week6_q3_and_4

August 28, 2024

[1]:
```
import numpy as np
import pandas as pd

from matplotlib import pyplot as plt
from sklearn.linear_model import LinearRegression, SGDRegressor
from sklearn.metrics import mean_squared_error, mean_absolute_error
```

[2]:
```
df = pd.read_csv('salary.csv')
df
```

[2]:

	salary	exp
0	1.7	1.2
1	2.4	1.5
2	2.3	1.9
3	3.1	2.2
4	3.7	2.4
5	4.2	2.5
6	4.4	2.8
7	6.1	3.1
8	5.4	3.3
9	5.7	3.7
10	6.4	4.2
11	6.2	4.4

[3]:
```
X = df['salary'].values
Y = df['exp'].values
X = X.reshape((X.shape[0]), 1)
Y = Y.reshape((Y.shape[0]), 1)
X
```

[3]:
```
array([[1.7],
       [2.4],
       [2.3],
       [3.1],
       [3.7],
       [4.2],
       [4.4],
       [6.1],
```

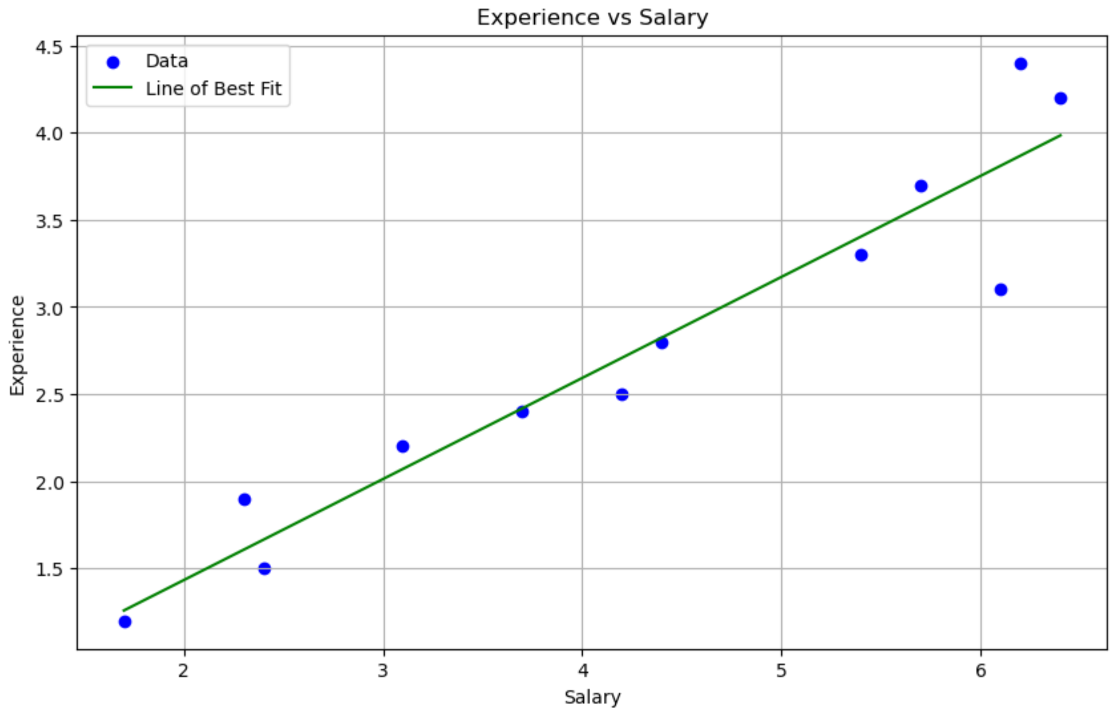
```
       [5.4],
       [5.7],
       [6.4],
       [6.2]])
```

[4]:
```
model = LinearRegression()
model.fit(X, Y)
sklearn_coeffs = [model.coef_, model.intercept_]
```

[5]:
```
sklearn_predictions = model.predict(X)

sklearn_mse = mean_squared_error(Y, sklearn_predictions)
sklearn_rmse = np.sqrt(sklearn_mse)

print(f'Sklearn Coefficients: {sklearn_coeffs}')

print(f'Sklearn MSE: {sklearn_mse}')

print(f'Sklearn RMSE: {sklearn_rmse}')
```

```
Sklearn Coefficients: [array([[0.57968648]]), array([0.27401481])]
Sklearn MSE: 0.08643597140576244
Sklearn RMSE: 0.29399995137034024
```

[6]:
```
plt.figure(figsize=(10, 6))

# Plotting the data points
plt.scatter(X, Y, color='blue', label='Data')

# Plotting the line of best fit from gradient descent
x_range = np.linspace(X.min(), X.max(), 100).reshape(-1, 1)

# Plotting the line of best fit from sklearn
sklearn_line = model.predict(x_range)

plt.plot(x_range, sklearn_line, color='green', label='Line of Best Fit')

plt.xlabel('Salary')
plt.ylabel('Experience')
plt.title('Experience vs Salary')
plt.legend()
plt.grid(True)
plt.show()
```



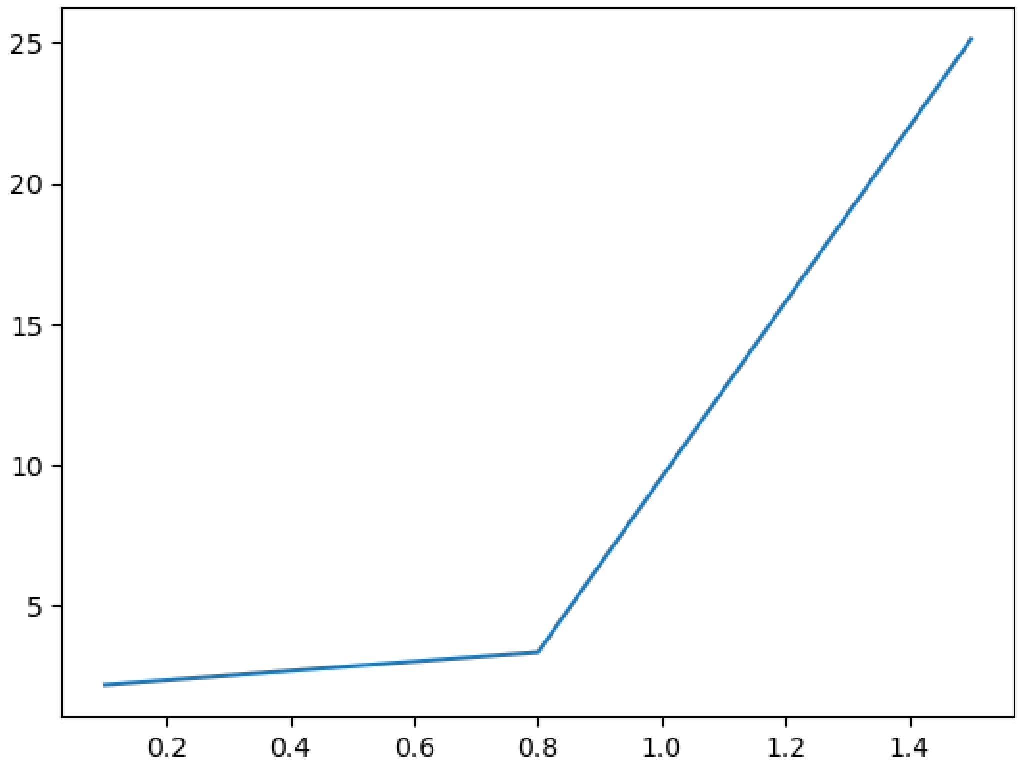
[7]:
```
def predict(X, w, b):
    return w*X + b
```

[8]:
```
slope_values = [0.1, 0.8, 1.5]
intercept = 1.1

mses = []
for s in slope_values:
    pred = predict(X, s, intercept)
    mse = mean_squared_error(Y, pred)
    print(mse)
    mses.append(mse)
```

```
2.2029166666666664
3.3550000000000018
25.127916666666668
```

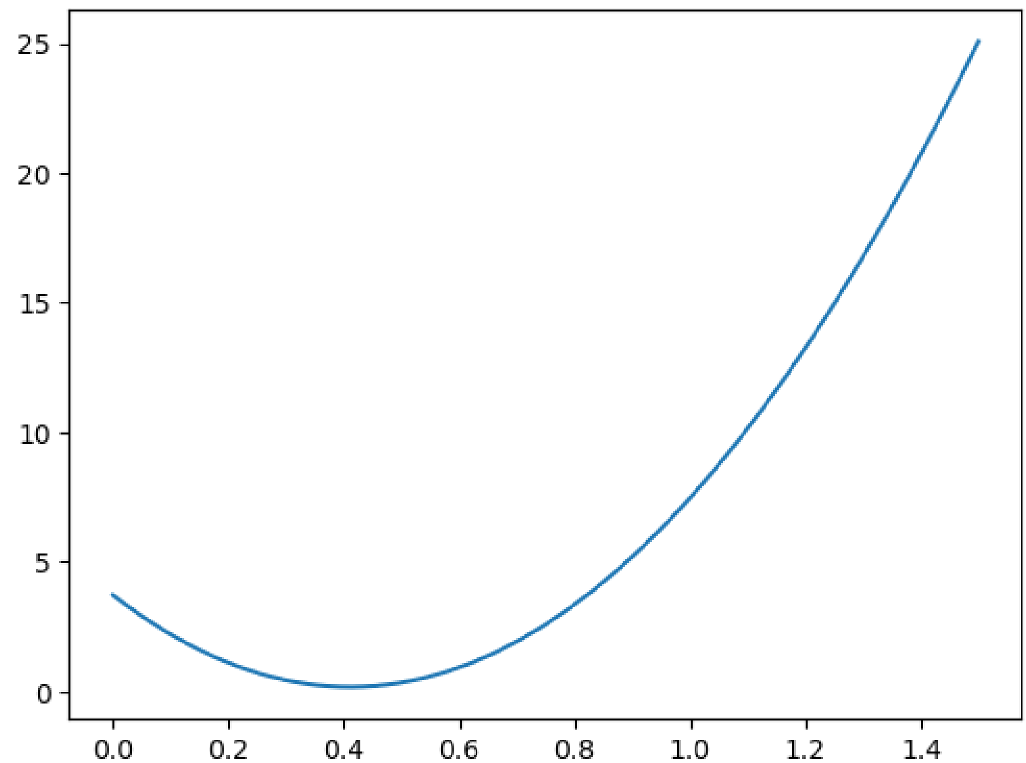
[9]:
```
plt.plot(slope_values, mses)
```

[9]: [<matplotlib.lines.Line2D at 0x7ba6c4cadf40>]



[10]:
```
slope_values = np.arange(0, 1.5, 0.001)
intercept = 1.1

mses = []
for s in slope_values:
    pred = predict(X, s, intercept)
    mse = mean_squared_error(Y, pred)
#     print(mse)
    mses.append(mse)

plt.plot(slope_values, mses)
```

[10]:
```
[<matplotlib.lines.Line2D at 0x7ba6c4afcef0>]
```



1 Q4 - Stochastic GD for above

def get_mse(yhat, y): diffs = yhat - y m = diffs.shape[0] mse = (1/2*m)* np.sum(np.square(diffs)) return mse

def gradient_descent(X, Y, lr, eps): m = X.shape[0] Xm = np.hstack([np.ones((m, 1)), X]) wandb = np.random.randn(2,1) errors = [] slopes = []

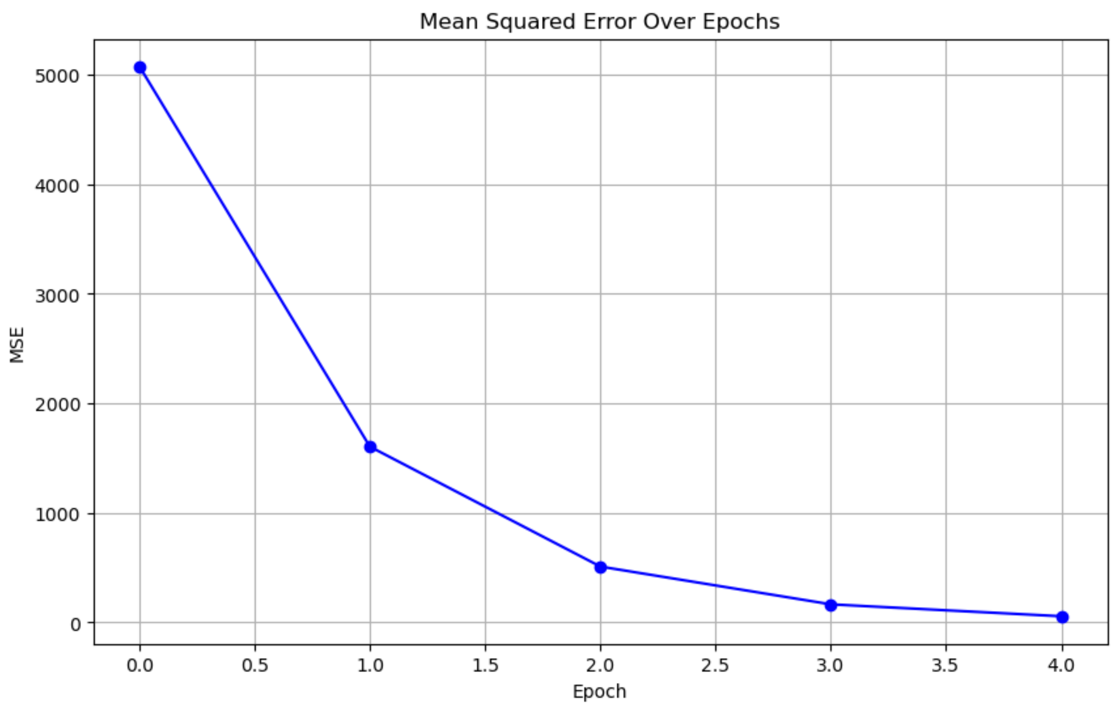
```
for e in range(eps):
    # Current Predictions
    yhat = np.dot(Xm, wandb)
    # Current Error
    error = get_mse(yhat, Y)
    errors.append(error)

    slopes.append(wandb[1, 0])

    # Gradient at this point ~
    grads = (1/m) * np.dot(Xm.T, (yhat - Y))

    # Update wandb
    wandb -= lr*grads
```

```
    print(f'Epoch {e+1}/{eps} \t MSE = {error}')

return errors, wandb, slopes
```

[12]:
```
learning_rate = 0.02
epochs = 5
errors, wandb, slopes_gd = gradient_descent(X, Y, learning_rate, epochs)
```

```
Epoch 1/5        MSE = 5077.347041857036
Epoch 2/5        MSE = 1605.1030138881774
Epoch 3/5        MSE = 510.3880958068073
Epoch 4/5        MSE = 165.25060329159538
Epoch 5/5        MSE = 56.436744953212624
```

[13]:
```
plt.figure(figsize=(10, 6))
plt.plot(errors, marker='o', linestyle='-', color='b')
plt.title('Mean Squared Error Over Epochs')
plt.xlabel('Epoch')
plt.ylabel('MSE')
plt.grid(True)
plt.show()
```



[14]:
```
sgd_regressor = SGDRegressor(max_iter=5, n_iter_no_change=60)
sgd_regressor.fit(X, Y)
```

```
B0 = sgd_regressor.intercept_[0]   # Intercept
B1 = sgd_regressor.coef_[0]        # Slope

y_pred = sgd_regressor.predict(X)
error = mean_squared_error(Y, y_pred)
error
```

```
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```

[14]: 0.09074009128525883

[15]:
```
sgd_regressor = SGDRegressor(max_iter=1, warm_start=True,␣
 ↪learning_rate='constant', eta0=0.01)

slopes_sgd = []

for i in range(60):  # 60 iterations
    sgd_regressor.fit(X, Y)
    slopes_sgd.append(sgd_regressor.coef_[0])
```

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```

```
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```
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Maximum number of iteration reached before convergence. Consider increasing
max_iter to improve the fit.
  warnings.warn(
```
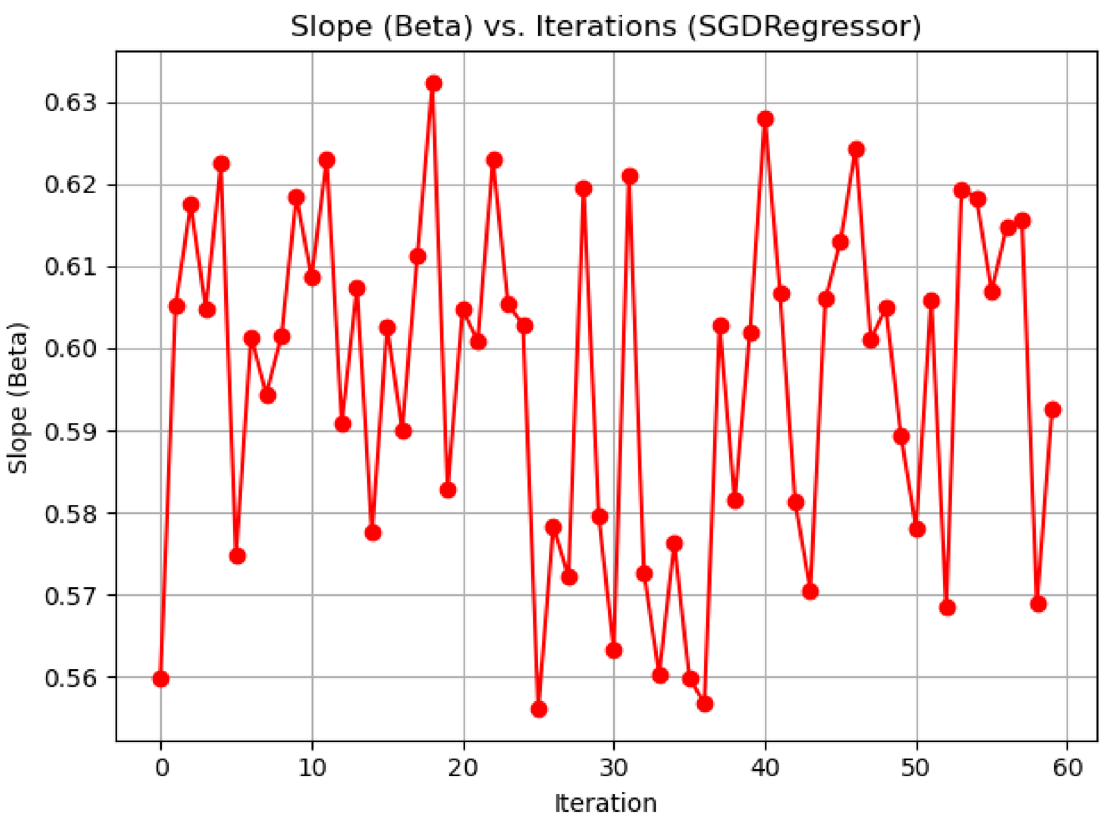
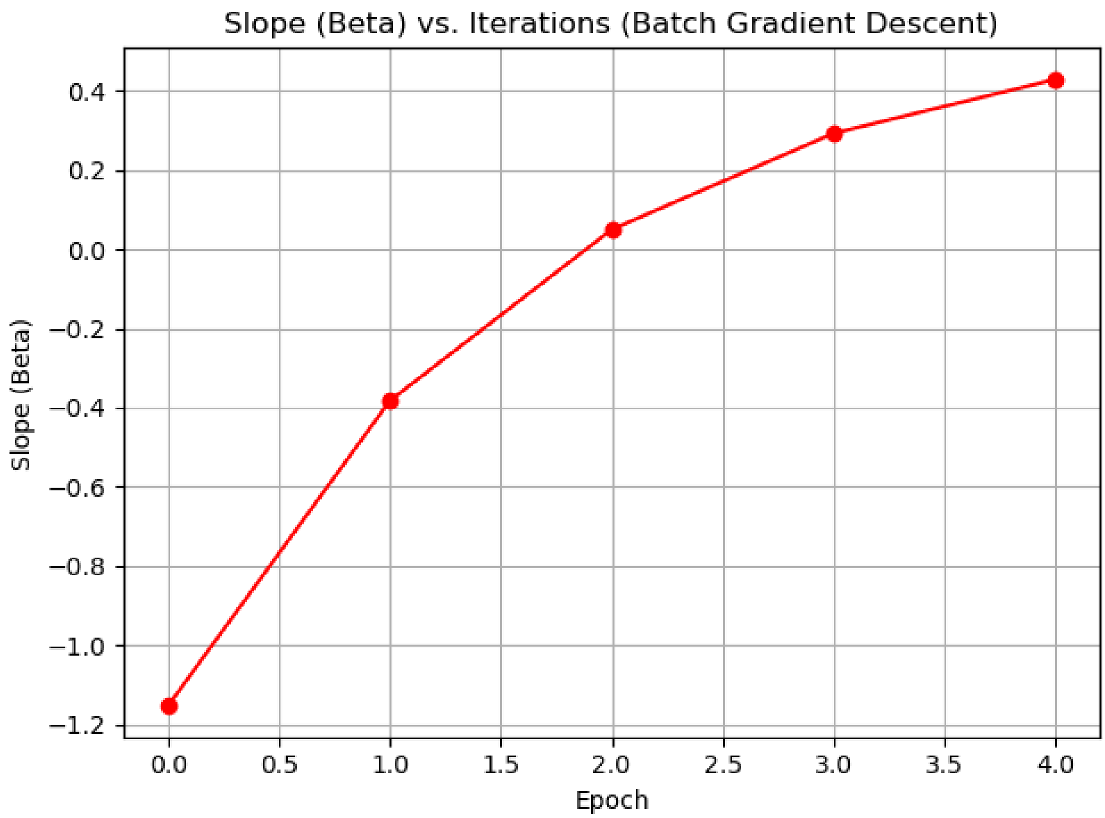

[16]:
```
plt.plot(range(len(slopes_sgd)), slopes_sgd, marker='o', linestyle='-',␣
 ↪color='r')
plt.title('Slope (Beta) vs. Iterations (SGDRegressor)')
plt.xlabel('Iteration')
plt.ylabel('Slope (Beta)')
plt.grid(True)

plt.tight_layout()
plt.show()
```



[20]:
```
plt.plot(slopes_gd, marker='o', linestyle='-', color='r')
plt.title('Slope (Beta) vs. Iterations (Batch Gradient Descent)')
plt.xlabel('Epoch')
plt.ylabel('Slope (Beta)')
plt.grid(True)
```

```
plt.tight_layout()
plt.show()
```



- We observe that batch GD is more stable, whileSGD has fluctuations

1.0.1 Use study dataset

[23]:
```
from sklearn.linear_model import LogisticRegression
```

[21]:
```
df = pd.read_csv('study.csv')
df
```

[21]:

	hours	pass
0	1	0
1	2	0
2	3	0
3	4	0
4	5	1
5	6	1
6	7	1

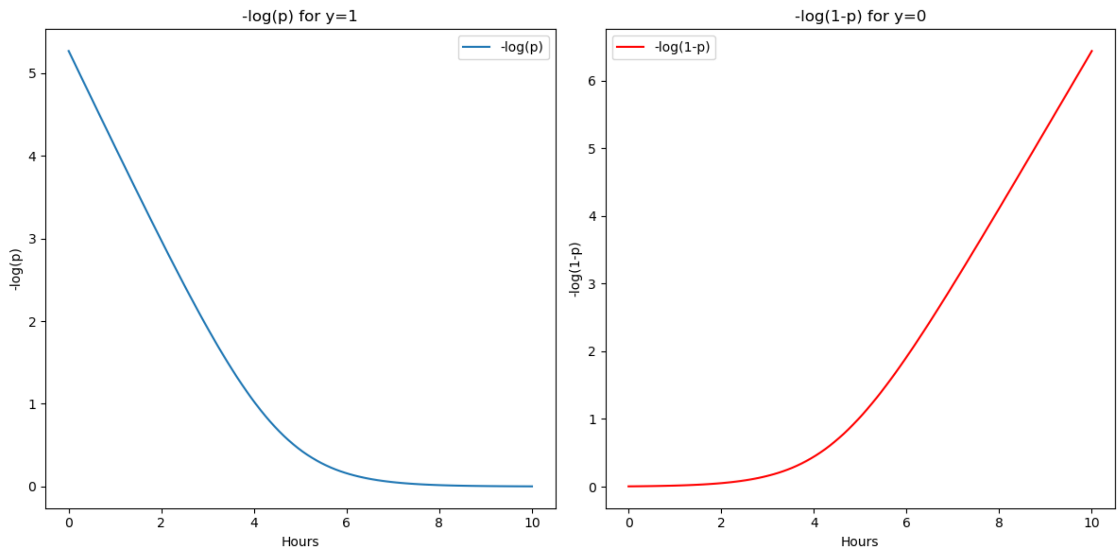
7 8 1

[29]:
```
X = df['hours'].values
Y = df['pass'].values
X = X.reshape((X.shape[0]), 1)
# Y = Y.reshape((Y.shape[0]), 1)
X
```

[29]:
```
array([[1],
       [2],
       [3],
       [4],
       [5],
       [6],
       [7],
       [8]])
```

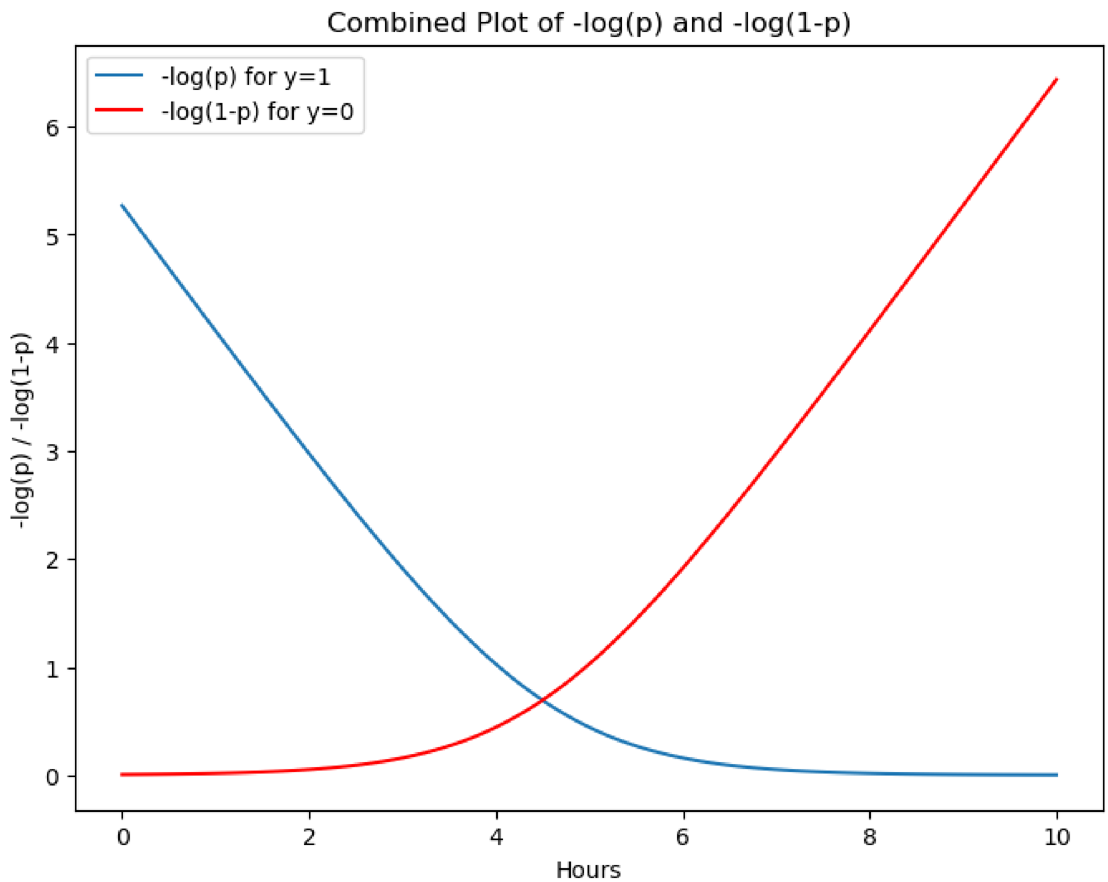
[30]:
```
# Logistic Regression Model
model = LogisticRegression()
model.fit(X, Y)
# Coefficients
beta_0, beta_1 = model.intercept_[0], model.coef_[0][0]
```

[31]:
```
hours_range = np.linspace(0, 10, 100).reshape(-1, 1)
prob = model.predict_proba(hours_range)[:, 1]

# Plot -log(x) for y=1
plt.figure(figsize=(12, 6))

plt.subplot(1, 2, 1)
plt.plot(hours_range, -np.log(prob), label='-log(p)')
plt.title('-log(p) for y=1')
plt.xlabel('Hours')
plt.ylabel('-log(p)')
plt.legend()

# Plot -log(1-x) for y=0
plt.subplot(1, 2, 2)
plt.plot(hours_range, -np.log(1 - prob), label='-log(1-p)', color='red')
plt.title('-log(1-p) for y=0')
plt.xlabel('Hours')
plt.ylabel('-log(1-p)')
plt.legend()

plt.tight_layout()
plt.show()
```



[32]:

```
# Combined plot
plt.figure(figsize=(8, 6))
plt.plot(hours_range, -np.log(prob), label='-log(p) for y=1')
plt.plot(hours_range, -np.log(1 - prob), label='-log(1-p) for y=0', color='red')
plt.title('Combined Plot of -log(p) and -log(1-p)')
plt.xlabel('Hours')
plt.ylabel('-log(p) / -log(1-p)')
plt.legend()
plt.show()
```


Combined Plot of -log(p) and -log(1-p)
-log(p) for y=1
-log(1-p) for y=0
-log(p) / -log(1-p)
Hours
0
1
2
3
4
5
6
0
2
4
6
8
10

```
[ ]:
```

week6_q5

August 28, 2024

[1]:
```python
import numpy as np
import matplotlib.pyplot as plt
```

[19]:
```python
# Positive slope dataset
x_pos = np.array([1, 2, 4, 3, 5]).reshape(-1, 1)
y_pos = np.array([1, 3, 3, 2, 5])

# Negative slope dataset
x_neg = np.array([1, 2, 3, 4, 5]).reshape(-1, 1)
y_neg = np.array([10, 8, 6, 4, 2])

x_neg
```

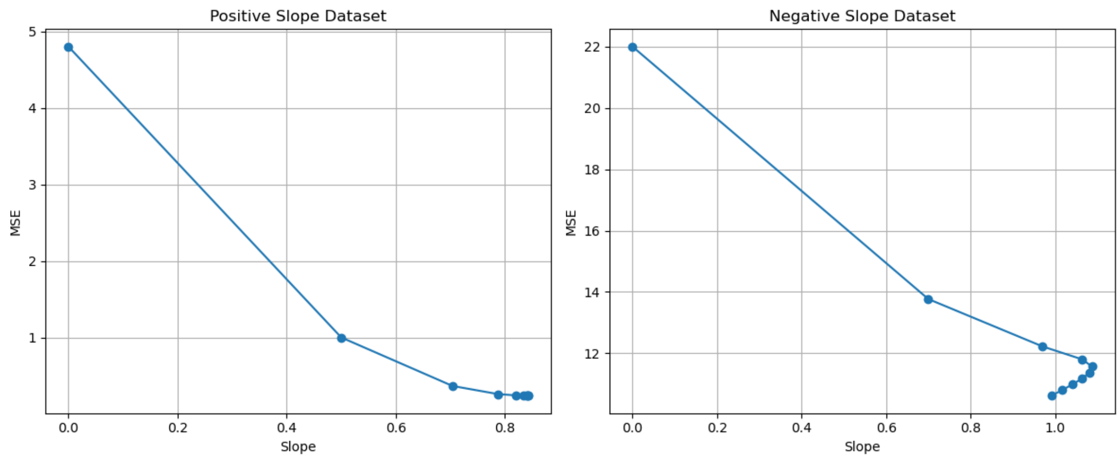
[19]:
```
array([[1],
       [2],
       [3],
       [4],
       [5]])
```

[22]:
```python
def get_mse(yhat, y):
    diffs = yhat - y
    m = diffs.shape[0]
    mse = (1/2*m) * np.sum(np.square(diffs))
    return mse

def gradient_descent(X, Y, learning_rate=0.01, iterations=1000):
    m = len(Y)
    theta = np.zeros(2)  # theta[0] is slope, theta[1] is intercept
    history = []

    for _ in range(iterations):
        predictions = X @ theta[0:1] + theta[1]

        # Compute error and cost
        error = predictions - Y
        cost = (1/(2*m)) * np.sum(error**2)
        history.append((theta[0], cost))
```

```
        # Compute gradients
        gradient_slope = (1/m) * np.sum(error * X[:, 0])
        gradient_intercept = (1/m) * np.sum(error)

        # Update parameters
        theta[0] -= learning_rate * gradient_slope
        theta[1] -= learning_rate * gradient_intercept

    return theta, history
```

[23]:
```
lr = 0.05
eps = 10
theta_pos, history_pos = gradient_descent(x_pos, y_pos, lr, eps)
theta_neg, history_neg = gradient_descent(x_neg, y_neg, lr, eps)
```

[24]:
```
def plot_slope_vs_mse(history, title):
    slopes, mse_values = zip(*history)
    plt.plot(slopes, mse_values, marker='o')
    plt.xlabel('Slope')
    plt.ylabel('MSE')
    plt.title(title)
    plt.grid(True)

plt.figure(figsize=(12, 5))

plt.subplot(1, 2, 1)
plot_slope_vs_mse(history_pos, 'Positive Slope Dataset')

plt.subplot(1, 2, 2)
plot_slope_vs_mse(history_neg, 'Negative Slope Dataset')

plt.tight_layout()
plt.show()
```



[20]:

```
```

week6_ad1

August 28, 2024

[4]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDRegressor
from sklearn.metrics import mean_squared_error
```

[5]:
```python
df = pd.read_csv('salary.csv')
df
```

[5]:

	salary	exp
0	1.7	1.2
1	2.4	1.5
2	2.3	1.9
3	3.1	2.2
4	3.7	2.4
5	4.2	2.5
6	4.4	2.8
7	6.1	3.1
8	5.4	3.3
9	5.7	3.7
10	6.4	4.2
11	6.2	4.4

[7]:
```python
X = df[['exp']].values
y = df['salary'].values
```

[12]:
```python
max_iter = 10
learning_rate = 'constant'
eta0 = 0.01

sgd_regressor = SGDRegressor(max_iter=1, warm_start=True,␣
↪learning_rate=learning_rate, eta0=eta0)
```

[13]:
```python
errors = []
b0_values = []
b1_values = []

for epoch in range(max_iter):
```

```
    sgd_regressor.fit(X, y)
    y_pred = sgd_regressor.predict(X)
    error = mean_squared_error(y, y_pred)

    b0_values.append(sgd_regressor.intercept_[0])
    b1_values.append(sgd_regressor.coef_[0])
    errors.append(error)
```

```
/usr/lib/python3/dist-
packages/sklearn/linear_model/_stochastic_gradient.py:1575: ConvergenceWarning:
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Maximum number of iteration reached before convergence. Consider increasing
max_iter to improve the fit.
  warnings.warn(
```
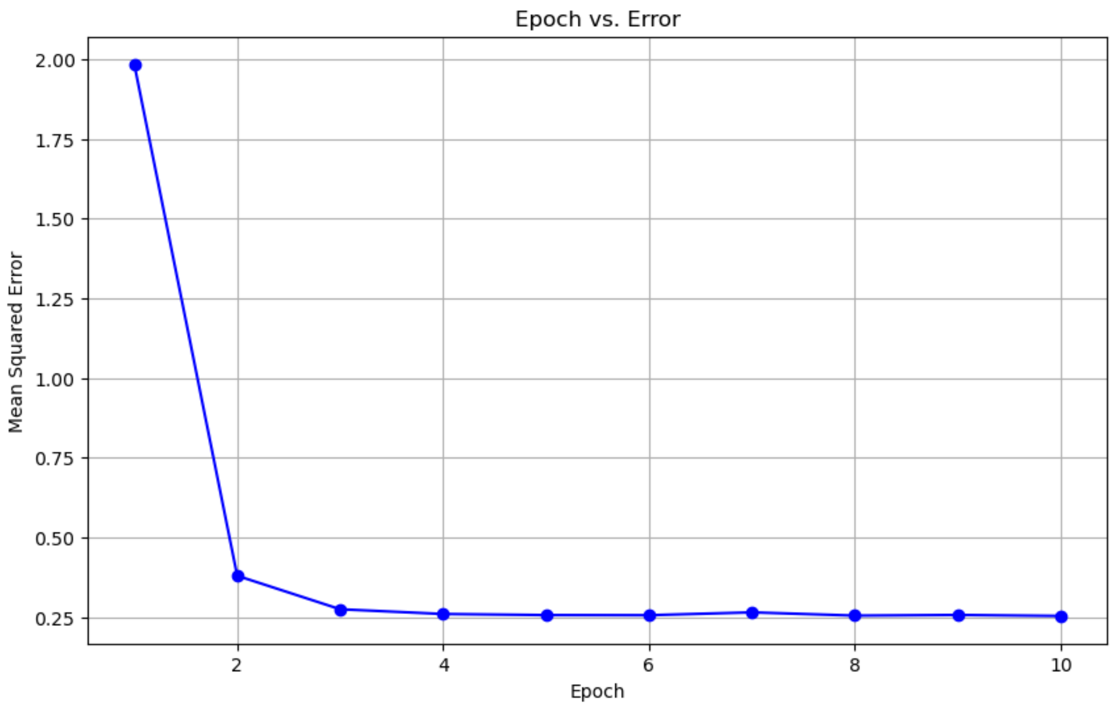

[14]:

```python
plt.figure(figsize=(10, 6))
plt.plot(range(1, max_iter + 1), errors, marker='o', linestyle='-', color='b')
plt.title('Epoch vs. Error')
plt.xlabel('Epoch')
plt.ylabel('Mean Squared Error')
plt.grid(True)
plt.show()
```



[15]:

```python
print(f"Final value of B0 (Intercept): {b0_values[-1]}")
print(f"Final value of B1 (Coefficient): {b1_values[-1]}")
print(f"Final Mean Squared Error: {errors[-1]}")
```

```
Final value of B0 (Intercept): 0.3878095985053993
Final value of B1 (Coefficient): 1.4330841530710507
```

```
Final Mean Squared Error: 0.253393889277146
```

[ ]:

week6_ad2

August 28, 2024

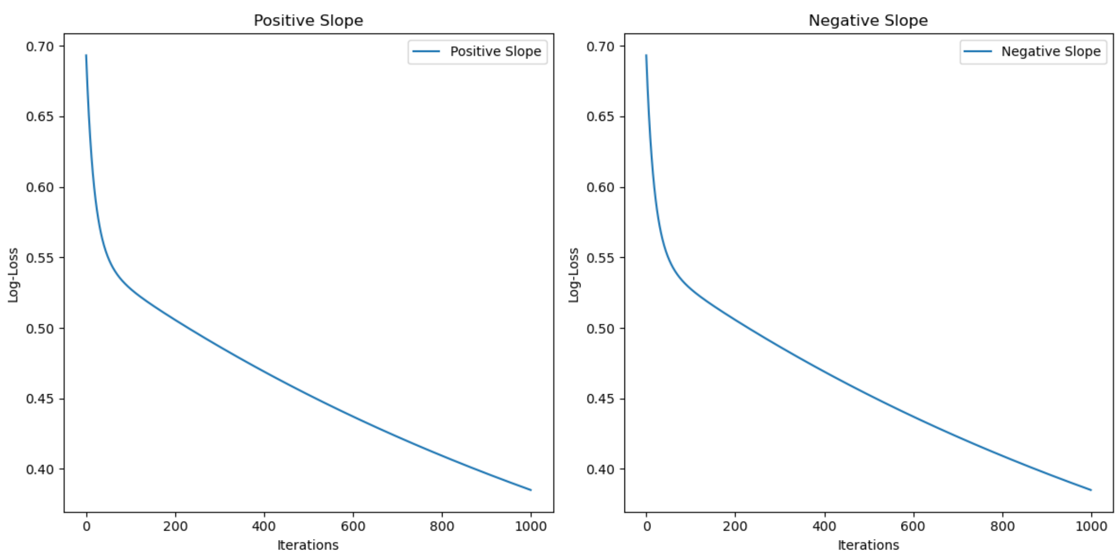
[1]:
```python
import numpy as np
import matplotlib.pyplot as plt
```

[2]:
```python
def sigmoid(z):
    return 1 / (1 + np.exp(-z))

def compute_log_loss(y, y_pred):
    epsilon = 1e-15
    y_pred = np.clip(y_pred, epsilon, 1 - epsilon)
    return -np.mean(y * np.log(y_pred) + (1 - y) * np.log(1 - y_pred))

def gradient_descent(x, y, learning_rate=0.01, iterations=1000):
    m = len(y)
    theta = np.zeros(x.shape[1])  # Initialize parameters
    log_losses = []

    for i in range(iterations):
        # Compute predictions
        y_pred = sigmoid(np.dot(x, theta))

        # Compute gradient
        gradient = np.dot(x.T, (y_pred - y)) / m

        # Update parameters
        theta -= learning_rate * gradient

        # Compute log-loss
        loss = compute_log_loss(y, y_pred)
        log_losses.append(loss)

    return theta, log_losses

# Prepare datasets
x_positive = np.array([1, 2, 3, 4, 5])
y_positive = np.array([0, 0, 1, 1, 1])  # Positive slope

x_negative = np.array([1, 2, 3, 4, 5])
y_negative = np.array([1, 1, 0, 0, 0])  # Negative slope
```

```
# Add intercept term (bias) to the data
x_positive = np.vstack((np.ones_like(x_positive), x_positive)).T
x_negative = np.vstack((np.ones_like(x_negative), x_negative)).T
```

[3]:
```
# Run gradient descent for positive slope
theta_positive, log_losses_positive = gradient_descent(x_positive, y_positive)

# Run gradient descent for negative slope
theta_negative, log_losses_negative = gradient_descent(x_negative, y_negative)
```

[4]:
```
# Plot log-loss vs iteration for positive slope
plt.figure(figsize=(12, 6))

plt.subplot(1, 2, 1)
plt.plot(log_losses_positive, label='Positive Slope')
plt.xlabel('Iterations')
plt.ylabel('Log-Loss')
plt.title('Positive Slope')
plt.legend()

# Plot log-loss vs iteration for negative slope
plt.subplot(1, 2, 2)
plt.plot(log_losses_negative, label='Negative Slope')
plt.xlabel('Iterations')
plt.ylabel('Log-Loss')
plt.title('Negative Slope')
plt.legend()

plt.tight_layout()
plt.show()
```



```
[ ]:
```