Error Backpropagation

```
import warnings
warnings.filterwarnings('ignore')
```

I. 실습용 데이터 생성

```
import numpy as np
np.set_printoptions(suppress = True, precision = 3)
```

1) Input : X (4 * 3)

```
X = np.array([[0, 0, 1],
              [0, 1, 1],
              [1, 0, 1],
              [1, 1, 1]])

X
```

```
array([[0, 0, 1],
       [0, 1, 1],
       [1, 0, 1],
       [1, 1, 1]])
```

2) Output : y (4 * 1)

```
y = np.array([0., 1., 1., 0.]).reshape(4, 1)

y
```

```
array([[0.],
       [1.],
       [1.],
       [0.]])
```

3) W1 (3 * 4)

```
np.random.seed(2045)
W1 = np.random.rand(3, 4)

W1
```

```
array([[0.844, 0.886, 0.139, 0.061],
       [0.192, 0.532, 0.155, 0.827],
       [0.92 , 0.015, 0.49 , 0.692]])
```

4) W2 (4 * 1)

```
np.random.seed(2046)
W2 = np.random.rand(4)

W2 = W2.reshape(4, 1)
W2
```

```
array([[0.895],
       [0.596],
       [0.436],
       [0.153]])
```

5) y_hat (4 * 1)

```
np.random.seed(2045)
y_hat = np.random.rand(4).reshape(4, 1)

y_hat
```

```
array([[0.844],
       [0.886],
       [0.139],
       [0.061]])
```

6) Layer1 (4 * 4)

```
Layer1 = np.ones([4, 4])

Layer1
```

```
array([[1., 1., 1., 1.],
       [1., 1., 1., 1.],
       [1., 1., 1., 1.],
       [1., 1., 1., 1.]])
```

II. 함수 정의

1) sigmoid( )

- Activation Function

```
def sigmoid(x):
    y_hat = 1 / (1 + np.exp(-x))
    return y_hat
```

2) d_sigmoid( )

- sigmoid( ) 미분함수

```
def d_sigmoid(x):
    dy = x * (1.0 - x)
    return dy
```

3)Loss function

- Mean Squared Error

```
# def loss_function(y, y_hat):
#   Loss = np.mean((y - y_hat) ** 2)
#   return Loss
```

- Binary Cross Entropy Error

```
def loss_function(y, y_hat):
  Loss = -np.mean((y * np.log(y_hat) + (1 - y) * np.log(1 - y_hat)))
  return Loss
```

III. 순방향과 역방향 함수 정의

1) Forward_Propagation

- Layer1 Output
    - Layer1 = sigmoid(np.dot(X, W1))
- y_hat Output
    - y_hat = sigmoid(np.dot(Layer1, W2))

```
def forwardProp(X, W1, Layer1, W2, y_hat):
    Layer1 = sigmoid(np.dot(X, W1))
    y_hat = sigmoid(np.dot(Layer1, W2))

    return Layer1, y_hat
```

2) Back_Propagation

- d_W2
    - d_W2 = np.dot(np.transpose(Layer1), (-2 * (y - y_hat) * d_sigmoid(y_hat)))
- d_W1
    - d_W1 = np.dot((-2 * (y - y_hat) * d_sigmoid(y_hat)), np.transpose(W2))
    - d_W1 = d_W1 * d_sigmoid(Layer1)
    - d_W1 = np.dot(np.transpose(X), d_W1)
- Gradient Descent
    - W1 = W1 - 0.8 * d_W1
    - W2 = W2 - 0.8 * d_W2

```
def backProp(X, y, y_hat, Layer1, W1, W2):
    d_W2 = np.dot(np.transpose(Layer1), (-2 * (y - y_hat) * d_sigmoid(y_hat)))

    d_W1 = np.dot((-2 * (y - y_hat) * d_sigmoid(y_hat)), np.transpose(W2))
    d_W1 = d_W1 * d_sigmoid(Layer1)
    d_W1 = np.dot(np.transpose(X), d_W1)

    W1 = W1 - 0.8 * d_W1
    W2 = W2 - 0.8 * d_W2

    return y_hat, Layer1, W1, W2
```

IV. 오차역전파를 적용한 Gradient Descent

- 학습 과정의 Loss 값 저장 객체

```
Loss_Record = []
```

1) Learning with Error Backpropagation

```
for k in range(0, 1000):
    Layer1, y_hat = forwardProp(X, W1, Layer1, W2, y_hat)
    y_hat, Layer1, W1, W2 = backProp(X, y, y_hat, Layer1, W1, W2)

    Loss_Record.append(loss_function(y, y_hat))
```

2) Parameter Update Check

- W1

```
W1
```

```
array([[ 2.105,  4.49 ,  6.092, -4.23 ],
       [ 2.4  ,  4.834, -2.847,  6.438],
       [ 1.519, -0.554,  0.28 ,  1.49 ]])
```

- W2

```
W2
```

```
array([[ 3.678],
       [ 7.183],
       [-7.062],
       [-7.074]])
```

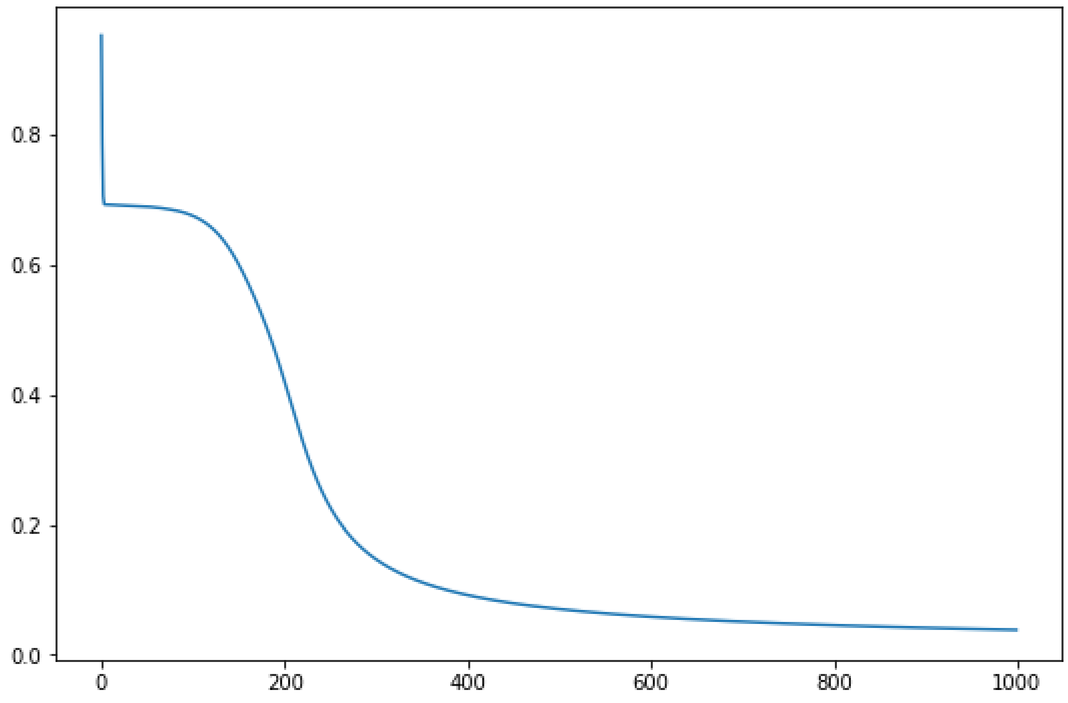
- y_hat

```
# y_hat.round()

y_hat
```

```
array([[0.015],
       [0.958],
       [0.959],
       [0.052]])
```

3) Visualization

```
import matplotlib.pyplot as plt

plt.figure(figsize = (9, 6))
plt.plot(Loss_Record)
plt.show()
```



#

#

#

The End

#

#

#