

Adaptive Computation and ML Assignment 1

March 25, 2021

0.0.1 INTRODUCTION

The aim of this assignment is to implement a simple linear regression (using gradient descent) model on a dataset

Two columns are extracted from the bank client data namely: 1. age (numeric) - X 1.
balance: client's total balance? (numeric) - Y (Target)

The linear regression model should be able to predict the client's balance based on their age

0.0.2 IMPORTING THE DATASET

```
In [1]: import pandas as pd
import numpy as np
import warnings
import matplotlib.pyplot as plt
plt.style.use('ggplot')
warnings.filterwarnings('ignore')
```

```
In [2]: bank = pd.read_csv('bank-full.csv')
bank.head()
```

```
Out[2]:
```

	age	job	marital	education	default	balance	housing	loan	\
0	58	management	married	tertiary	no	2143	yes	no	
1	44	technician	single	secondary	no	29	yes	no	
2	33	entrepreneur	married	secondary	no	2	yes	yes	
3	47	blue-collar	married	unknown	no	1506	yes	no	
4	33	unknown	single	unknown	no	1	no	no	

	contact	day	month	duration	campaign	pdays	previous	outcome	y
0	unknown	5	may	261	1	-1	0	unknown	no
1	unknown	5	may	151	1	-1	0	unknown	no
2	unknown	5	may	76	1	-1	0	unknown	no
3	unknown	5	may	92	1	-1	0	unknown	no
4	unknown	5	may	198	1	-1	0	unknown	no

```
In [3]: len(bank)
```

```
Out[3]: 45211
```

```
In [4]: # the bank dataset consists of over 45000 rows so lets focus on random 100 customers
        bank = bank.iloc[3100:3200, :]
```

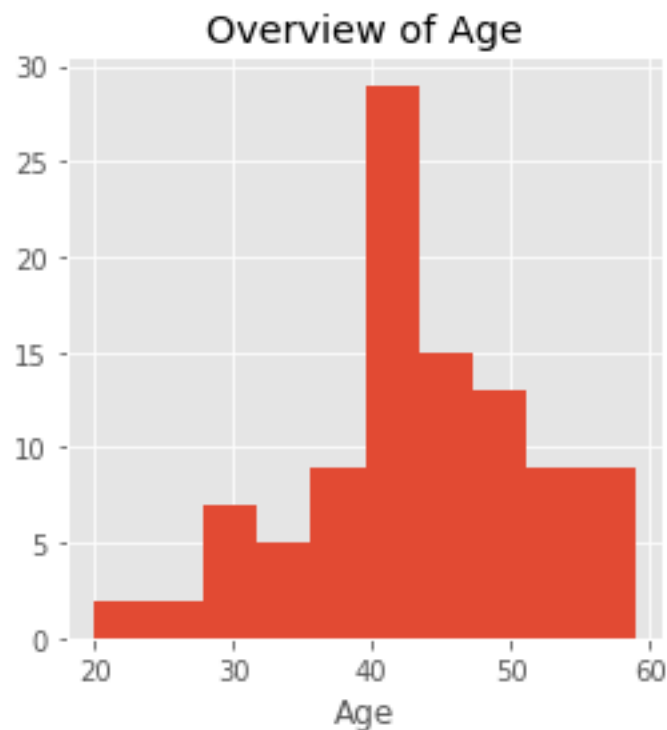
```
In [5]: # Check/Remove null values
        bank.isnull().values.any()
```

```
Out[5]: False
```

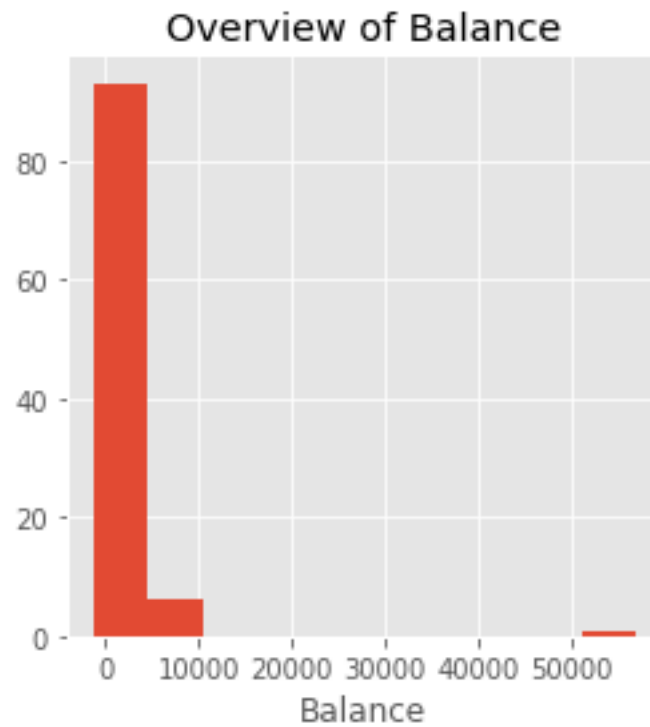
0.0.3 Exploring the data & implementing the Linear Regression model with the data as is

```
In [6]: # Predict Balance based on Age
        X = bank['age'] # Feature
        Y = bank['balance'] # Target
```

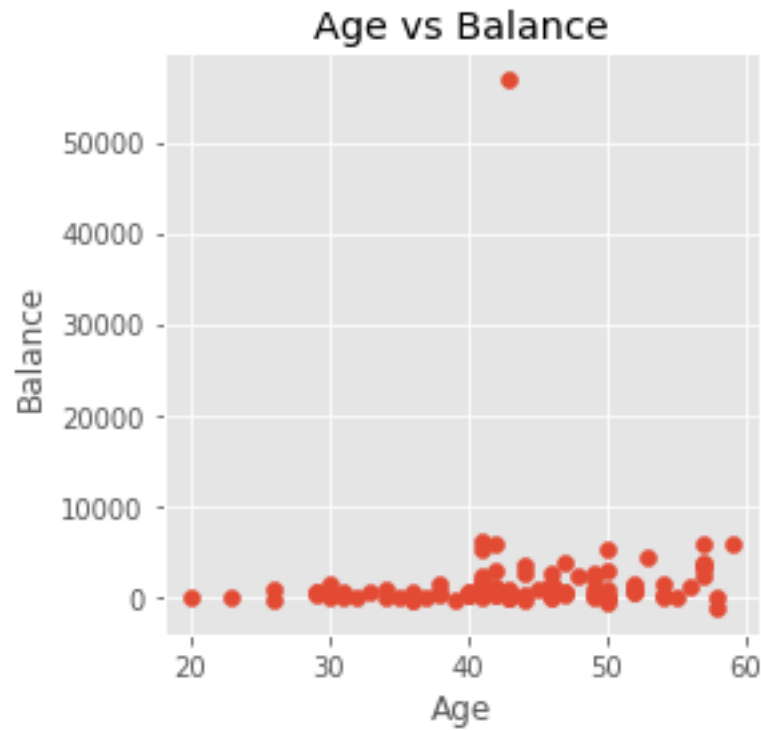
```
In [7]: plt.figure(figsize = (4,4))
        plt.hist(X)
        plt.xlabel('Age')
        plt.title("Overview of Age")
        plt.show()
```



```
In [8]: plt.figure(figsize = (4,4))
        plt.hist(Y)
        plt.xlabel('Balance')
        plt.title("Overview of Balance")
        plt.show()
```



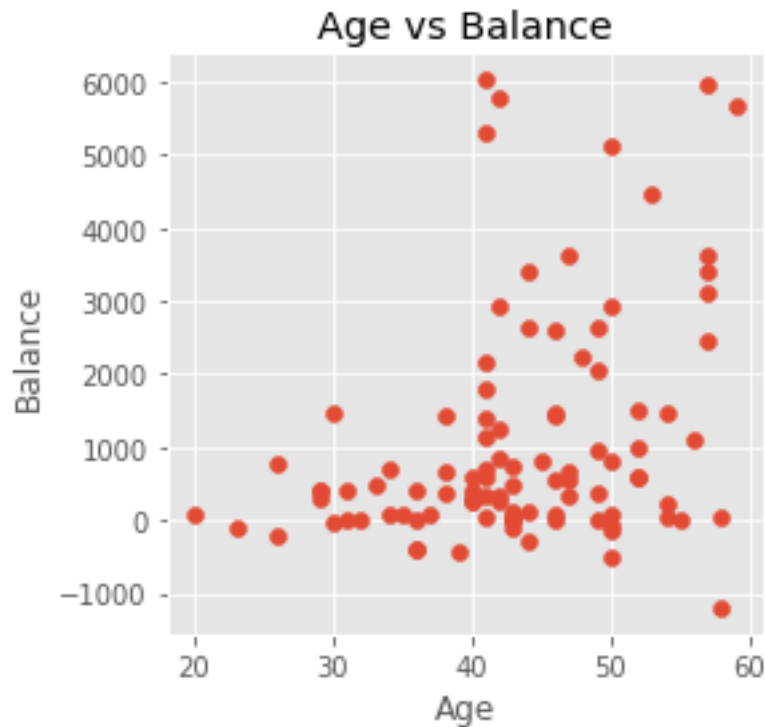
```
In [9]: plt.figure(figsize = (4,4))
plt.scatter(X,Y)
plt.xlabel('Age')
plt.ylabel('Balance')
plt.title("Age vs Balance")
plt.show()
```



```
In [10]: # removing the outlier
         bank = bank[bank['balance'] != bank['balance'].max()]

In [11]: X = bank['age'] # Feature
         Y = bank['balance'] # Target

In [12]: plt.figure(figsize = (4,4))
         plt.scatter(X,Y)
         plt.xlabel('Age')
         plt.ylabel('Balance')
         plt.title("Age vs Balance")
         plt.show()
```



0.0.4 Building the model

```
In [13]: m = 0 # gradient
         c = 0 # Intercept

alpha = 0.005 # The learning Rate
epochs = 100 # The number of iterations to perform gradient descent

n = float(len(X)) # Number of elements in X

# Performing Gradient Descent
for i in range(epochs):
    Y_pred = m*X + c # The current predicted value of Y
    D_m = (-2/n) * sum(X * (Y - Y_pred)) # Partial derivative wrt m
    D_c = (-2/n) * sum(Y - Y_pred) # Partial derivative wrt c
    m = m - alpha * D_m # Update m
    c = c - alpha * D_c # Update c

    print("Iteration: {}".format(i+1), "\nGradient: {}".format(m), "\nIntercept: {}".format(c))

print("\nProcess Complete... after {} epochs".format(epochs))
print("Gradient(m): {}".format(m), "Intercept(c): {}".format(c))
```

Iteration: 1

Gradient: 521.789898989899
Intercept: 11.029797979797982

Iteration: 2
Gradient: -9134.364625905524
Intercept: -204.2123642995613

Iteration: 3
Gradient: 169565.6002481972
Intercept: 3768.006891642485

Iteration: 4
Gradient: -3137509.779618302
Intercept: -69754.19799192189

Iteration: 5
Gradient: 58064228.211913906
Intercept: 1290858.8651336674

Iteration: 6
Gradient: -1074553655.267811
Intercept: -23889069.325772442

Iteration: 7
Gradient: 19886015641.805317
Intercept: 442098290.4532609

Iteration: 8
Gradient: -368016622715.0586
Intercept: -8181604814.652449

Iteration: 9
Gradient: 6810626987185.738
Intercept: 151411254483.9497

Iteration: 10
Gradient: -126039524010132.92
Intercept: -2802062494616.931

Iteration: 11
Gradient: 2332525572558898.0
Intercept: 51855816466449.39

Iteration: 12
Gradient: -4.316642409886063e+16
Intercept: -959659431784086.4

Iteration: 13

Gradient: 7.988509071043288e+17
Intercept: 1.7759747850231842e+16

Iteration: 14
Gradient: -1.4783776629722096e+19
Intercept: -3.286672680509649e+17

Iteration: 15
Gradient: 2.735930440759623e+20
Intercept: 6.082415921613136e+18

Iteration: 16
Gradient: -5.063195666543197e+21
Intercept: -1.1256302966487112e+20

Iteration: 17
Gradient: 9.370103119501844e+22
Intercept: 2.083125490039541e+21

Iteration: 18
Gradient: -1.7340596384662574e+24
Intercept: -3.85509506999946e+22

Iteration: 19
Gradient: 3.20910324188363e+25
Intercept: 7.134355596816227e+23

Iteration: 20
Gradient: -5.93886357113802e+26
Intercept: -1.3203054362503735e+25

Iteration: 21
Gradient: 1.0990640642613899e+28
Intercept: 2.443397194513561e+26

Iteration: 22
Gradient: -2.0339612164542376e+29
Intercept: -4.5218247885973213e+27

Iteration: 23
Gradient: 3.764110177526558e+30
Intercept: 8.368225790176473e+28

Iteration: 24
Gradient: -6.965976201482702e+31
Intercept: -1.548649188088007e+30

Iteration: 25

Gradient: 1.2891446358116332e+33
Intercept: 2.8659770516482044e+31

Iteration: 26
Gradient: -2.3857300742545976e+34
Intercept: -5.303863860036041e+32

Iteration: 27
Gradient: 4.415104270762761e+35
Intercept: 9.815490961317521e+33

Iteration: 28
Gradient: -8.170725570367821e+36
Intercept: -1.8164844602751782e+35

Iteration: 29
Gradient: 1.5120991997484328e+38
Intercept: 3.3616411114073376e+36

Iteration: 30
Gradient: -2.7983365371760024e+39
Intercept: -6.221154768476254e+37

Iteration: 31
Gradient: 5.178686277062358e+40
Intercept: 1.1513057274913005e+39

Iteration: 32
Gradient: -9.583833538227222e+41
Intercept: -2.1306412193293293e+40

Iteration: 33
Gradient: 1.7736132365320905e+43
Intercept: 3.943029116511953e+41

Iteration: 34
Gradient: -3.28230232740845e+44
Intercept: -7.297089004292793e+42

Iteration: 35
Gradient: 6.074328013911389e+45
Intercept: 1.3504213730908003e+44

Iteration: 36
Gradient: -1.1241335239743485e+47
Intercept: -2.499130658578532e+45

Iteration: 37

Gradient: 2.0803555172340454e+48
Intercept: 4.624966823764291e+46

Iteration: 38
Gradient: -3.8499688745025707e+49
Intercept: -8.559103561670856e+47

Iteration: 39
Gradient: 7.124868904304227e+50
Intercept: 1.5839736061021393e+49

Iteration: 40
Gradient: -1.3185498002261162e+52
Intercept: -2.9313494885887606e+50

Iteration: 41
Gradient: 2.440148161359202e+53
Intercept: 5.4248440700946263e+51

Iteration: 42
Gradient: -4.5158120295218264e+54
Intercept: -1.0039380599073094e+53

Iteration: 43
Gradient: 8.357098396277322e+55
Intercept: 1.8579181541578795e+54

Iteration: 44
Gradient: -1.5465899189000638e+57
Intercept: -3.438319559145036e+55

Iteration: 45
Gradient: 2.8621661057727876e+58
Intercept: 6.36305822425088e+56

Iteration: 46
Gradient: -5.2968112082747315e+59
Intercept: -1.1775668104355765e+58

Iteration: 47
Gradient: 9.802439110545472e+60
Intercept: 2.179240774121109e+59

Iteration: 48
Gradient: -1.8140690452746768e+62
Intercept: -4.0329689232964176e+60

Iteration: 49

Gradient: 3.357171071313755e+63
Intercept: 7.463534332425615e+61

Iteration: 50
Gradient: -6.212882377009751e+64
Intercept: -1.3812242492006354e+63

Iteration: 51
Gradient: 1.1497748136931585e+66
Intercept: 2.556135393243161e+64

Iteration: 52
Gradient: -2.1278080639270125e+67
Intercept: -4.7304615107733125e+65

Iteration: 53
Gradient: 3.9377859933893956e+68
Intercept: 8.754335221858506e+66

Iteration: 54
Gradient: -7.287385921978343e+69
Intercept: -1.620103767933288e+68

Iteration: 55
Gradient: 1.3486256913148768e+71
Intercept: 2.998213059419967e+69

Iteration: 56
Gradient: -2.495807515544303e+72
Intercept: -5.548583817654936e+70

Iteration: 57
Gradient: 4.618816914702445e+73
Intercept: 1.0268377120436608e+72

Iteration: 58
Gradient: -8.547722353856626e+74
Intercept: -1.9002969433751722e+73

Iteration: 59
Gradient: 1.5818673653429972e+76
Intercept: 3.516747028908764e+74

Iteration: 60
Gradient: -2.927451615702262e+77
Intercept: -6.5081984731146015e+75

Iteration: 61

Gradient: 5.417630548576083e+78
Intercept: 1.2044269041038828e+77

Iteration: 62
Gradient: -1.0026031037860172e+80
Intercept: -2.2289488762856323e+78

Iteration: 63
Gradient: 1.8554476439622787e+81
Intercept: 4.124960241394994e+79

Iteration: 64
Gradient: -3.433747558216152e+82
Intercept: -7.63377624947779e+80

Iteration: 65
Gradient: 6.3545971409771e+83
Intercept: 1.4127297335448678e+82

Iteration: 66
Gradient: -1.1760009767605734e+85
Intercept: -2.614440395968224e+83

Iteration: 67
Gradient: 2.176342994937949e+86
Intercept: 4.838362513202805e+84

Iteration: 68
Gradient: -4.027606205449435e+87
Intercept: -8.954020082181548e+85

Iteration: 69
Gradient: 7.453609924495054e+88
Intercept: 1.657058052457466e+87

Iteration: 70
Gradient: -1.3793876082364342e+90
Intercept: -3.0666017766459305e+88

Iteration: 71
Gradient: 2.5527364498956257e+91
Intercept: 5.675146047286336e+89

Iteration: 72
Gradient: -4.7241713233578403e+92
Intercept: -1.0502597012532918e+91

Iteration: 73

Gradient: 8.742694410678035e+93
Intercept: 1.9436423853868828e+92

Iteration: 74
Gradient: -1.6179494841895935e+95
Intercept: -3.5969634155860375e+93

Iteration: 75
Gradient: 2.9942262767324124e+96
Intercept: 6.6566493457534944e+94

Iteration: 76
Gradient: -5.5412057569680364e+97
Intercept: -1.2318996718264127e+96

Iteration: 77
Gradient: 1.0254723058059561e+99
Intercept: 2.279790811595231e+97

Iteration: 78
Gradient: -1.897770081272674e+100
Intercept: -4.219049865423137e+98

Iteration: 79
Gradient: 3.5120707414356927e+101
Intercept: 7.807901354980727e+99

Iteration: 80
Gradient: -6.499544394006281e+102
Intercept: -1.4449538524948384e+101

Iteration: 81
Gradient: 1.202825354035711e+104
Intercept: 2.674075325641491e+102

Iteration: 82
Gradient: -2.22598499926445e+105
Intercept: -4.948724718687992e+103

Iteration: 83
Gradient: 4.119475200888759e+106
Intercept: 9.158259719358732e+104

Iteration: 84
Gradient: -7.623625467532367e+107
Intercept: -1.6948552577696285e+106

Iteration: 85

Gradient: 1.410851199120438e+109
Intercept: 3.1365504285900416e+107

Iteration: 86
Gradient: -2.6109639233154365e+110
Intercept: -5.804595139312819e+108

Iteration: 87
Gradient: 4.831928847708896e+111
Intercept: 1.0742159419537868e+110

Iteration: 88
Gradient: -8.942113746127297e+112
Intercept: -1.9879765293747444e+111

Iteration: 89
Gradient: 1.6548546298771186e+114
Intercept: 3.6790095240598034e+112

Iteration: 90
Gradient: -3.0625240561402624e+115
Intercept: -6.808486356918804e+113

Iteration: 91
Gradient: 5.6675996943213334e+116
Intercept: 1.2599990885915405e+115

Iteration: 92
Gradient: -1.0488631503373286e+118
Intercept: -2.3317924425862914e+116

Iteration: 93
Gradient: 1.9410578860003225e+119
Intercept: 4.315285657373333e+117

Iteration: 94
Gradient: -3.5921804628109e+120
Intercept: -7.985998223786084e+118

Iteration: 95
Gradient: 6.647797868609357e+121
Intercept: 1.477912997980636e+120

Iteration: 96
Gradient: -1.2302615906803773e+123
Intercept: -2.735070517664843e+121

Iteration: 97

```
Gradient: 2.2767593290558745e+124
Intercept: 5.061604266841583e+122
```

```
Iteration: 98
Gradient: -4.2134397120991405e+125
Intercept: -9.36715802705618e+123
```

```
Iteration: 99
Gradient: 7.797519035468681e+126
Intercept: 1.7335146107460257e+125
```

```
Iteration: 100
Gradient: -1.443032469027667e+128
Intercept: -3.208094597091305e+126
```

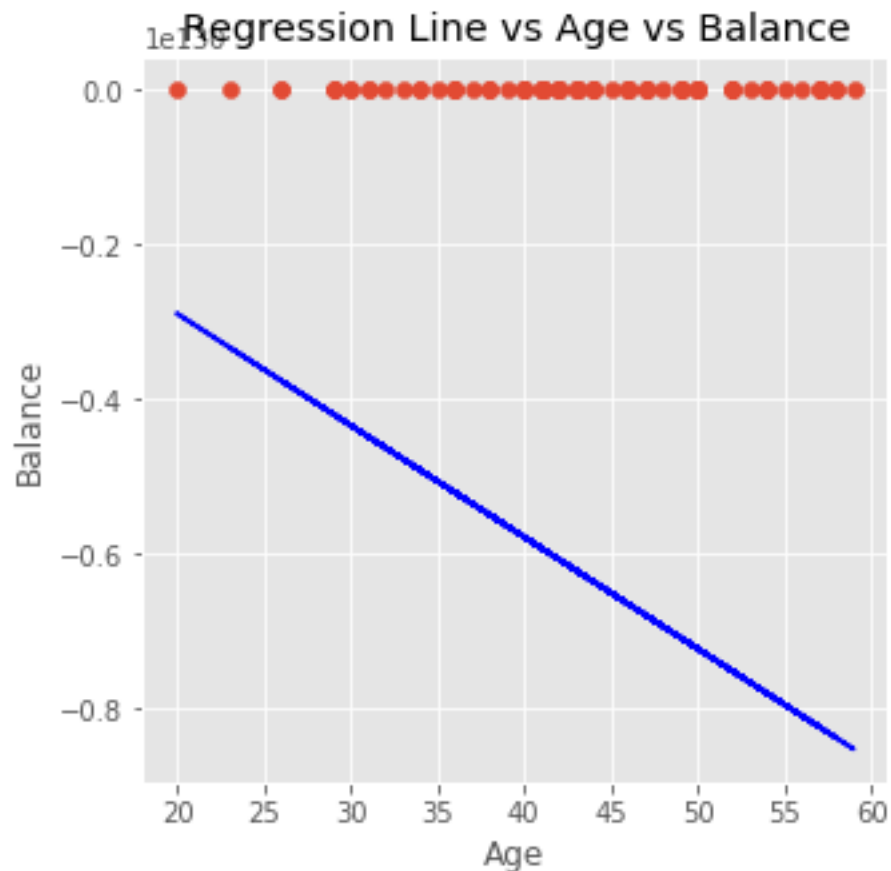
```
Process Complete... after 100 epochs
Gradient(m): -1.443032469027667e+128 Intercept(c): -3.208094597091305e+126
```

0.0.5 Making predictions

- Using the m & c generated after training the model and hopefully reaching global/local minima

```
In [14]: Y_pred = m*X + c
```

```
In [15]: plt.figure(figsize=(5,5))
plt.scatter(X, Y)
plt.plot(X, Y_pred, color='blue') # regression line
plt.xlabel('Age')
plt.ylabel('Balance')
plt.title("Regression Line vs Age vs Balance")
plt.show()
```



As seen above the model performs poorly and fails to produce a line of best fit due to each column not being represented on the same scale

Lets see how the model performs after each column is standardized.

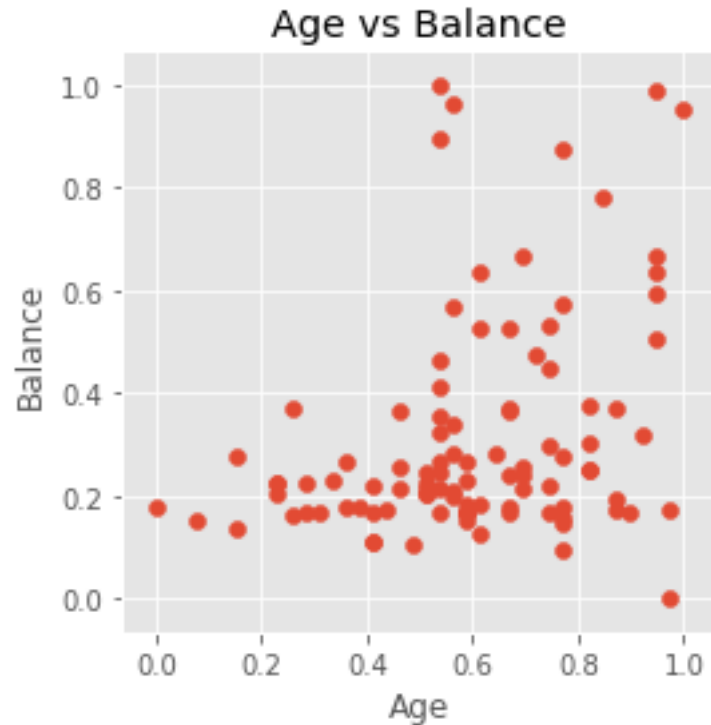
Making use of a Standardization / Normalising technique to normalise columns with high variance: scaling between 0 and 1

0.0.6 Performing Feature Standardization before implementing the model

In [16]: *# for every value within the column value v: apply the formula*
taking the minimum and maximum value within the balance column and using the standard deviation

```
new_X = (X - X.min()) / (X.max() - X.min())
new_Y = (Y - Y.min()) / (Y.max() - Y.min())
```

In [17]: `plt.figure(figsize = (4,4))`
`plt.scatter(new_X,new_Y)`
`plt.xlabel('Age')`
`plt.ylabel('Balance')`
`plt.title("Age vs Balance")`
`plt.show()`



0.0.7 Fitting the model on the Standardized variables

- $\alpha = 0.0001$ & iterations = 100

```
In [18]: new_m = 0 # gradient
        new_c = 0 # Intercept

        new_alpha = 0.0001 # The learning Rate
        new_epochs = 100 # The number of iterations to perform gradient descent

        new_n = float(len(new_X)) # Number of elements in X

        # Performing Gradient Descent
        for i in range(new_epochs):
            new_Y_pred = new_m*new_X + new_c # The current predicted value of Y
            new_D_m = (-2/new_n) * sum(new_X * (new_Y - new_Y_pred)) # Partial derivative wrt m
            new_D_c = (-2/new_n) * sum(new_Y - new_Y_pred) # Partial derivative wrt c
            new_m = new_m - new_alpha * new_D_m # Update m
            new_c = new_c - new_alpha * new_D_c # Update c

            print("Iteration: {}".format(i+1), "\nGradient: {}".format(new_m), "\nIntercept: {}".format(new_c))

        print("\nProcess Complete... after {} epochs".format(new_epochs))
        print("Gradient(m): {}".format(new_m), "Intercept(c): {}".format(new_c))
```


Iteration: 1
Gradient: 0.002059733525477471
Intercept: 0.0031819789591415876

Iteration: 2
Gradient: 0.004092080433113708
Intercept: 0.006319809601943824

Iteration: 3
Gradient: 0.006097415874649621
Intercept: 0.009414097334061247

Iteration: 4
Gradient: 0.008076109858995185
Intercept: 0.012465439261622609

Iteration: 5
Gradient: 0.010028527322732126
Intercept: 0.015474424305008535

Iteration: 6
Gradient: 0.011955028199650079
Intercept: 0.018441633311069388

Iteration: 7
Gradient: 0.0138559674893295
Intercept: 0.021367639163804786

Iteration: 8
Gradient: 0.015731695324784366
Intercept: 0.02425300689352578

Iteration: 9
Gradient: 0.01758255703917756
Intercept: 0.02709829378452057

Iteration: 10
Gradient: 0.019408893231621673
Intercept: 0.0299040494812442

Iteration: 11
Gradient: 0.021211039832077748
Intercept: 0.03267081609305256

Iteration: 12
Gradient: 0.02298932816536432
Intercept: 0.035399128297500526

Iteration: 13
Gradient: 0.02474408501428896
Intercept: 0.038089513442224075

Iteration: 14
Gradient: 0.02647563268191437
Intercept: 0.04074249164542563

Iteration: 15
Gradient: 0.02818428905297086
Intercept: 0.0433585758949819

Iteration: 16
Gradient: 0.02987036765442693
Intercept: 0.04593827214619305

Iteration: 17
Gradient: 0.0315341777152295
Intercept: 0.048482079418191854

Iteration: 18
Gradient: 0.03317602422522514
Intercept: 0.0509904898890311

Iteration: 19
Gradient: 0.03479620799327362
Intercept: 0.053463988989467574

Iteration: 20
Gradient: 0.036395025704564675
Intercept: 0.05590305549546026

Iteration: 21
Gradient: 0.03797276997714914
Intercept: 0.058308161619400556

Iteration: 22
Gradient: 0.03952972941769501
Intercept: 0.06067977310009175

Iteration: 23
Gradient: 0.04106618867647919
Intercept: 0.06301834929149507

Iteration: 24
Gradient: 0.04258242850162535
Intercept: 0.06532434325025901

Iteration: 25
Gradient: 0.044078725792598264
Intercept: 0.06759820182204887

Iteration: 26
Gradient: 0.04555535365296475
Intercept: 0.0698403657266926

Iteration: 27
Gradient: 0.04701258144243136
Intercept: 0.07205126964215959

Iteration: 28
Gradient: 0.04845067482816867
Intercept: 0.0742313422873881

Iteration: 29
Gradient: 0.049869895835431964
Intercept: 0.07638100650397724

Iteration: 30
Gradient: 0.05127050289748797
Intercept: 0.07850067933675897

Iteration: 31
Gradient: 0.052652750904857146
Intercept: 0.0805907721132657

Iteration: 32
Gradient: 0.05401689125388093
Intercept: 0.08265169052210829

Iteration: 33
Gradient: 0.05536317189462314
Intercept: 0.08468383469027972

Iteration: 34
Gradient: 0.05669183737811477
Intercept: 0.08668759925939892

Iteration: 35
Gradient: 0.05800312890295101
Intercept: 0.08866337346090943

Iteration: 36
Gradient: 0.05929728436124955
Intercept: 0.0906115411902471

Iteration: 37
Gradient: 0.060574538383978846
Intercept: 0.09253248107999114

Iteration: 38
Gradient: 0.06183512238566492
Intercept: 0.09442656657201223

Iteration: 39
Gradient: 0.06307926460848534
Intercept: 0.09629416598863165

Iteration: 40
Gradient: 0.06430719016575868
Intercept: 0.0981356426028048

Iteration: 41
Gradient: 0.0655191210848378
Intercept: 0.09995135470734266

Iteration: 42
Gradient: 0.06671527634941513
Intercept: 0.1017416556831843

Iteration: 43
Gradient: 0.06789587194124794
Intercept: 0.10350689406673337

Iteration: 44
Gradient: 0.06906112088131164
Intercept: 0.10524741361627153

Iteration: 45
Gradient: 0.0702112332703889
Intercept: 0.10696355337746147

Iteration: 46
Gradient: 0.07134641632910237
Intercept: 0.1086556477479518

Iteration: 47
Gradient: 0.0724668744373985
Intercept: 0.1103240265410965

Iteration: 48
Gradient: 0.07357280917349023
Intercept: 0.11196901504880064

Iteration: 49
Gradient: 0.07466441935226562
Intercept: 0.11359093410350463

Iteration: 50
Gradient: 0.07574190106317015
Intercept: 0.1151901001393188

Iteration: 51
Gradient: 0.07680544770756954
Intercept: 0.11676682525231975

Iteration: 52
Gradient: 0.07785525003560044
Intercept: 0.11832141726002027

Iteration: 53
Gradient: 0.07889149618251588
Intercept: 0.11985417976002379

Iteration: 54
Gradient: 0.07991437170453256
Intercept: 0.12136541218787492

Iteration: 55
Gradient: 0.08092405961418656
Intercept: 0.12285540987411685

Iteration: 56
Gradient: 0.08192074041520454
Intercept: 0.12432446410056652

Iteration: 57
Gradient: 0.08290459213689677
Intercept: 0.12577286215581837

Iteration: 58
Gradient: 0.08387579036807867
Intercept: 0.1272008873899872

Iteration: 59
Gradient: 0.0848345082905274
Intercept: 0.12860881926870046

Iteration: 60
Gradient: 0.08578091671197972
Intercept: 0.12999693342635057

Iteration: 61
Gradient: 0.08671518409867755
Intercept: 0.13136550171861694

Iteration: 62
Gradient: 0.08763747660746729
Intercept: 0.1327147922742682

Iteration: 63
Gradient: 0.08854795811745914
Intercept: 0.13404506954625411

Iteration: 64
Gradient: 0.08944679026125239
Intercept: 0.13535659436209724

Iteration: 65
Gradient: 0.09033413245573273
Intercept: 0.13664962397359362

Iteration: 66
Gradient: 0.09121014193244714
Intercept: 0.13792441210583223

Iteration: 67
Gradient: 0.09207497376756266
Intercept: 0.13918120900554232

Iteration: 68
Gradient: 0.0929287809114142
Intercept: 0.1404202614887781

Iteration: 69
Gradient: 0.09377171421764746
Intercept: 0.1416418129879496

Iteration: 70
Gradient: 0.09460392247196225
Intercept: 0.14284610359820887

Iteration: 71
Gradient: 0.0954255524204618
Intercept: 0.14403337012320028

Iteration: 72
Gradient: 0.09623674879761338
Intercept: 0.14520384612018344

Iteration: 73
Gradient: 0.09703765435382566
Intercept: 0.1463577619445379

Iteration: 74
Gradient: 0.09782840988264806
Intercept: 0.14749534479365733

Iteration: 75
Gradient: 0.09860915424759704
Intercept: 0.1486168187502423

Iteration: 76
Gradient: 0.0993800244086149
Intercept: 0.14972240482499932

Iteration: 77
Gradient: 0.10014115544816563
Intercept: 0.15081232099875466

Iteration: 78
Gradient: 0.10089268059697307
Intercept: 0.15188678226399077

Iteration: 79
Gradient: 0.10163473125940636
Intercept: 0.15294600066581335

Iteration: 80
Gradient: 0.10236743703851721
Intercept: 0.15399018534235667

Iteration: 81
Gradient: 0.103090925760734
Intercept: 0.15501954256463513

Iteration: 82
Gradient: 0.10380532350021739
Intercept: 0.1560342757758484

Iteration: 83
Gradient: 0.10451075460288196
Intercept: 0.15703458563014785

Iteration: 84
Gradient: 0.10520734171008866
Intercept: 0.15802067003087125

Iteration: 85
Gradient: 0.1058952057820123
Intercept: 0.1589927241682537

Iteration: 86
Gradient: 0.1065744661206888
Intercept: 0.15995094055662124

Iteration: 87
Gradient: 0.10724524039274654
Intercept: 0.16089550907107486

Iteration: 88
Gradient: 0.10790764465182594
Intercept: 0.16182661698367137

Iteration: 89
Gradient: 0.10856179336069181
Intercept: 0.16274444899910842

Iteration: 90
Gradient: 0.10920779941304251
Intercept: 0.16364918728992026

Iteration: 91
Gradient: 0.10984577415502014
Intercept: 0.16454101153119102

Iteration: 92
Gradient: 0.11047582740642584
Intercept: 0.16542009893479212

Iteration: 93
Gradient: 0.11109806748164427
Intercept: 0.16628662428315027

Iteration: 94
Gradient: 0.11171260121028126
Intercept: 0.16714075996255262

Iteration: 95
Gradient: 0.11231953395751845
Intercept: 0.16798267599599523

Iteration: 96
Gradient: 0.112918969644189
Intercept: 0.16881254007558136


```
Iteration: 97
Gradient: 0.113511010766578
Intercept: 0.1696305175944755
```

```
Iteration: 98
Gradient: 0.1140957584159515
Intercept: 0.1704367716784194
```

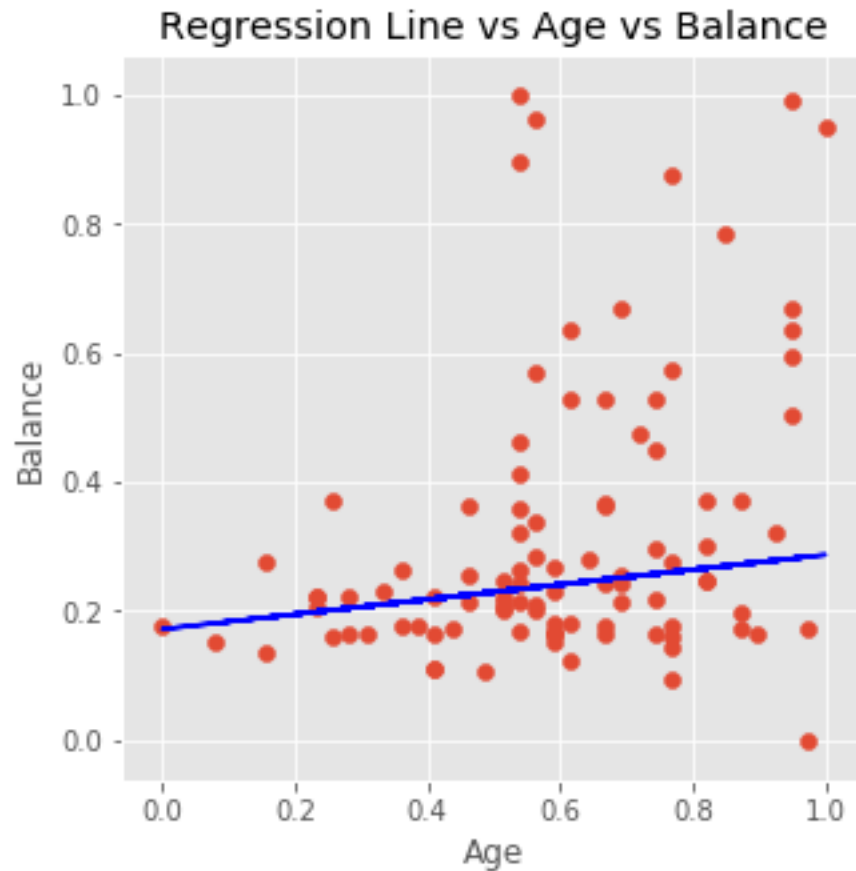
```
Iteration: 99
Gradient: 0.11467331229781773
Intercept: 0.17123146321681598
```

```
Iteration: 100
Gradient: 0.11524377075092439
Intercept: 0.1720147508933873
```

```
Process Complete... after 100 epochs
Gradient(m): 0.11524377075092439 Intercept(c): 0.1720147508933873
```

```
In [19]: new_Y_pred = new_m*new_X + new_c
```

```
In [20]: plt.figure(figsize=(5,5))
plt.scatter(new_X, new_Y)
plt.plot(new_X, new_Y_pred, color='blue') # regression line
plt.xlabel('Age')
plt.ylabel('Balance')
plt.title("Regression Line vs Age vs Balance")
plt.show()
```



As expected the linear regression model performs well once the data has been standardized, unlike the unstandardized data. The model was unable to properly converge which resulted in almost random gradient values as it attempted to find the global/local minima. A learning rate of 0.005 was used, with 100 iterations.

0.0.8 Using a higher learning rate with a higher iteration

- alpha = 0.005 & epochs = 1000

```
In [21]: new_m = 0 # gradient
         new_c = 0 # Intercept

         new_alpha = 0.005 # The learning Rate
         new_epochs = 1000 # The number of iterations to perform gradient descent

         new_n = float(len(new_X)) # Number of elements in X

         # Performing Gradient Descent
         for i in range(new_epochs):
             new_Y_pred = new_m*new_X + new_c # The current predicted value of Y
```

```

new_D_m = (-2/new_n) * sum(new_X * (new_Y - new_Y_pred)) # Partial derivative wrt m
new_D_c = (-2/new_n) * sum(new_Y - new_Y_pred) # Partial derivative wrt c
new_m = new_m - new_alpha * new_D_m # Update m
new_c = new_c - new_alpha * new_D_c # Update c

print("Iteration: {}".format(i+ 1), "\nGradient: {}".format(new_m), "\nIntercept: {}".format(new_c))

print("\nProcess Complete... after {} epochs".format(new_epochs))
print("Gradient(m): {}".format(new_m), "Intercept(c): {}".format(new_c))

```

```

Iteration: 1
Gradient: 0.002059733525477471
Intercept: 0.0031819789591415876

```

```

Iteration: 2
Gradient: 0.004092080433113708
Intercept: 0.006319809601943824

```

```

Iteration: 3
Gradient: 0.006097415874649621
Intercept: 0.009414097334061247

```

```

Iteration: 4
Gradient: 0.008076109858995185
Intercept: 0.012465439261622609

```

```

Iteration: 5
Gradient: 0.010028527322732126
Intercept: 0.015474424305008535

```

```

Iteration: 6
Gradient: 0.011955028199650079
Intercept: 0.018441633311069388

```

```

Iteration: 7
Gradient: 0.0138559674893295
Intercept: 0.021367639163804786

```

```

Iteration: 8
Gradient: 0.015731695324784366
Intercept: 0.02425300689352578

```

```

Iteration: 9
Gradient: 0.01758255703917756
Intercept: 0.02709829378452057

```

```

Iteration: 10
Gradient: 0.019408893231621673

```

Intercept: 0.0299040494812442

Iteration: 11
Gradient: 0.021211039832077748
Intercept: 0.03267081609305256

Iteration: 12
Gradient: 0.02298932816536432
Intercept: 0.035399128297500526

Iteration: 13
Gradient: 0.02474408501428896
Intercept: 0.038089513442224075

Iteration: 14
Gradient: 0.02647563268191437
Intercept: 0.04074249164542563

Iteration: 15
Gradient: 0.02818428905297086
Intercept: 0.0433585758949819

Iteration: 16
Gradient: 0.02987036765442693
Intercept: 0.04593827214619305

Iteration: 17
Gradient: 0.0315341777152295
Intercept: 0.048482079418191854

Iteration: 18
Gradient: 0.03317602422522514
Intercept: 0.0509904898890311

Iteration: 19
Gradient: 0.03479620799327362
Intercept: 0.053463988989467574

Iteration: 20
Gradient: 0.036395025704564675
Intercept: 0.05590305549546026

Iteration: 21
Gradient: 0.03797276997714914
Intercept: 0.058308161619400556

Iteration: 22
Gradient: 0.03952972941769501

Intercept: 0.06067977310009175

Iteration: 23

Gradient: 0.04106618867647919

Intercept: 0.06301834929149507

Iteration: 24

Gradient: 0.04258242850162535

Intercept: 0.06532434325025901

Iteration: 25

Gradient: 0.044078725792598264

Intercept: 0.06759820182204887

Iteration: 26

Gradient: 0.04555535365296475

Intercept: 0.0698403657266926

Iteration: 27

Gradient: 0.04701258144243136

Intercept: 0.07205126964215959

Iteration: 28

Gradient: 0.04845067482816867

Intercept: 0.0742313422873881

Iteration: 29

Gradient: 0.049869895835431964

Intercept: 0.07638100650397724

Iteration: 30

Gradient: 0.05127050289748797

Intercept: 0.07850067933675897

Iteration: 31

Gradient: 0.052652750904857146

Intercept: 0.0805907721132657

Iteration: 32

Gradient: 0.05401689125388093

Intercept: 0.08265169052210829

Iteration: 33

Gradient: 0.05536317189462314

Intercept: 0.08468383469027972

Iteration: 34

Gradient: 0.05669183737811477

Intercept: 0.08668759925939892

Iteration: 35

Gradient: 0.05800312890295101

Intercept: 0.08866337346090943

Iteration: 36

Gradient: 0.05929728436124955

Intercept: 0.0906115411902471

Iteration: 37

Gradient: 0.060574538383978846

Intercept: 0.09253248107999114

Iteration: 38

Gradient: 0.06183512238566492

Intercept: 0.09442656657201223

Iteration: 39

Gradient: 0.06307926460848534

Intercept: 0.09629416598863165

Iteration: 40

Gradient: 0.06430719016575868

Intercept: 0.0981356426028048

Iteration: 41

Gradient: 0.0655191210848378

Intercept: 0.09995135470734266

Iteration: 42

Gradient: 0.06671527634941513

Intercept: 0.1017416556831843

Iteration: 43

Gradient: 0.06789587194124794

Intercept: 0.10350689406673337

Iteration: 44

Gradient: 0.06906112088131164

Intercept: 0.10524741361627153

Iteration: 45

Gradient: 0.0702112332703889

Intercept: 0.10696355337746147

Iteration: 46

Gradient: 0.07134641632910237

Intercept: 0.1086556477479518

Iteration: 47

Gradient: 0.0724668744373985

Intercept: 0.1103240265410965

Iteration: 48

Gradient: 0.07357280917349023

Intercept: 0.11196901504880064

Iteration: 49

Gradient: 0.07466441935226562

Intercept: 0.11359093410350463

Iteration: 50

Gradient: 0.07574190106317015

Intercept: 0.1151901001393188

Iteration: 51

Gradient: 0.07680544770756954

Intercept: 0.11676682525231975

Iteration: 52

Gradient: 0.07785525003560044

Intercept: 0.11832141726002027

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Gradient: 0.09377171421764746
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Iteration: 70
Gradient: 0.09460392247196225

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Gradient: 0.0954255524204618

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Gradient: 0.09782840988264806

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Gradient: 0.0993800244086149

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Gradient: 0.10014115544816563

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Iteration: 78

Gradient: 0.10089268059697307

Intercept: 0.15188678226399077

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Gradient: 0.1065744661206888

Intercept: 0.15995094055662124

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Intercept: 0.16628662428315027

Iteration: 94

Gradient: 0.11171260121028126

Intercept: 0.16714075996255262

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Gradient: 0.11231953395751845

Intercept: 0.16798267599599523

Iteration: 96

Gradient: 0.112918969644189

Intercept: 0.16881254007558136

Iteration: 97

Gradient: 0.113511010766578

Intercept: 0.1696305175944755

Iteration: 98

Gradient: 0.1140957584159515

Intercept: 0.1704367716784194

Iteration: 99

Gradient: 0.11467331229781773

Intercept: 0.17123146321681598

Iteration: 100

Gradient: 0.11524377075092439

Intercept: 0.1720147508933873

Iteration: 101

Gradient: 0.11580723076599542

Intercept: 0.17278679121641194

Iteration: 102

Gradient: 0.11636378800421092

Intercept: 0.17354773854854813

Iteration: 103

Gradient: 0.11691353681543376

Intercept: 0.17429774513624793

Iteration: 104

Gradient: 0.11745657025618629

Intercept: 0.17503696113876813

Iteration: 105

Gradient: 0.11799298010738066

Intercept: 0.17576553465678352

Iteration: 106

Gradient: 0.11852285689180599

Intercept: 0.17648361176060784

Iteration: 107

Gradient: 0.11904628989137589

Intercept: 0.17719133651802793

Iteration: 108

Gradient: 0.11956336716413951

Intercept: 0.17788885102175622

Iteration: 109

Gradient: 0.12007417556105937

Intercept: 0.1785762954165069

Iteration: 110

Gradient: 0.1205788007425592

Intercept: 0.17925380792570098

Iteration: 111

Gradient: 0.12107732719484489

Intercept: 0.17992152487780505

Iteration: 112

Gradient: 0.12156983824600179

Intercept: 0.18057958073230926

Iteration: 113

Gradient: 0.12205641608187123

Intercept: 0.18122810810534892

Iteration: 114

Gradient: 0.12253714176170945

Intercept: 0.18186723779497496

Iteration: 115

Gradient: 0.12301209523363184

Intercept: 0.18249709880607792

Iteration: 116

Gradient: 0.12348135534984546

Intercept: 0.18311781837497038

Iteration: 117

Gradient: 0.12394499988167273

Intercept: 0.18372952199363216

Iteration: 118

Gradient: 0.12440310553436922

Intercept: 0.18433233343362337

Iteration: 119

Gradient: 0.12485574796173816

Intercept: 0.18492637476966953

Iteration: 120

Gradient: 0.12530300178054482

Intercept: 0.18551176640292333

Iteration: 121

Gradient: 0.12574494058473304

Intercept: 0.18608862708390764

Iteration: 122

Gradient: 0.12618163695944706

Intercept: 0.1866570739351438

Iteration: 123

Gradient: 0.12661316249486107

Intercept: 0.18721722247346986

Iteration: 124

Gradient: 0.12703958779981905

Intercept: 0.1877691866320528

Iteration: 125

Gradient: 0.12746098251528784

Intercept: 0.188313078782099

Iteration: 126

Gradient: 0.1278774153276256

Intercept: 0.18884900975426697

Iteration: 127

Gradient: 0.12828895398166845

Intercept: 0.18937708885978677

Iteration: 128

Gradient: 0.1286956652936378

Intercept: 0.18989742391128975

Iteration: 129

Gradient: 0.12909761516387047

Intercept: 0.19041012124335263

Iteration: 130

Gradient: 0.12949486858937453

Intercept: 0.19091528573276023

Iteration: 131

Gradient: 0.129887489676213

Intercept: 0.19141302081849018

Iteration: 132

Gradient: 0.13027554165171762

Intercept: 0.19190342852142375

Iteration: 133

Gradient: 0.13065908687653535

Intercept: 0.19238660946378644

Iteration: 134

Gradient: 0.13103818685650967

Intercept: 0.1928626628883221

Iteration: 135

Gradient: 0.1314129022543989

Intercept: 0.19333168667720416

Iteration: 136

Gradient: 0.13178329290143406

Intercept: 0.19379377737068762

Iteration: 137

Gradient: 0.1321494178087182

Intercept: 0.19424903018550535

Iteration: 138

Gradient: 0.13251133517846933

Intercept: 0.19469753903301218

Iteration: 139

Gradient: 0.13286910241510946

Intercept: 0.1951393965370802

Iteration: 140

Gradient: 0.13322277613620143

Intercept: 0.1955746940517489

Iteration: 141

Gradient: 0.13357241218323587

Intercept: 0.19600352167863314

Iteration: 142

Gradient: 0.13391806563227038

Intercept: 0.19642596828409262

Iteration: 143

Gradient: 0.13425979080442263

Intercept: 0.19684212151616592

Iteration: 144

Gradient: 0.13459764127621984

Intercept: 0.19725206782127244

Iteration: 145

Gradient: 0.13493166988980632

Intercept: 0.19765589246068527

Iteration: 146

Gradient: 0.1352619287630109

Intercept: 0.1980536795267783

Iteration: 147

Gradient: 0.13558846929927665

Intercept: 0.19844551195905066

Iteration: 148

Gradient: 0.1359113421974542

Intercept: 0.1988314715599314

Iteration: 149

Gradient: 0.13623059746146102

Intercept: 0.19921163901036743

Iteration: 150

Gradient: 0.136546284409808

Intercept: 0.19958609388519805

Iteration: 151

Gradient: 0.13685845168499589

Intercept: 0.19995491466831836

Iteration: 152

Gradient: 0.1371671472627823

Intercept: 0.20031817876763502

Iteration: 153

Gradient: 0.13747241846132238

Intercept: 0.20067596252981695

Iteration: 154

Gradient: 0.13777431195018347

Intercept: 0.2010283412548437

Iteration: 155

Gradient: 0.13807287375923674

Intercept: 0.20137538921035456

Iteration: 156

Gradient: 0.1383681492874266

Intercept: 0.2017171796458008

Iteration: 157

Gradient: 0.13866018331142008

Intercept: 0.20205378480640399

Iteration: 158

Gradient: 0.13894901999413747

Intercept: 0.2023852759469229

Iteration: 159

Gradient: 0.1392347028931662

Intercept: 0.20271172334523174

Iteration: 160

Gradient: 0.13951727496905914

Intercept: 0.20303319631571223

Iteration: 161

Gradient: 0.13979677859351938

Intercept: 0.20334976322246207

Iteration: 162

Gradient: 0.14007325555747271

Intercept: 0.20366149149232224

Iteration: 163

Gradient: 0.14034674707902936

Intercept: 0.203968447627726

Iteration: 164

Gradient: 0.14061729381133664

Intercept: 0.20427069721937138

Iteration: 165

Gradient: 0.14088493585032405

Intercept: 0.2045683049587202

Iteration: 166

Gradient: 0.14114971274234203

Intercept: 0.2048613346503256

Iteration: 167
Gradient: 0.14141166349169607
Intercept: 0.20514984922399074

Iteration: 168
Gradient: 0.14167082656807756
Intercept: 0.20543391074676057

Iteration: 169
Gradient: 0.14192723991389275
Intercept: 0.20571358043474944

Iteration: 170
Gradient: 0.14218094095149122
Intercept: 0.2059889186648064

Iteration: 171
Gradient: 0.1424319665902953
Intercept: 0.20625998498602072

Iteration: 172
Gradient: 0.14268035323383163
Intercept: 0.2065268381310696

Iteration: 173
Gradient: 0.14292613678666652
Intercept: 0.20678953602741024

Iteration: 174
Gradient: 0.1431693526612461
Intercept: 0.20704813580831868

Iteration: 175
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Iteration: 904

Gradient: 0.1950959398590906

Intercept: 0.20431823796452764

Iteration: 905

Gradient: 0.19514268594313913

Intercept: 0.2042892885792108

Iteration: 906

Gradient: 0.19518941600524453

Intercept: 0.2042603488892487

Iteration: 907

Gradient: 0.19523613005225615

Intercept: 0.20423141889358712

Iteration: 908

Gradient: 0.19528282809100198

Intercept: 0.20420249859114128

Iteration: 909

Gradient: 0.1953295101282888

Intercept: 0.20417358798079646

Iteration: 910

Gradient: 0.19537617617090253

Intercept: 0.20414468706140831

Iteration: 911

Gradient: 0.19542282622560844

Intercept: 0.20411579583180334

Iteration: 912

Gradient: 0.19546946029915147

Intercept: 0.20408691429077924

Iteration: 913

Gradient: 0.1955160783982564

Intercept: 0.2040580424371054

Iteration: 914

Gradient: 0.19556268052962816

Intercept: 0.20402918026952324

Iteration: 915

Gradient: 0.19560926669995207

Intercept: 0.20400032778674668

Iteration: 916

Gradient: 0.19565583691589403

Intercept: 0.20397148498746243

Iteration: 917

Gradient: 0.19570239118410088

Intercept: 0.20394265187033045

Iteration: 918

Gradient: 0.1957489295112005

Intercept: 0.20391382843398434

Iteration: 919

Gradient: 0.19579545190380213

Intercept: 0.20388501467703166

Iteration: 920

Gradient: 0.1958419583684966

Intercept: 0.20385621059805434

Iteration: 921

Gradient: 0.19588844891185653

Intercept: 0.20382741619560907

Iteration: 922

Gradient: 0.19593492354043654

Intercept: 0.2037986314682276

Iteration: 923
Gradient: 0.19598138226077352
Intercept: 0.20376985641441717

Iteration: 924
Gradient: 0.19602782507938682
Intercept: 0.20374109103266078

Iteration: 925
Gradient: 0.19607425200277845
Intercept: 0.20371233532141758

Iteration: 926
Gradient: 0.19612066303743333
Intercept: 0.20368358927912322

Iteration: 927
Gradient: 0.1961670581898195
Intercept: 0.20365485290419022

Iteration: 928
Gradient: 0.19621343746638825
Intercept: 0.2036261261950082

Iteration: 929
Gradient: 0.19625980087357447
Intercept: 0.20359740914994426

Iteration: 930
Gradient: 0.1963061484177967
Intercept: 0.20356870176734337

Iteration: 931
Gradient: 0.19635248010545742
Intercept: 0.20354000404552863

Iteration: 932
Gradient: 0.1963987959429432
Intercept: 0.20351131598280153

Iteration: 933
Gradient: 0.19644509593662496
Intercept: 0.20348263757744237

Iteration: 934
Gradient: 0.19649138009285805

Intercept: 0.2034539688277105

Iteration: 935

Gradient: 0.19653764841798255

Intercept: 0.2034253097318446

Iteration: 936

Gradient: 0.1965839009183234

Intercept: 0.2033966602880631

Iteration: 937

Gradient: 0.19663013760019057

Intercept: 0.2033680204945643

Iteration: 938

Gradient: 0.1966763584698793

Intercept: 0.20333939034952678

Iteration: 939

Gradient: 0.19672256353367018

Intercept: 0.20331076985110966

Iteration: 940

Gradient: 0.19676875279782946

Intercept: 0.2032821589974529

Iteration: 941

Gradient: 0.19681492626860908

Intercept: 0.2032535577866775

Iteration: 942

Gradient: 0.19686108395224697

Intercept: 0.20322496621688588

Iteration: 943

Gradient: 0.1969072258549671

Intercept: 0.20319638428616205

Iteration: 944

Gradient: 0.19695335198297972

Intercept: 0.20316781199257195

Iteration: 945

Gradient: 0.19699946234248156

Intercept: 0.20313924933416372

Iteration: 946

Gradient: 0.19704555693965586

Intercept: 0.2031106963089679

Iteration: 947
Gradient: 0.19709163578067265
Intercept: 0.20308215291499768

Iteration: 948
Gradient: 0.1971376988716889
Intercept: 0.20305361915024925

Iteration: 949
Gradient: 0.19718374621884854
Intercept: 0.20302509501270194

Iteration: 950
Gradient: 0.19722977782828283
Intercept: 0.20299658050031852

Iteration: 951
Gradient: 0.19727579370611034
Intercept: 0.20296807561104546

Iteration: 952
Gradient: 0.19732179385843715
Intercept: 0.20293958034281315

Iteration: 953
Gradient: 0.19736777829135702
Intercept: 0.20291109469353608

Iteration: 954
Gradient: 0.19741374701095146
Intercept: 0.20288261866111312

Iteration: 955
Gradient: 0.19745970002329002
Intercept: 0.20285415224342782

Iteration: 956
Gradient: 0.1975056373344303
Intercept: 0.20282569543834847

Iteration: 957
Gradient: 0.1975515589504181
Intercept: 0.20279724824372852

Iteration: 958
Gradient: 0.1975974648772876

Intercept: 0.20276881065740662

Iteration: 959

Gradient: 0.19764335512106154

Intercept: 0.20274038267720695

Iteration: 960

Gradient: 0.1976892296877512

Intercept: 0.2027119643009394

Iteration: 961

Gradient: 0.1977350885833567

Intercept: 0.20268355552639977

Iteration: 962

Gradient: 0.197780931813867

Intercept: 0.20265515635137

Iteration: 963

Gradient: 0.19782675938526012

Intercept: 0.20262676677361832

Iteration: 964

Gradient: 0.19787257130350322

Intercept: 0.20259838679089956

Iteration: 965

Gradient: 0.19791836757455272

Intercept: 0.20257001640095526

Iteration: 966

Gradient: 0.19796414820435448

Intercept: 0.20254165560151388

Iteration: 967

Gradient: 0.19800991319884384

Intercept: 0.20251330439029103

Iteration: 968

Gradient: 0.1980556625639458

Intercept: 0.20248496276498962

Iteration: 969

Gradient: 0.1981013963055751

Intercept: 0.20245663072330006

Iteration: 970

Gradient: 0.19814711442963634

Intercept: 0.20242830826290048

Iteration: 971

Gradient: 0.19819281694202415

Intercept: 0.20239999538145687

Iteration: 972

Gradient: 0.1982385038486232

Intercept: 0.20237169207662326

Iteration: 973

Gradient: 0.19828417515530844

Intercept: 0.20234339834604195

Iteration: 974

Gradient: 0.1983298308679451

Intercept: 0.20231511418734363

Iteration: 975

Gradient: 0.19837547099238884

Intercept: 0.2022868395981476

Iteration: 976

Gradient: 0.19842109553448586

Intercept: 0.20225857457606192

Iteration: 977

Gradient: 0.19846670450007303

Intercept: 0.2022303191186835

Iteration: 978

Gradient: 0.19851229789497793

Intercept: 0.20220207322359846

Iteration: 979

Gradient: 0.198557875725019

Intercept: 0.20217383688838209

Iteration: 980

Gradient: 0.19860343799600566

Intercept: 0.20214561011059914

Iteration: 981

Gradient: 0.19864898471373832

Intercept: 0.20211739288780395

Iteration: 982

Gradient: 0.19869451588400858

Intercept: 0.20208918521754057

Iteration: 983

Gradient: 0.1987400315125993

Intercept: 0.20206098709734296

Iteration: 984

Gradient: 0.19878553160528467

Intercept: 0.2020327985247351

Iteration: 985

Gradient: 0.1988310161678303

Intercept: 0.20200461949723122

Iteration: 986

Gradient: 0.19887648520599335

Intercept: 0.20197645001233586

Iteration: 987

Gradient: 0.1989219387255226

Intercept: 0.20194829006754406

Iteration: 988

Gradient: 0.19896737673215856

Intercept: 0.2019201396603415

Iteration: 989

Gradient: 0.19901279923163348

Intercept: 0.20189199878820469

Iteration: 990

Gradient: 0.19905820622967157

Intercept: 0.20186386744860096

Iteration: 991

Gradient: 0.199103597731989

Intercept: 0.20183574563898882

Iteration: 992

Gradient: 0.19914897374429397

Intercept: 0.2018076333568179

Iteration: 993

Gradient: 0.1991943342722869

Intercept: 0.2017795305995292

Iteration: 994

Gradient: 0.19923967932166037

Intercept: 0.20175143736455517

Iteration: 995

Gradient: 0.19928500889809933

Intercept: 0.2017233536493199

Iteration: 996

Gradient: 0.1993303230072811

Intercept: 0.2016952794512392

Iteration: 997

Gradient: 0.1993756216548755

Intercept: 0.20166721476772068

Iteration: 998

Gradient: 0.19942090484654484

Intercept: 0.20163915959616405

Iteration: 999

Gradient: 0.19946617258794416

Intercept: 0.20161111393396103

Iteration: 1000

Gradient: 0.19951142488472115

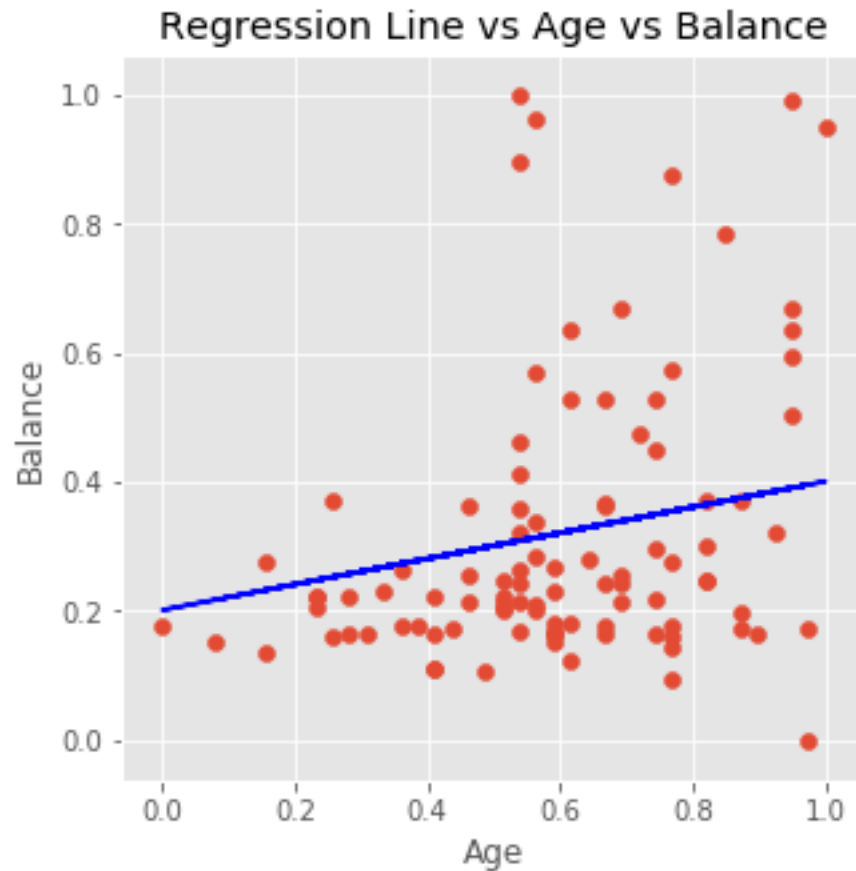
Intercept: 0.20158307777849563

Process Complete... after 1000 epochs

Gradient(m): 0.19951142488472115 Intercept(c): 0.20158307777849563

```
In [22]: new_Y_pred = new_m*new_X + new_c
```

```
In [23]: plt.figure(figsize=(5,5))
plt.scatter(new_X, new_Y)
plt.plot(new_X, new_Y_pred, color='blue') # regression line
plt.xlabel('Age')
plt.ylabel('Balance')
plt.title("Regression Line vs Age vs Balance")
plt.show()
```



0.0.9 Using a lower learning rate with a higher iteration

- $\alpha = 0.001$ & epochs = 2000

```
In [80]: new_m = 0 # gradient
         new_c = 0 # Intercept

         m_list = []
         c_list = []

         new_alpha = 0.001 # The learning Rate
         new_epochs = 2000 # The number of iterations to perform gradient descent

         new_n = float(len(new_X)) # Number of elements in X

         # Performing Gradient Descent
         for i in range(new_epochs):
             # append current m and c into a list
             m_list.append(new_m)
```

```

c_list.append(new_c)

new_Y_pred = new_m*new_X + new_c # The current predicted value of Y
new_D_m = (-2/new_n) * sum(new_X * (new_Y - new_Y_pred)) # Partial derivative wr
new_D_c = (-2/new_n) * sum(new_Y - new_Y_pred) # Partial derivative wrt c
new_m = new_m - new_alpha * new_D_m # Update m
new_c = new_c - new_alpha * new_D_c # Update c

print("Iteration: {}".format(i+ 1), "\nGradient: {}".format(new_m), "\nIntercept:

print("\nProcess Complete... after {} epochs".format(new_epochs))
print("Gradient(m): {}".format(new_m), "Intercept(c): {}".format(new_c))

```

```

Iteration: 1
Gradient: 0.0004119467050954942
Intercept: 0.0006363957918283175

```

```

Iteration: 2
Gradient: 0.0008227979454773387
Intercept: 0.001271025651003061

```

```

Iteration: 3
Gradient: 0.0012325567223594614
Intercept: 0.0019038944207694667

```

```

Iteration: 4
Gradient: 0.0016412260287272597
Intercept: 0.00253500693109353

```

```

Iteration: 5
Gradient: 0.002048808849360163
Intercept: 0.0031643679986984134

```

```

Iteration: 6
Gradient: 0.0024553081608541306
Intercept: 0.003791982427100756

```

```

Iteration: 7
Gradient: 0.00286072693164409
Intercept: 0.004417855006646883

```

```

Iteration: 8
Gradient: 0.0032650681220263117
Intercept: 0.005041990514548915

```

```

Iteration: 9
Gradient: 0.003668334684180724
Intercept: 0.005664393714920784

```


Iteration: 10
Gradient: 0.004070529562193167
Intercept: 0.006285069358814137

Iteration: 11
Gradient: 0.004471655692077583
Intercept: 0.006904022184254156

Iteration: 12
Gradient: 0.004871716001798152
Intercept: 0.007521256916275276

Iteration: 13
Gradient: 0.005270713411291356
Intercept: 0.008136778266956796

Iteration: 14
Gradient: 0.005668650832487994
Intercept: 0.008750590935458404

Iteration: 15
Gradient: 0.006065531169335133
Intercept: 0.009362699608055598

Iteration: 16
Gradient: 0.006461357317817992
Intercept: 0.009973108958175013

Iteration: 17
Gradient: 0.006856132165981776
Intercept: 0.01058182364642965

Iteration: 18
Gradient: 0.007249858593953447
Intercept: 0.011188848320654006

Iteration: 19
Gradient: 0.007642539473963428
Intercept: 0.011794187615939112

Iteration: 20
Gradient: 0.00803417767036726
Intercept: 0.01239784615466747

Iteration: 21
Gradient: 0.008424776039667192
Intercept: 0.012999828546547904

Iteration: 22
Gradient: 0.008814337430533708
Intercept: 0.0136001393886503

Iteration: 23
Gradient: 0.009202864683827007
Intercept: 0.014198783265440265

Iteration: 24
Gradient: 0.009590360632618413
Intercept: 0.01479576474881368

Iteration: 25
Gradient: 0.009976828102211732
Intercept: 0.015391088398131171

Iteration: 26
Gradient: 0.010362269910164547
Intercept: 0.015984758760252474

Iteration: 27
Gradient: 0.010746688866309457
Intercept: 0.016576780369570703

Iteration: 28
Gradient: 0.011130087772775262
Intercept: 0.017167157748046547

Iteration: 29
Gradient: 0.011512469424008078
Intercept: 0.01775589540524234

Iteration: 30
Gradient: 0.011893836606792402
Intercept: 0.018342997838356065

Iteration: 31
Gradient: 0.012274192100272125
Intercept: 0.01892846953225525

Iteration: 32
Gradient: 0.012653538675971476
Intercept: 0.01951231495951078

Iteration: 33
Gradient: 0.013031879097815913
Intercept: 0.020094538580430605

Iteration: 34
Gradient: 0.01340921612215296
Intercept: 0.020675144843093372

Iteration: 35
Gradient: 0.01378555249777298
Intercept: 0.021254138183381944

Iteration: 36
Gradient: 0.014160890965929901
Intercept: 0.021831523025016845

Iteration: 37
Gradient: 0.014535234260361874
Intercept: 0.022407303779589605

Iteration: 38
Gradient: 0.01490858510731188
Intercept: 0.022981484846596015

Iteration: 39
Gradient: 0.015280946225548285
Intercept: 0.023554070613469293

Iteration: 40
Gradient: 0.01565232032638533
Intercept: 0.024125065455613152

Iteration: 41
Gradient: 0.016022710113703563
Intercept: 0.02469447373643479

Iteration: 42
Gradient: 0.016392118283970237
Intercept: 0.02526229980737777

Iteration: 43
Gradient: 0.01676054752625962
Intercept: 0.025828548007954838

Iteration: 44
Gradient: 0.017128000522273267
Intercept: 0.02639322266578062

Iteration: 45
Gradient: 0.017494479946360244
Intercept: 0.026956328096604247

Iteration: 46
Gradient: 0.017859988465537276
Intercept: 0.0275178686043419

Iteration: 47
Gradient: 0.018224528739508857
Intercept: 0.028077848481109238

Iteration: 48
Gradient: 0.0185881034206873
Intercept: 0.02863627200725376

Iteration: 49
Gradient: 0.01895071515421272
Intercept: 0.02919314345138707

Iteration: 50
Gradient: 0.019312366577972986
Intercept: 0.02974846707041705

Iteration: 51
Gradient: 0.0196730603226236
Intercept: 0.030302247109579957

Iteration: 52
Gradient: 0.020032799011607524
Intercept: 0.030854487802472418

Iteration: 53
Gradient: 0.02039158526117496
Intercept: 0.03140519337108335

Iteration: 54
Gradient: 0.02074942168040306
Intercept: 0.03195436802582577

Iteration: 55
Gradient: 0.021106310871215613
Intercept: 0.03250201596556855

Iteration: 56
Gradient: 0.021462255428402636
Intercept: 0.033048141377668074

Iteration: 57
Gradient: 0.02181725793963995
Intercept: 0.033592748437999774

Iteration: 58
Gradient: 0.022171320985508673
Intercept: 0.034135841310989644

Iteration: 59
Gradient: 0.022524447139514684
Intercept: 0.0346774241496456

Iteration: 60
Gradient: 0.022876638968108015
Intercept: 0.03521750109558881

Iteration: 61
Gradient: 0.023227899030702194
Intercept: 0.035756076279084906

Iteration: 62
Gradient: 0.023578229879693546
Intercept: 0.0362931538190751

Iteration: 63
Gradient: 0.023927634060480426
Intercept: 0.036828737823207267

Iteration: 64
Gradient: 0.024276114111482405
Intercept: 0.03736283238786688

Iteration: 65
Gradient: 0.02462367256415941
Intercept: 0.03789544159820792

Iteration: 66
Gradient: 0.0249703119430308
Intercept: 0.038426569528183636

Iteration: 67
Gradient: 0.025316034765694405
Intercept: 0.038956220240577266

Iteration: 68
Gradient: 0.025660843542845486
Intercept: 0.03948439778703268

Iteration: 69
Gradient: 0.026004740778295683
Intercept: 0.0400111062080849

Iteration: 70
Gradient: 0.02634772896899187
Intercept: 0.04053634953319058

Iteration: 71
Gradient: 0.026689810605034985
Intercept: 0.041060131780758354

Iteration: 72
Gradient: 0.027030988169698796
Intercept: 0.04158245695817914

Iteration: 73
Gradient: 0.027371264139448626
Intercept: 0.042103329061856355

Iteration: 74
Gradient: 0.027710640983960012
Intercept: 0.04262275207723604

Iteration: 75
Gradient: 0.02804912116613733
Intercept: 0.04314072997883688

Iteration: 76
Gradient: 0.028386707142132348
Intercept: 0.043657266730280204

Iteration: 77
Gradient: 0.028723401361362758
Intercept: 0.04417236628431982

Iteration: 78
Gradient: 0.02905920626653062
Intercept: 0.044686032582871855

Iteration: 79
Gradient: 0.029394124293640793
Intercept: 0.045198269557044424

Iteration: 80
Gradient: 0.029728157872019278
Intercept: 0.0457090811271673

Iteration: 81
Gradient: 0.030061309424331547
Intercept: 0.04621847120282145

Iteration: 82
Gradient: 0.030393581366600798
Intercept: 0.04672644368286851

Iteration: 83
Gradient: 0.030724976108226162
Intercept: 0.047233002455480164

Iteration: 84
Gradient: 0.03105549605200087
Intercept: 0.04773815139816747

Iteration: 85
Gradient: 0.03138514359413037
Intercept: 0.04824189437781009

Iteration: 86
Gradient: 0.03171392112425037
Intercept: 0.048744235250685414

Iteration: 87
Gradient: 0.03204183102544489
Intercept: 0.04924517786249765

Iteration: 88
Gradient: 0.03236887567426418
Intercept: 0.04974472604840682

Iteration: 89
Gradient: 0.03269505744074265
Intercept: 0.050242883633057664

Iteration: 90
Gradient: 0.03302037868841675
Intercept: 0.05073965443060844

Iteration: 91
Gradient: 0.03334484177434277
Intercept: 0.05123504224475973

Iteration: 92
Gradient: 0.03366844904911462
Intercept: 0.05172905086878306

Iteration: 93
Gradient: 0.03399120285688153
Intercept: 0.05222168408554954

Iteration: 94
Gradient: 0.034313105535365734
Intercept: 0.052712945667558346

Iteration: 95
Gradient: 0.03463415941588009
Intercept: 0.05320283937696518

Iteration: 96
Gradient: 0.034954366823345656
Intercept: 0.053691368965610616

Iteration: 97
Gradient: 0.0352737300763092
Intercept: 0.05417853817504838

Iteration: 98
Gradient: 0.035592251486960685
Intercept: 0.05466435073657355

Iteration: 99
Gradient: 0.03590993336115071
Intercept: 0.05514881037125073

Iteration: 100
Gradient: 0.036226777998407886
Intercept: 0.05563192078994203

Iteration: 101
Gradient: 0.036542787691956145
Intercept: 0.05611368569333508

Iteration: 102
Gradient: 0.03685796472873206
Intercept: 0.05659410877197092

Iteration: 103
Gradient: 0.037172311389402066
Intercept: 0.05707319370627182

Iteration: 104
Gradient: 0.03748582994837965
Intercept: 0.05755094416656902

Iteration: 105
Gradient: 0.03779852267384251
Intercept: 0.0580273638131304

Iteration: 106
Gradient: 0.03811039182774964
Intercept: 0.05850245629618807

Iteration: 107
Gradient: 0.03842143966585837
Intercept: 0.058976225255965874

Iteration: 108
Gradient: 0.038731668437741396
Intercept: 0.05944867432270687

Iteration: 109
Gradient: 0.03904108038680372
Intercept: 0.05991980711670064

Iteration: 110
Gradient: 0.03934967775029956
Intercept: 0.06038962724831063

Iteration: 111
Gradient: 0.03965746275934921
Intercept: 0.06085813831800133

Iteration: 112
Gradient: 0.039964437638955894
Intercept: 0.06132534391636544

Iteration: 113
Gradient: 0.040270604608022474
Intercept: 0.06179124762415091

Iteration: 114
Gradient: 0.040575965879368237
Intercept: 0.06225585301228796

Iteration: 115
Gradient: 0.04088052365974553
Intercept: 0.06271916364191599

Iteration: 116
Gradient: 0.04118428014985643
Intercept: 0.0631811830644104

Iteration: 117
Gradient: 0.0414872375443693
Intercept: 0.06364191482140939

Iteration: 118
Gradient: 0.04178939803193537
Intercept: 0.06410136244484066

Iteration: 119
Gradient: 0.04209076379520518
Intercept: 0.06455952945694801

Iteration: 120
Gradient: 0.042391337010845104
Intercept: 0.06501641937031791

Iteration: 121
Gradient: 0.042691119849553684
Intercept: 0.06547203568790594

Iteration: 122
Gradient: 0.04299011447607804
Intercept: 0.06592638190306328

Iteration: 123
Gradient: 0.043288323049230186
Intercept: 0.06637946149956296

Iteration: 124
Gradient: 0.04358574772190327
Intercept: 0.06683127795162615

Iteration: 125
Gradient: 0.043882390641087836
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Intercept: 0.14701850542054248

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Intercept: 0.14724410863946433

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Intercept: 0.14769339952267307

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Intercept: 0.1516242653222779

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Intercept: 0.20602489075399677

Iteration: 857
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Intercept: 0.20607888839796845

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Intercept: 0.2150434901385506

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Iteration: 1809
Gradient: 0.16624192528035642
Intercept: 0.21993351152591425

Iteration: 1810
Gradient: 0.16625595034514165
Intercept: 0.2199310322194134

Iteration: 1811
Gradient: 0.1662699670189964
Intercept: 0.21992854108213175

Iteration: 1812
Gradient: 0.16628397532287914
Intercept: 0.21992603814777564

Iteration: 1813
Gradient: 0.16629797527769094
Intercept: 0.21992352344995894

Iteration: 1814
Gradient: 0.16631196690427577
Intercept: 0.2199209970222032

Iteration: 1815
Gradient: 0.16632595022342056
Intercept: 0.219918458897938

Iteration: 1816
Gradient: 0.1663399252558554
Intercept: 0.21991590911050124

Iteration: 1817
Gradient: 0.16635389202225365
Intercept: 0.21991334769313922

Iteration: 1818
Gradient: 0.16636785054323217
Intercept: 0.2199107746790071

Iteration: 1819
Gradient: 0.1663818008393514
Intercept: 0.219908190101169

Iteration: 1820
Gradient: 0.16639574293111556
Intercept: 0.21990559399259826

Iteration: 1821
Gradient: 0.1664096768389728
Intercept: 0.21990298638617783

Iteration: 1822
Gradient: 0.16642360258331532
Intercept: 0.21990036731470033

Iteration: 1823
Gradient: 0.1664375201844796
Intercept: 0.2198977368108684

Iteration: 1824
Gradient: 0.16645142966274645
Intercept: 0.21989509490729497

Iteration: 1825
Gradient: 0.1664653310383412
Intercept: 0.21989244163650343

Iteration: 1826
Gradient: 0.16647922433143394
Intercept: 0.21988977703092788

Iteration: 1827
Gradient: 0.16649310956213953
Intercept: 0.2198871011229135

Iteration: 1828
Gradient: 0.16650698675051784
Intercept: 0.21988441394471658

Iteration: 1829
Gradient: 0.1665208559165739
Intercept: 0.21988171552850502

Iteration: 1830
Gradient: 0.166534717080258
Intercept: 0.21987900590635834

Iteration: 1831
Gradient: 0.16654857026146586
Intercept: 0.21987628511026802

Iteration: 1832
Gradient: 0.16656241548003883
Intercept: 0.21987355317213778

Iteration: 1833
Gradient: 0.166576252755764
Intercept: 0.21987081012378376

Iteration: 1834
Gradient: 0.16659008210837428
Intercept: 0.2198680559969348

Iteration: 1835
Gradient: 0.1666039035575487
Intercept: 0.2198652908232326

Iteration: 1836
Gradient: 0.1666177171229124
Intercept: 0.21986251463423212

Iteration: 1837
Gradient: 0.16663152282403693
Intercept: 0.21985972746140164

Iteration: 1838
Gradient: 0.16664532068044025
Intercept: 0.21985692933612308

Iteration: 1839
Gradient: 0.16665911071158696
Intercept: 0.21985412028969226

Iteration: 1840
Gradient: 0.16667289293688844
Intercept: 0.2198513003533191

Iteration: 1841
Gradient: 0.16668666737570303
Intercept: 0.2198484695581278

Iteration: 1842
Gradient: 0.16670043404733606
Intercept: 0.21984562793515727

Iteration: 1843
Gradient: 0.1667141929710401
Intercept: 0.21984277551536113

Iteration: 1844
Gradient: 0.16672794416601505
Intercept: 0.21983991232960806

Iteration: 1845
Gradient: 0.16674168765140837
Intercept: 0.21983703840868202

Iteration: 1846
Gradient: 0.1667554234463151
Intercept: 0.2198341537832825

Iteration: 1847
Gradient: 0.16676915156977812
Intercept: 0.21983125848402474

Iteration: 1848
Gradient: 0.16678287204078815
Intercept: 0.2198283525414399

Iteration: 1849
Gradient: 0.16679658487828405
Intercept: 0.2198254359859754

Iteration: 1850
Gradient: 0.1668102901011529
Intercept: 0.2198225088479951

Iteration: 1851
Gradient: 0.1668239877282301
Intercept: 0.21981957115777945

Iteration: 1852
Gradient: 0.16683767777829953
Intercept: 0.21981662294552587

Iteration: 1853
Gradient: 0.16685136027009376
Intercept: 0.21981366424134885

Iteration: 1854
Gradient: 0.16686503522229412
Intercept: 0.21981069507528023

Iteration: 1855
Gradient: 0.16687870265353086
Intercept: 0.21980771547726943

Iteration: 1856
Gradient: 0.16689236258238324
Intercept: 0.21980472547718372

Iteration: 1857
Gradient: 0.16690601502737978
Intercept: 0.2198017251048083

Iteration: 1858
Gradient: 0.16691966000699834
Intercept: 0.2197987143898467

Iteration: 1859
Gradient: 0.1669332975396662
Intercept: 0.21979569336192087

Iteration: 1860
Gradient: 0.16694692764376032
Intercept: 0.2197926620505715

Iteration: 1861
Gradient: 0.16696055033760737
Intercept: 0.21978962048525813

Iteration: 1862
Gradient: 0.16697416563948392
Intercept: 0.21978656869535954

Iteration: 1863
Gradient: 0.16698777356761657
Intercept: 0.2197835067101738

Iteration: 1864
Gradient: 0.16700137414018212
Intercept: 0.2197804345589186

Iteration: 1865
Gradient: 0.1670149673753076
Intercept: 0.21977735227073142

Iteration: 1866
Gradient: 0.16702855329107055
Intercept: 0.21977425987466975

Iteration: 1867
Gradient: 0.16704213190549905
Intercept: 0.21977115739971134

Iteration: 1868
Gradient: 0.16705570323657187
Intercept: 0.21976804487475443

Iteration: 1869
Gradient: 0.16706926730221866
Intercept: 0.2197649223286179

Iteration: 1870
Gradient: 0.16708282412032005
Intercept: 0.21976178979004155

Iteration: 1871
Gradient: 0.16709637370870775
Intercept: 0.21975864728768627

Iteration: 1872
Gradient: 0.16710991608516476
Intercept: 0.21975549485013432

Iteration: 1873
Gradient: 0.16712345126742542
Intercept: 0.2197523325058895

Iteration: 1874
Gradient: 0.16713697927317564
Intercept: 0.21974916028337735

Iteration: 1875
Gradient: 0.16715050012005292
Intercept: 0.2197459782109454

Iteration: 1876
Gradient: 0.16716401382564655
Intercept: 0.2197427863168634

Iteration: 1877
Gradient: 0.16717752040749778
Intercept: 0.21973958462932341

Iteration: 1878
Gradient: 0.16719101988309987
Intercept: 0.21973637317644024

Iteration: 1879
Gradient: 0.16720451226989824
Intercept: 0.21973315198625143

Iteration: 1880
Gradient: 0.16721799758529066
Intercept: 0.2197299210867176

Iteration: 1881
Gradient: 0.1672314758466273
Intercept: 0.21972668050572258

Iteration: 1882
Gradient: 0.16724494707121088
Intercept: 0.21972343027107374

Iteration: 1883
Gradient: 0.1672584112762969
Intercept: 0.21972017041050207

Iteration: 1884
Gradient: 0.16727186847909362
Intercept: 0.21971690095166244

Iteration: 1885
Gradient: 0.16728531869676228
Intercept: 0.2197136219221338

Iteration: 1886
Gradient: 0.1672987619464172
Intercept: 0.21971033334941947

Iteration: 1887
Gradient: 0.16731219824512594
Intercept: 0.2197070352609472

Iteration: 1888
Gradient: 0.16732562760990935
Intercept: 0.21970372768406948

Iteration: 1889
Gradient: 0.1673390500577418
Intercept: 0.21970041064606372

Iteration: 1890
Gradient: 0.16735246560555123
Intercept: 0.21969708417413245

Iteration: 1891
Gradient: 0.1673658742702193
Intercept: 0.21969374829540353

Iteration: 1892
Gradient: 0.16737927606858155
Intercept: 0.21969040303693035

Iteration: 1893
Gradient: 0.1673926710174275
Intercept: 0.21968704842569206

Iteration: 1894
Gradient: 0.16740605913350076
Intercept: 0.21968368448859374

Iteration: 1895
Gradient: 0.16741944043349918
Intercept: 0.21968031125246662

Iteration: 1896
Gradient: 0.16743281493407497
Intercept: 0.21967692874406827

Iteration: 1897
Gradient: 0.16744618265183478
Intercept: 0.21967353699008282

Iteration: 1898
Gradient: 0.16745954360333992
Intercept: 0.21967013601712113

Iteration: 1899
Gradient: 0.16747289780510644
Intercept: 0.21966672585172103

Iteration: 1900
Gradient: 0.16748624527360517
Intercept: 0.21966330652034755

Iteration: 1901
Gradient: 0.167499586025262
Intercept: 0.21965987804939296

Iteration: 1902
Gradient: 0.16751292007645785
Intercept: 0.2196564404651772

Iteration: 1903
Gradient: 0.16752624744352895
Intercept: 0.2196529937939479

Iteration: 1904
Gradient: 0.1675395681427668
Intercept: 0.21964953806188062

Iteration: 1905
Gradient: 0.16755288219041842
Intercept: 0.21964607329507913

Iteration: 1906
Gradient: 0.1675661896026864
Intercept: 0.2196425995195755

Iteration: 1907
Gradient: 0.16757949039572906
Intercept: 0.2196391167613303

Iteration: 1908
Gradient: 0.16759278458566051
Intercept: 0.21963562504623294

Iteration: 1909
Gradient: 0.1676060721885509
Intercept: 0.21963212440010169

Iteration: 1910
Gradient: 0.16761935322042637
Intercept: 0.21962861484868393

Iteration: 1911
Gradient: 0.16763262769726933
Intercept: 0.21962509641765643

Iteration: 1912
Gradient: 0.16764589563501847
Intercept: 0.2196215691326254

Iteration: 1913
Gradient: 0.16765915704956894
Intercept: 0.2196180330191268

Iteration: 1914
Gradient: 0.1676724119567724
Intercept: 0.2196144881026265

Iteration: 1915
Gradient: 0.16768566037243723
Intercept: 0.21961093440852042

Iteration: 1916
Gradient: 0.16769890231232862
Intercept: 0.2196073719621348

Iteration: 1917
Gradient: 0.16771213779216862
Intercept: 0.21960380078872635

Iteration: 1918
Gradient: 0.16772536682763634
Intercept: 0.2196002209134824

Iteration: 1919
Gradient: 0.16773858943436804
Intercept: 0.21959663236152124

Iteration: 1920
Gradient: 0.16775180562795727
Intercept: 0.21959303515789208

Iteration: 1921
Gradient: 0.16776501542395494
Intercept: 0.21958942932757544

Iteration: 1922
Gradient: 0.16777821883786945
Intercept: 0.21958581489548326

Iteration: 1923
Gradient: 0.16779141588516683
Intercept: 0.21958219188645905

Iteration: 1924
Gradient: 0.16780460658127083
Intercept: 0.21957856032527817

Iteration: 1925
Gradient: 0.1678177909415631
Intercept: 0.21957492023664796

Iteration: 1926
Gradient: 0.1678309689813832
Intercept: 0.21957127164520787

Iteration: 1927
Gradient: 0.16784414071602877
Intercept: 0.21956761457552978

Iteration: 1928
Gradient: 0.1678573061607557
Intercept: 0.21956394905211807

Iteration: 1929
Gradient: 0.16787046533077815
Intercept: 0.21956027509940987

Iteration: 1930
Gradient: 0.16788361824126868
Intercept: 0.21955659274177522

Iteration: 1931
Gradient: 0.16789676490735844
Intercept: 0.21955290200351726

Iteration: 1932
Gradient: 0.16790990534413722
Intercept: 0.2195492029088724

Iteration: 1933
Gradient: 0.16792303956665355
Intercept: 0.2195454954820105

Iteration: 1934
Gradient: 0.16793616758991486
Intercept: 0.2195417797470351

Iteration: 1935
Gradient: 0.1679492894288876
Intercept: 0.21953805572798354

Iteration: 1936
Gradient: 0.16796240509849722
Intercept: 0.2195343234488272

Iteration: 1937
Gradient: 0.1679755146136285
Intercept: 0.2195305829334716

Iteration: 1938
Gradient: 0.1679886179891255
Intercept: 0.2195268342057567

Iteration: 1939
Gradient: 0.1680017152397917
Intercept: 0.2195230772894569

Iteration: 1940
Gradient: 0.16801480638039018
Intercept: 0.21951931220828147

Iteration: 1941
Gradient: 0.16802789142564364
Intercept: 0.21951553898587448

Iteration: 1942
Gradient: 0.16804097039023455
Intercept: 0.21951175764581513

Iteration: 1943
Gradient: 0.1680540432888053
Intercept: 0.2195079682116179

Iteration: 1944
Gradient: 0.16806711013595824
Intercept: 0.21950417070673267

Iteration: 1945
Gradient: 0.16808017094625582
Intercept: 0.219500365154545

Iteration: 1946
Gradient: 0.16809322573422072
Intercept: 0.21949655157837616

Iteration: 1947
Gradient: 0.16810627451433593
Intercept: 0.21949273000148348

Iteration: 1948
Gradient: 0.16811931730104487
Intercept: 0.21948890044706038

Iteration: 1949
Gradient: 0.1681323541087515
Intercept: 0.21948506293823664

Iteration: 1950
Gradient: 0.1681453849518204
Intercept: 0.2194812174980785

Iteration: 1951
Gradient: 0.16815840984457697
Intercept: 0.2194773641495889

Iteration: 1952
Gradient: 0.16817142880130742
Intercept: 0.21947350291570764

Iteration: 1953
Gradient: 0.1681844418362589
Intercept: 0.21946963381931148

Iteration: 1954
Gradient: 0.16819744896363972
Intercept: 0.2194657568832144

Iteration: 1955
Gradient: 0.1682104501976193
Intercept: 0.2194618721301678

Iteration: 1956
Gradient: 0.16822344555232835
Intercept: 0.2194579795828605

Iteration: 1957
Gradient: 0.168236435041859
Intercept: 0.21945407926391916

Iteration: 1958
Gradient: 0.1682494186802649
Intercept: 0.2194501711959082

Iteration: 1959
Gradient: 0.1682623964815613
Intercept: 0.21944625540133014

Iteration: 1960
Gradient: 0.16827536845972513
Intercept: 0.21944233190262574

Iteration: 1961
Gradient: 0.16828833462869514
Intercept: 0.2194384007221741

Iteration: 1962
Gradient: 0.168301295002372
Intercept: 0.2194344618822929

Iteration: 1963
Gradient: 0.16831424959461844
Intercept: 0.21943051540523853

Iteration: 1964
Gradient: 0.16832719841925928
Intercept: 0.2194265613132063

Iteration: 1965
Gradient: 0.1683401414900816
Intercept: 0.21942259962833055

Iteration: 1966
Gradient: 0.16835307882083483
Intercept: 0.21941863037268486

Iteration: 1967
Gradient: 0.16836601042523078
Intercept: 0.21941465356828221

Iteration: 1968
Gradient: 0.16837893631694387
Intercept: 0.21941066923707514

Iteration: 1969
Gradient: 0.1683918565096111
Intercept: 0.21940667740095587

Iteration: 1970
Gradient: 0.1684047710168323
Intercept: 0.2194026780817566

Iteration: 1971
Gradient: 0.16841767985217007
Intercept: 0.21939867130124946

Iteration: 1972
Gradient: 0.16843058302915
Intercept: 0.21939465708114694

Iteration: 1973
Gradient: 0.16844348056126077
Intercept: 0.21939063544310183

Iteration: 1974
Gradient: 0.1684563724619541
Intercept: 0.21938660640870747

Iteration: 1975
Gradient: 0.1684692587446451
Intercept: 0.21938256999949793

Iteration: 1976
Gradient: 0.16848213942271217
Intercept: 0.21937852623694815

Iteration: 1977
Gradient: 0.16849501450949717
Intercept: 0.21937447514247407

Iteration: 1978
Gradient: 0.1685078840183055
Intercept: 0.2193704167374329

Iteration: 1979
Gradient: 0.16852074796240626
Intercept: 0.21936635104312316

Iteration: 1980
Gradient: 0.1685336063550323
Intercept: 0.21936227808078487

Iteration: 1981
Gradient: 0.1685464592093803
Intercept: 0.21935819787159977

Iteration: 1982
Gradient: 0.1685593065386109
Intercept: 0.21935411043669142

Iteration: 1983
Gradient: 0.1685721483558488
Intercept: 0.2193500157971254

Iteration: 1984
Gradient: 0.16858498467418287
Intercept: 0.2193459139739094

Iteration: 1985
Gradient: 0.16859781550666622
Intercept: 0.21934180498799347

Iteration: 1986
Gradient: 0.1686106408663163
Intercept: 0.21933768886027008

Iteration: 1987
Gradient: 0.168623460766115
Intercept: 0.2193335656115744

Iteration: 1988
Gradient: 0.16863627521900879
Intercept: 0.21932943526268436

Iteration: 1989
Gradient: 0.16864908423790873
Intercept: 0.21932529783432084

Iteration: 1990
Gradient: 0.16866188783569067
Intercept: 0.2193211533471478

Iteration: 1991
Gradient: 0.16867468602519525
Intercept: 0.2193170018217725

Iteration: 1992
Gradient: 0.16868747881922808
Intercept: 0.21931284327874553

Iteration: 1993
Gradient: 0.16870026623055975
Intercept: 0.21930867773856116

Iteration: 1994
Gradient: 0.16871304827192604
Intercept: 0.21930450522165734

Iteration: 1995
Gradient: 0.1687258249560279
Intercept: 0.21930032574841588

Iteration: 1996
Gradient: 0.1687385962955316
Intercept: 0.2192961393391626

Iteration: 1997
Gradient: 0.16875136230306884
Intercept: 0.21929194601416754

Iteration: 1998
Gradient: 0.1687641229912368
Intercept: 0.21928774579364513

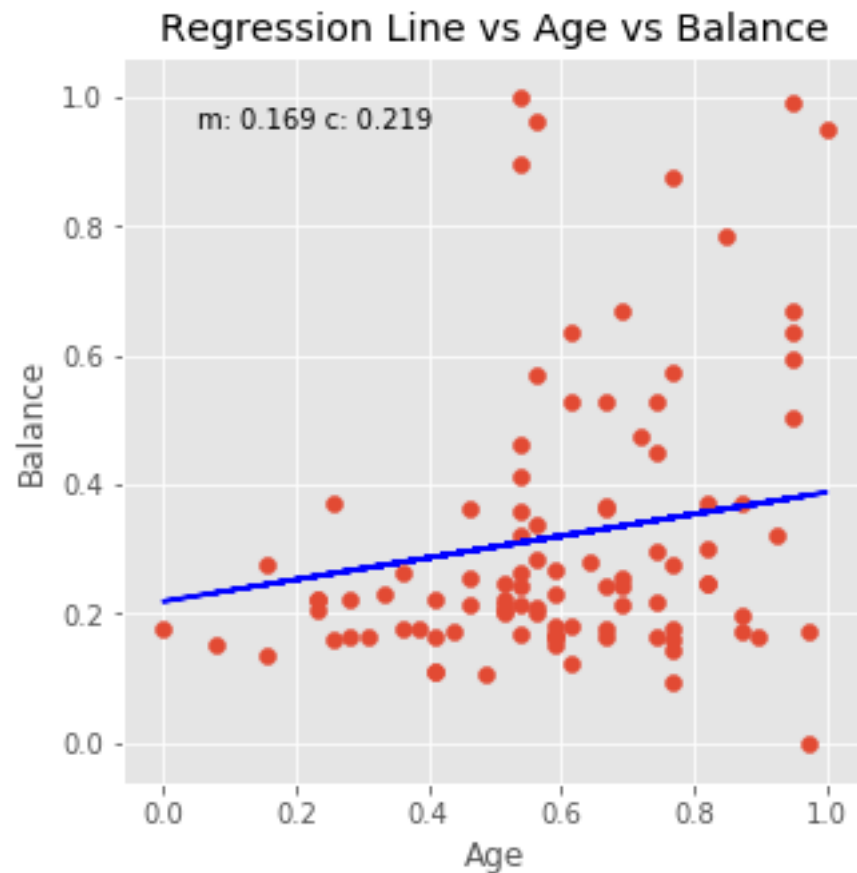
Iteration: 1999
Gradient: 0.16877687837259828
Intercept: 0.2192835386977542

Iteration: 2000
Gradient: 0.16878962845968176
Intercept: 0.21927932474659825

Process Complete... after 2000 epochs
Gradient(m): 0.16878962845968176 Intercept(c): 0.21927932474659825

```
In [81]: new_Y_pred = new_m*new_X + new_c
```

```
In [82]: plt.figure(figsize=(5,5))
plt.scatter(new_X, new_Y)
plt.plot(new_X, new_Y_pred, color='blue') # regression line
plt.xlabel('Age')
plt.ylabel('Balance')
plt.text(0.1,0.9,"m: {} c: {}".format(round(new_m, 3), round(new_c, 3)),transform=plt
plt.title("Regression Line vs Age vs Balance")
plt.show()
```



0.0.10 The algorithm in action as it finds the line of best fit

```
In [84]: y_pred_list = [] # list to store predictions
```

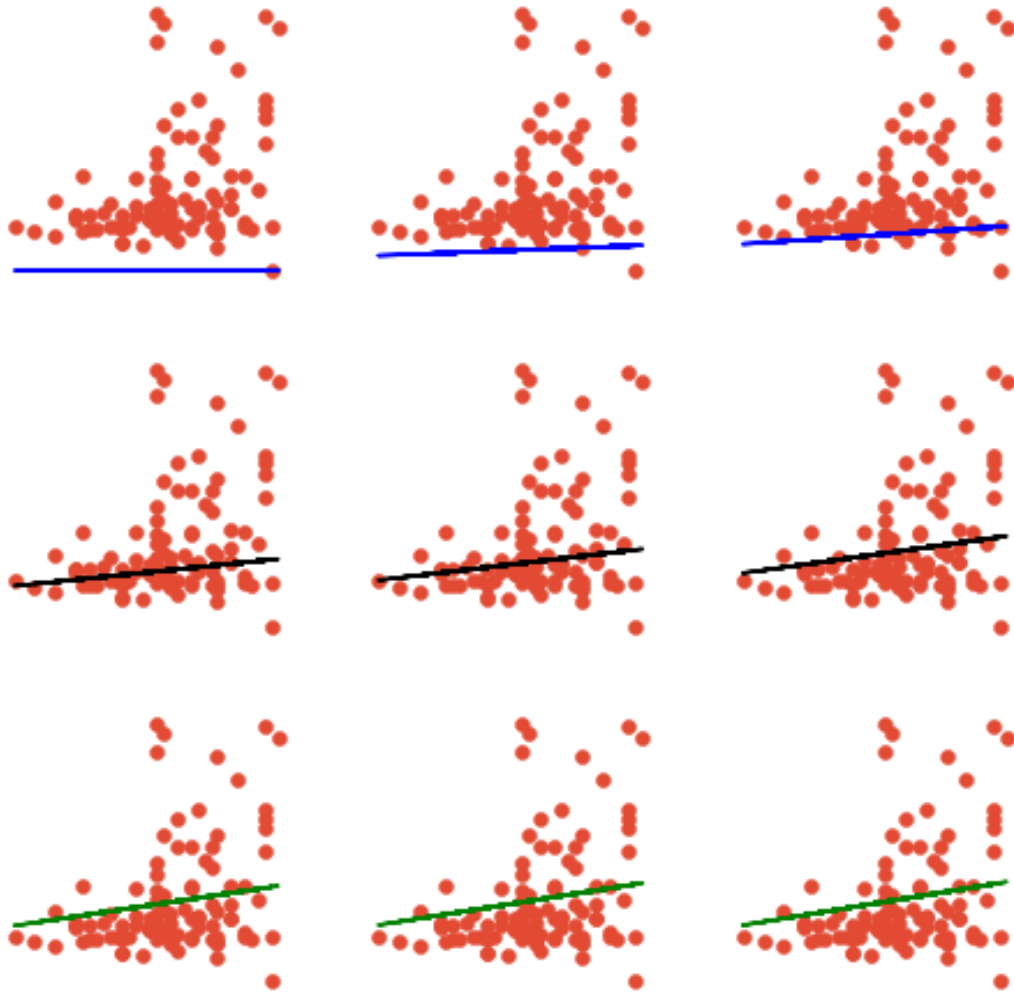
```
# Store every prediction for each combination of m and c
for i in range(len(m_list)):
    pred = m_list[i]*new_X + c_list[i]
    y_pred_list.append(pred)
```

```

In [90]: fig, ax = plt.subplots(3, 3, figsize=(8,8)) # 5 rows, 5 columns

ax[0, 0].scatter(new_X,new_Y) #row=0, col=0
ax[0, 0].plot(new_X, y_pred_list[0], 'b')
ax[0, 1].scatter(new_X,new_Y)
ax[0, 1].plot(new_X, y_pred_list[112], 'b')
ax[0, 2].scatter(new_X,new_Y)
ax[0, 2].plot(new_X, y_pred_list[224], 'b')
ax[1, 0].scatter(new_X,new_Y) #row=1, col=0
ax[1, 0].plot(new_X, y_pred_list[420], 'k')
ax[1, 1].scatter(new_X,new_Y)
ax[1, 1].plot(new_X, y_pred_list[560], 'k')
ax[1, 2].scatter(new_X,new_Y)
ax[1, 2].plot(new_X, y_pred_list[888], 'k')
ax[2, 0].scatter(new_X,new_Y) #row=2, col=0
ax[2, 0].plot(new_X, y_pred_list[1200], 'g')
ax[2, 1].scatter(new_X,new_Y)
ax[2, 1].plot(new_X, y_pred_list[1600], 'g')
ax[2, 2].scatter(new_X,new_Y)
ax[2, 2].plot(new_X, y_pred_list[1999], 'g')
[axi.set_axis_off() for axi in ax.ravel()]
plt.show()

```

0.0.11 New Prediction

```
In [91]: value = int(input("Enter Age: "))
         # Standardize value first
         my_x = (value - new_X.min()) / (new_X.max() - new_X.min())

         my_pred = new_m*my_x + new_c
         # value had been standardized so to get original value
         pred_balance = my_pred * 100
         print("Predicted Balance: {}".format(pred_balance))
```

Enter Age: 60

Predicted Balance: 1034.6657032327503
