loss = (\hat{y} - y)^2 = (x * w - y)^2$$

Hours, x	Points, y	Prediction, y^(w=2)	Loss (w=2)
1	2	2	0
2	4	4	0
3	6	6	0
			mean=0

Training Loss (error)

$$loss = (\hat{y} - y)^2 = (x * w - y)^2$$

$$loss = \frac{1}{N} \sum_{n=1}^{N} (\hat{y_n} - y_n)^2$$

MSE, mean square error

Hours, x	Loss (w=0)	Loss (w=1)	Loss (w=2)	Loss (w=3)	Loss (w=4)
1	4	1	0	1	4
2	16	4	0	4	16
3	36	9	0	9	36
	MSE=56/3=18.7	MSE=14/3=4.7	MSE=0	MSE=14/3=4.7	MSE=56/3=18.7

Loss graph

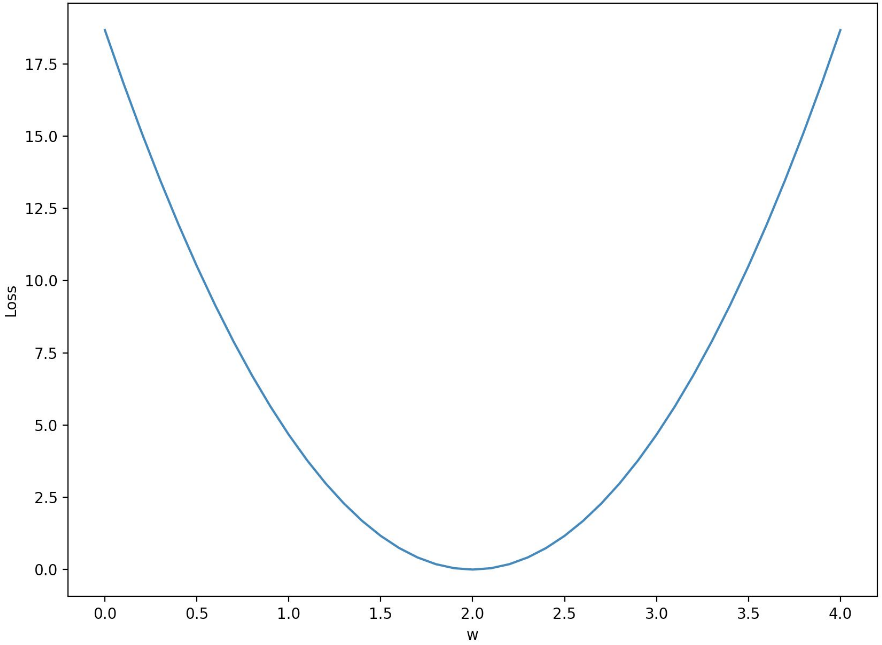
$$loss = \frac{1}{N}\sum_{n=1}^{N}(\hat{y_n} - y_n)^2$$

Loss (w=0)	Loss (w=1)	Loss (w=2)	Loss (w=3)	Loss (w=4)
mean=56/3=18.7	mean=14/3=4.7	mean=0	mean=14/3=4.7	mean=56/3=18.7

Loss graph

$$loss = \frac{1}{N}\sum_{n=1}^{N}(\hat{y_n} - y_n)^2$$

Loss (w=0)	Loss (w=1)	Loss (w=2)	Loss (w=3)	Loss (w=4)
mean=56/3=18.7	mean=14/3=4.7	mean=0	mean=14/3=4.7	mean=56/3=18.7



Model & Loss

$$\hat{y} = x * w$$

```python
# our model for the forward pass
def forward(x):
    return x * w
```

$$loss = (\hat{y} - y)^2$$

```python
# Loss function
def loss(x, y):
   y_pred = forward(x)
   return (y_pred - y) * (y_pred - y)
```

Compute loss for w

```python
for w in np.arange(0.0, 4.1, 0.1):
    print("w=", w)
    l_sum = 0
    for x_val, y_val in zip(x_data, y_data):
        y_pred_val = forward(x_val)
        l = loss(x_val, y_val)
        l_sum += l
        print("\t", x_val, y_val, y_pred_val, l)

    print("MSE=", l_sum / 3)
```

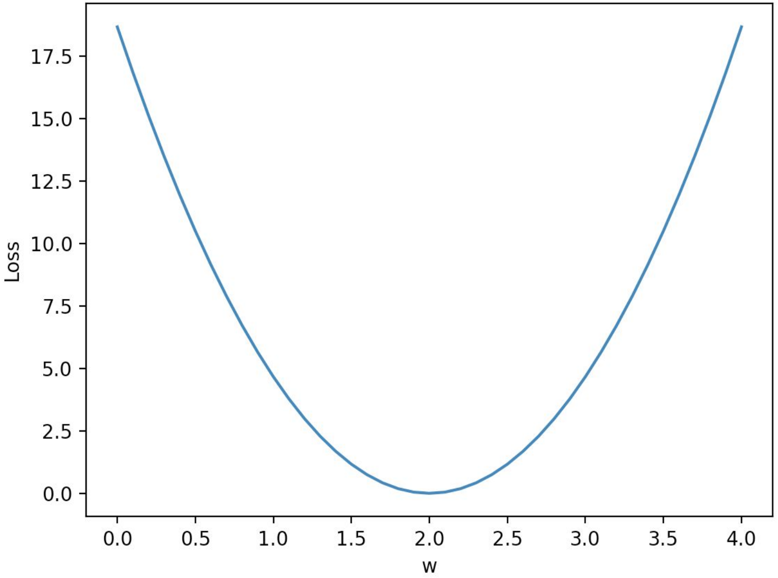
```
w= 0.0
        1.0 2.0 0.0 4.0
        2.0 4.0 0.0 16.0
        3.0 6.0 0.0 36.0
NSE= 18.6666666667
w= 0.1
        1.0 2.0 0.1 3.61
        2.0 4.0 0.2 14.44
        3.0 6.0 0.3 32.49
NSE= 16.8466666667
w= 0.2
        1.0 2.0 0.2 3.24
        2.0 4.0 0.4 12.96
        3.0 6.0 0.6 29.16
NSE= 15.12
w= 0.3
        1.0 2.0 0.3 2.89
        2.0 4.0 0.6 11.56
        3.0 6.0 0.9 26.01
NSE= 13.4866666667
w= 0.4
        1.0 2.0 0.4 2.56
        2.0 4.0 0.8 10.24
        3.0 6.0 1.2 23.04
NSE= 11.9466666667
w= 0.5
        1.0 2.0 0.5 2.25
        2.0 4.0 1.0 9.0
        3.0 6.0 1.5 20.25
NSE= 10.5
```

Plot graph

```
w_list = []
mse_list = []
for w in np.arange(0.0, 4.1, 0.1):
    print("w=", w)
    l_sum = 0
    for x_val, y_val in zip(x_data, y_data):
        y_pred_val = forward(x_val)
        l = loss(x_val, y_val)
        l_sum += l
        print("\t", x_val, y_val, y_pred_val, l)

    print("MSE=", l_sum / 3)
    w_list.append(w)
    mse_list.append(l_sum / 3)

plt.plot(w_list, mse_list)
plt.ylabel('Loss')
plt.xlabel('w')
plt.show()
```



```python
import numpy as np
import matplotlib.pyplot as plt
x_data = [1.0, 2.0, 3.0]
y_data = [2.0, 4.0, 6.0]

# our model for the forward pass
def forward(x):
   return x * w

# Loss function
def loss(x, y):
   y_pred = forward(x)
   return (y_pred - y) * (y_pred - y)

w_list = []
mse_list = []
for w in np.arange(0.0, 4.1, 0.1):
   print("w=", w)
   l_sum = 0
   for x_val, y_val in zip(x_data, y_data):
       y_pred_val = forward(x_val)
       l = loss(x_val, y_val)
       l_sum += l
       print("\t", x_val, y_val, y_pred_val, l)
   print("MSE=", l_sum / 3)
   w_list.append(w)
   mse_list.append(l_sum / 3)

plt.plot(w_list, mse_list)
plt.ylabel('Loss')
plt.xlabel('w')
plt.show()
```

Exercise 2-1

- Any other interesting linear prediction problems?
- Find some datasets for linear prediction
    - Draw the cost graph for one dataset

WHAT NEXT

Lecture 3: Gradient Descent