Define the methods for data formatting and validating train, dev, test splits.

```
# Define a method for creating a train, dev, test split
def train_dev_test_split(data, p_train, p_dev):
    total_number = len(data)
    # convert percentage to decimal
    p_train = p_train/100
    # convert percentage to decimal, append percentage from train
    p_dev = p_dev/100 + p_train
    # train off first x percentage
    train = data[:int(total_number * p_train)]
    # dev off the next x percent
    dev = data[int(total_number*p_train):int(total_number*p_dev)]
    # test off remaining percent
    test = data[int(total_number*p_dev):]
    # return all portions of data
    return train, dev, test

# Define a method to split X and Y
def get_features_and_labels(data):
    features = data[:, :-1]
    labels = data[:, -1]
    return features, labels

# Method for verifying against data leak
def data_leaking_check(data1, data2):
    data_leaking = False
    for d1 in data1:
        for d2 in data2:
            if(np.array_equal(d1, d2)):
                data_leaking = True
                print("Find same sample: ")
                print(d1)
    if(not data_leaking):
        print("No Data Leaking!")
```

Load the data set and get inputs/outputs separated

```
# Import and load dataset
from sklearn.datasets import load_diabetes
diabetes = load_diabetes()
data = diabetes.data
target = diabetes.target
```

Utilize SelectKBest and f_classif to isolate an individual featuer for input.

```
# Import Select K Best and f_regression from feature_selection
from sklearn.feature_selection import SelectKBest, f_regression

# Generate a new input based off feature selection
input = SelectKBest(f_regression, k=1).fit_transform(data, target)

# Verify the shape for data vs input
print(data.shape)
print(input.shape)
```

```
(442, 10)
(442, 1)
```

Perform transformations to allow for creation of train, dev, test splits.

Shuffle the data and create the splits.

Validate against leaks.

Separate X and Y from each Split.

```
# Import NumPy for data formatting
import numpy as np

# Define X and Y as array
X = np.squeeze(input)
X = np.expand_dims(X, 1)
Y = np.squeeze(target)
Y = np.expand_dims(Y, 1)

# Compress X and Y to single array for train, dev, test split
data = np.append(X, Y, 1)

# Shuffle the Data
np.random.shuffle(data)

# Create the splits
train, dev, test = train_dev_test_split(data, 70, 15)

# Verify Against Data Leaks
data_leaking_check(train, dev)
data_leaking_check(train, test)
data_leaking_check(dev, test)

# Extract X and Y from each split
train_X, train_Y = get_features_and_labels(train)
dev_X, dev_Y = get_features_and_labels(dev)
test_X, test_Y = get_features_and_labels(test)
```

```
Find same sample:
[-1.59062628e-02  1.04000000e+02]
```

```
No Data Leaking!
No Data Leaking!
```

Define the necessary methods for univariate linear regression.

```
# Linear Regression Model
def univariate_linear_regression(theta, input):
    pred = theta[0] + theta[1]*input
    return pred

# Cost Function
def compute_cost(Y_pred, Y_true):
    m = len(Y_true)
    J = 1/(2*m) * (np.sum((Y_pred - Y_true) ** 2)) #MSE
    #J = 1/(2*m) * (np.sum(np.abs(Y_pred - Y_true))) #MAE
    return J

# Gradient Descent Algorithm
def gd(theta, X, Y_true, Y_pred, learning_rate):
    m = len(Y_true)
    theta[0] = theta[0] - (learning_rate * (1/m) * np.sum(Y_pred - Y_true))
    theta[1] = theta[1] - (learning_rate * (1/m) * np.sum((Y_pred - Y_true) * X))
    return theta
```

Import plotting library and intiialize training values.
Initial values were 1.0,1.0 but were later updated to 50, 1000 to better match the behavior of the data. This was again increased up to 500, 1800.
Learning rate was initialized as 0.01 and reduced at each point of divergence by a factor of 10, then incrememnted by 1 at that decimal place until divergence. From there was stepped back to last greated non-divergent learning rate.

```
# Import pyplot from matpltolib
from matplotlib import pyplot as plt

# Initialize Theta
theta = [500, 1800.0]

# Initialize Learning Rate LR
lr = 0.004
```

Generate the plot with subfigures for iterations, each plot will contain train values.

```
# Define the figure
plt.figure(figsize=(30,30))
```

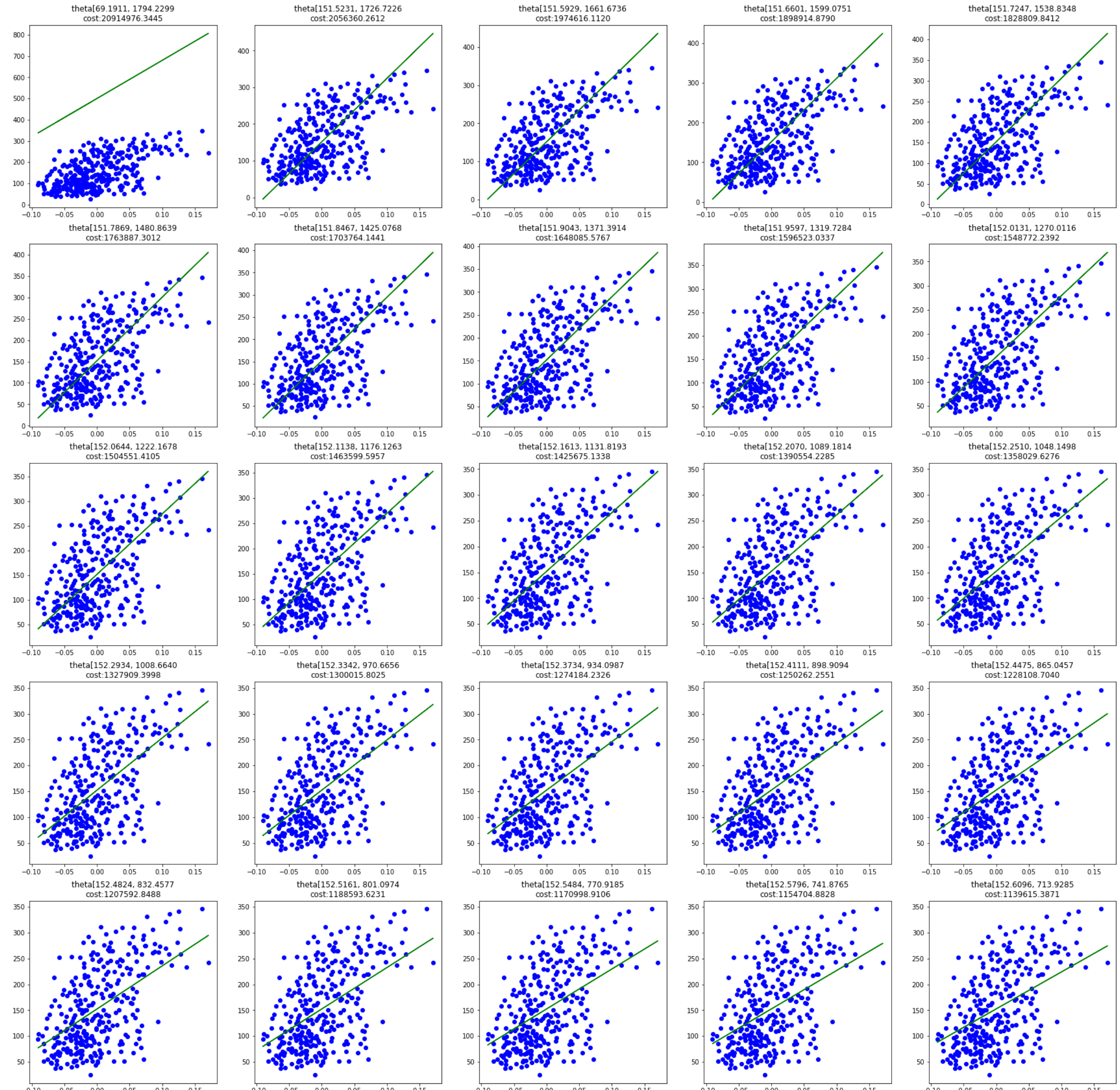
```
# Define iterations
iterations = 325

# Define subplot incremement
sub_plt_inc = iterations / 25

# Create 25 plots
for i in range(iterations):
  pred = univariate_linear_regression(theta, train_X)
  cost = compute_cost(pred, train_Y)
  theta = gd(theta, train_X, train_Y, pred, lr)

  if(i % sub_plt_inc == 0):
    k = i / sub_plt_inc
    plt.subplot(5,5, k + 1)
    plt.scatter(train_X, train_Y, color='b')
    plt.plot(train_X, pred, 'g')

    s = 'theta[%.4f, %.4f' % (theta[0], theta[1])
    c = 'cost:%.4f' % cost
    plt.title(s+'\n'+c)
```

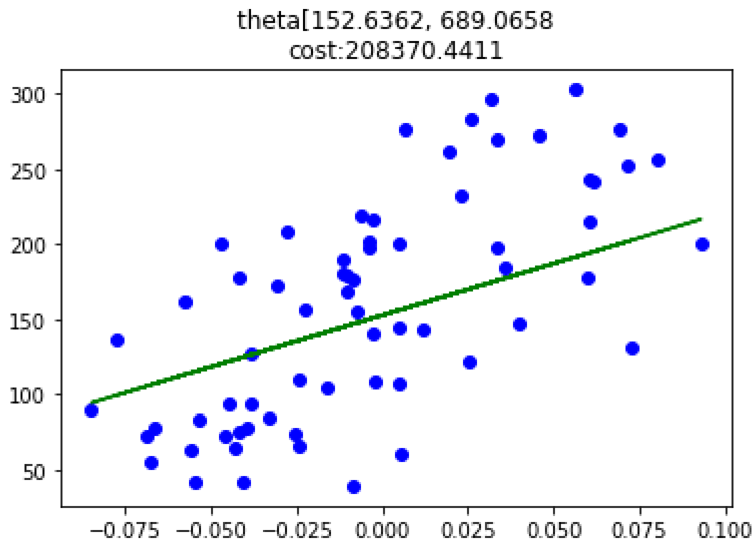


## Optimize the training against the dev set

```
pred = univariate_linear_regression(theta, dev_X)
cost = compute_cost(pred, dev_Y)
plt.scatter(dev_X, dev_Y, color='b')
```

```
plt.plot(dev_X, pred, 'g')
s = 'theta[%.4f, %.4f' % (theta[0], theta[1])
c = 'cost:%.4f' % cost
plt.title(s+'\n'+c)
```

```
Text(0.5, 1.0, 'theta[152.6362, 689.0658\ncost:208370.4411')
```

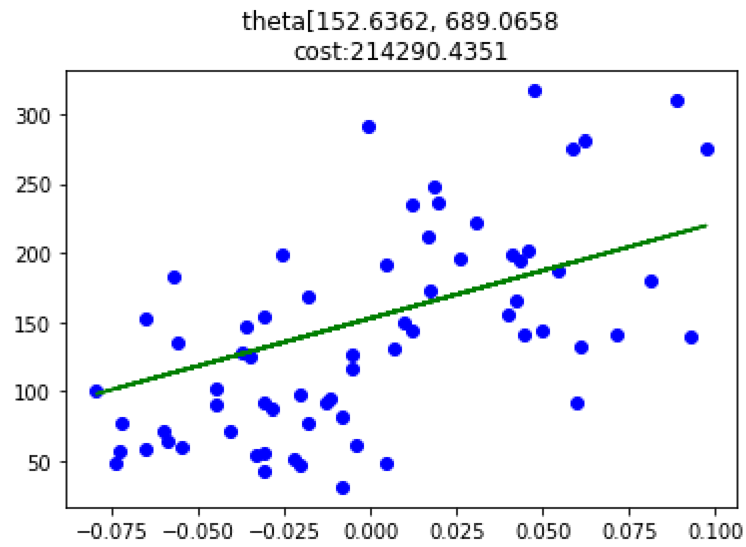



Validate final model against the test set, including additional metrics to ensure we are not losing correlation to match the data perfectly.

```
from sklearn.metrics import r2_score, explained_variance_score

pred = univariate_linear_regression(theta, test_X)
cost = compute_cost(pred, test_Y)
r2 = r2_score(test_Y, pred)
var = explained_variance_score(test_Y, pred)
print("R2: %s, Explained Variance: %s"%(r2, var))
plt.scatter(test_X, test_Y, color='b')
plt.plot(test_X, pred, 'g')
s = 'theta[%.4f, %.4f' % (theta[0], theta[1])
c = 'cost:%.4f' % cost
plt.title(s+'\n'+c)
```

```
R2: 0.3212917322868093, Explained Variance: 0.34701376696533914
Text(0.5, 1.0, 'theta[152.6362, 689.0658\ncost:214290.4351')
```

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