# report

July 21, 2023

Gerekli kütüphaneler aşağıda verilmiştir.

```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from LR import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
```

Data okunması ve Gender sütununun atılması görülmektedir.

```python
data = pd.read_csv('500_Person_Gender_Height_Weight_Index.csv')
data = data.drop('Gender', axis=1)
```

### 0.0.1 Veri setinin keşifsel veri analizi (EDA)

EDA gerçekleştirildi. Datanın istatistiksel değerleri yazıldı. Korelasyon matrisi, pair plots ve line plot çizdirildi. Aşağıda ortalama, standart sapma, min değer ve max değer gibi bilgiler görülmekte.

```python
data.describe()
```

```
            Height      Weight       Index
count  500.000000  500.000000  500.000000
mean   169.944000  106.000000    3.748000
std     16.375261   32.382607    1.355053
min    140.000000   50.000000    0.000000
25%    156.000000   80.000000    3.000000
50%    170.500000  106.000000    4.000000
75%    184.000000  136.000000    5.000000
max    199.000000  160.000000    5.000000
```
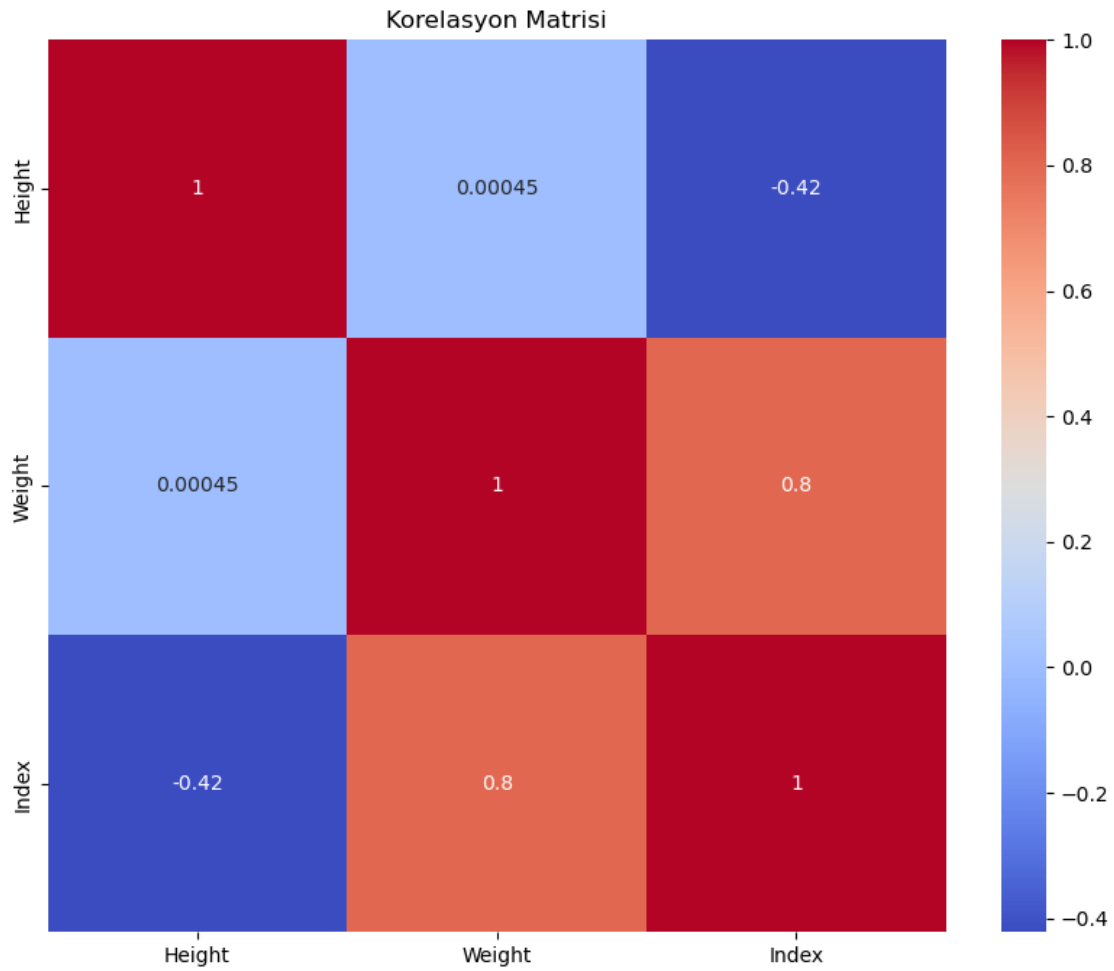
Aşağıda korelasyon matrisi gözlenmekte. Bu matrise göre boy ve kilo arasında çok düşük miktarda bir korelasyon olduğu görülmüştür. Bundan farklı olarak vücut kitle indeksi ile kilo yüksek değerde bir pozitif korelasyon gösterirken vücut kitle indeksi ile boy negatif korelasyon göstermiştir.
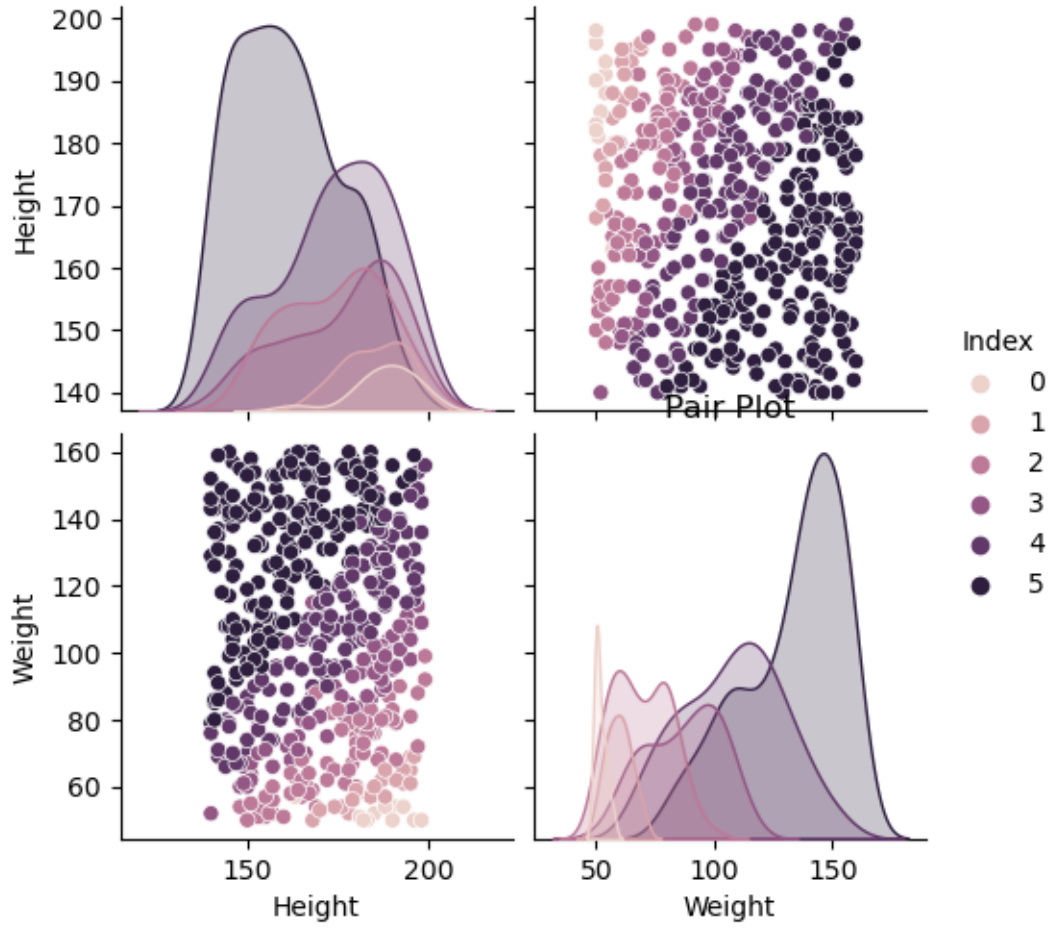
```python
data_correlation = data.corr()

plt.figure(figsize=(10, 8))
sns.heatmap(data_correlation, annot=True, cmap="coolwarm")
```

```
plt.title("Korelasyon Matrisi")
plt.show()
```
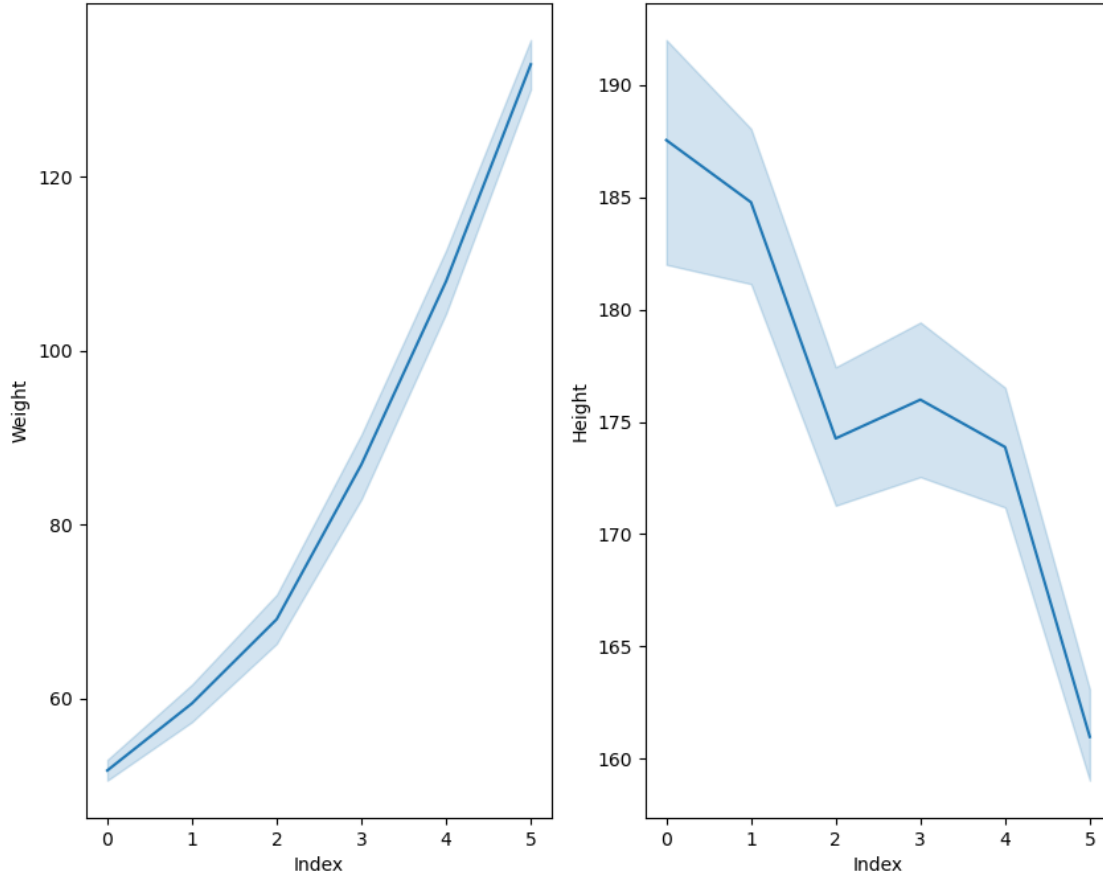

Korelasyon Matrisi

İkili grafiklerine baktığımız zaman aralarında lineer bir ilişki olduğu gözlenmekte. Doğrusal çizgiler ile index değerleri birbirlerinden ayrılabilir gözükmekte.

```
[ ]: sns.pairplot(data, hue="Index")
     plt.title("Pair Plot")
     plt.show()
```

Pair Plot

İkisinin ayrı ayrı çizgi grafiklerine baktığımızda da doğrusal bir ilişki gözlenebilmekte. Ağırlık ile olan lineer ilişki boya oranla çok daha yüksektir. Korelasyon matrisi ile burdaki grafiklerin birbirini doğruladığını görebiliriz.

```python
fig, ax= plt.subplots(1,2, figsize=(10,8))
sns.lineplot(x=data['Index'], y=data['Weight'], ax=ax[0])
sns.lineplot(x=data['Index'], y=data['Height'], ax=ax[1])
plt.show()
```

Buradaki grafiklerde ise daha çok data noktaları incelenmekte. Kilo ve boy arasında doğrudan bir ilişki gözlenemese de vücut kitle indeksi ile boy ve kilo arasında oldukça doğrusal bir ilişki gözlenmektedir. Ayrıca her iki girdiyi de alarak çizdirdiğimiz 3d grafik üzerinden çok bir bilgi okunamasa da görsellik açısından veri noktalarının daha iyi anlaşılması sağlanmıştır.

```python
data_list = data.values.tolist()
X = [row[:2]for row in data_list]
y = [row[2:3]for row in data_list]
y = [item for sublist in y for item in sublist]
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5,
 ↪random_state=42)
height = [row[0]for row in X_train]
weight = [row[1]for row in X_train]

fig, ax= plt.subplots(1,3, figsize=(15,8))
sns.scatterplot(x=height, y=y_train, ax=ax[0])
ax[0].set_xlabel('Height')
ax[0].set_ylabel('BMI')
sns.scatterplot(x=weight, y=y_train, ax=ax[1])
```
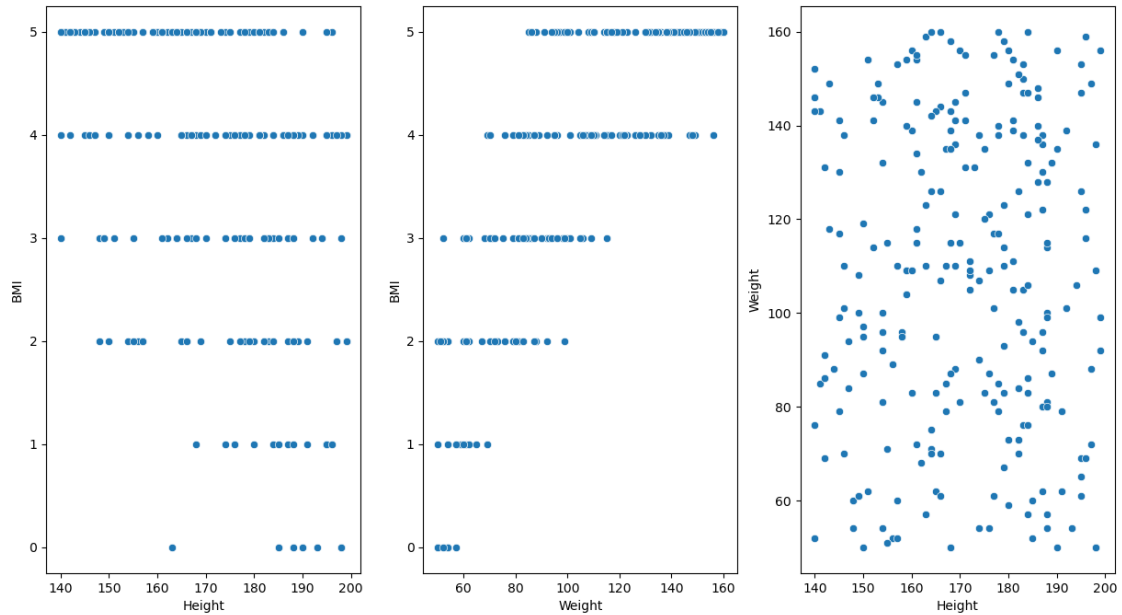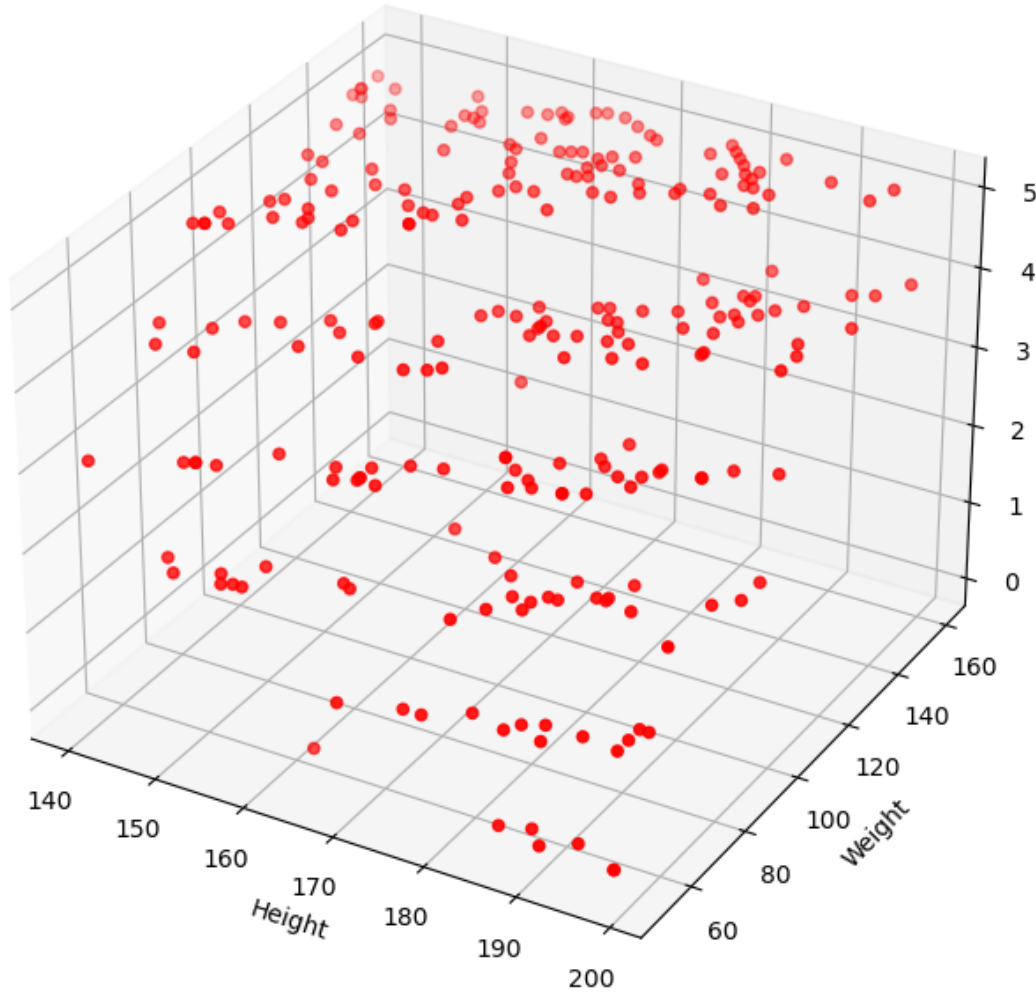
```
ax[1].set_xlabel('Weight')
ax[1].set_ylabel('BMI')
sns.scatterplot(x=height, y=weight, ax=ax[2])
ax[2].set_xlabel('Height')
ax[2].set_ylabel('Weight')
plt.show()

fig = plt.figure(figsize=(10, 8))
ax = fig.add_subplot(111, projection='3d')
ax.scatter(height, weight, y_train, c='r', marker='o')
ax.set_xlabel('Height')
ax.set_ylabel('Weight')
ax.set_zlabel('BMI')
plt.show()
```

### 0.0.2 Sınıflandırıcının eğitimi

Tanımlanan lineer regresyon class'ı kullanılarak ve ödevde verilen parametrelerle eğitim yapılmaktadır. Modelin başarımının ölçüsünü belirleyebilmek için test verileri üzerinden tahmin yapılmaktadır. Son olarak da modelin performans ölçümü için R2-score MSE MAE RMSE değerleri hesaplanmıştır. Bu hesaplanan değerlerden R2-score en çok kullanılandır. 0 ve 1 arasında değer almaktadır. Kullanılan farklı modelleri kıyaslamak için sıklıkla kullanılır. Eğitilen modelde R2-score değeri 0.63 gelmiş olup iyi eğitilmiş bir model olduğunu göstermektedir.

```
lr = LinearRegression(learning_rate=0.000005, num_epochs=1000)
lr.fit(height, weight, y_train)
new_height = [row[0]for row in X_test]
new_weight = [row[1]for row in X_test]
```

```
y_pred = lr.predict(new_height, new_weight)
print("R2 score: ", r2_score(y_test, y_pred))
print("Mean squared error: ", mean_squared_error(y_test, y_pred))
print("Mean absolute error: ", mean_absolute_error(y_test, y_pred))
print("Root mean squared error: ", np.sqrt(mean_squared_error(y_test, y_pred)))
```

Epoch: 1000 - Prediction: 3.5531566655352194
Epoch: 1000 - Prediction: 2.384061253108029
Epoch: 1000 - Prediction: 3.1948292052714757
Epoch: 1000 - Prediction: 3.495386379764411
Epoch: 1000 - Prediction: 4.917959097540316
Epoch: 1000 - Prediction: 5.600395343532225
Epoch: 1000 - Prediction: 5.042042661052706
Epoch: 1000 - Prediction: 5.383260784048661
Epoch: 1000 - Prediction: 2.712441534821582
Epoch: 1000 - Prediction: 5.687027418862197
Epoch: 1000 - Prediction: 3.5274809829704155
Epoch: 1000 - Prediction: 3.261165836339299
Epoch: 1000 - Prediction: 2.087775574600481
Epoch: 1000 - Prediction: 4.3222016335308595
Epoch: 1000 - Prediction: 4.387452875607655
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Epoch: 1000 - Prediction: 5.567238704661434
Epoch: 1000 - Prediction: 4.291192419315882
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Epoch: 1000 - Prediction: 1.8022036660457619
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Epoch: 1000 - Prediction: 1.9465826738203011
Epoch: 1000 - Prediction: 4.294378526310242
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Epoch: 1000 - Prediction: 3.7531585344247533
Epoch: 1000 - Prediction: 1.8952546620169346
Epoch: 1000 - Prediction: 4.724376149291983
Epoch: 1000 - Prediction: 1.5209032534764293
Epoch: 1000 - Prediction: 2.1701595072713062
Epoch: 1000 - Prediction: 2.6685711259979623
Epoch: 1000 - Prediction: 5.30623373635425
Epoch: 1000 - Prediction: 1.8396318009019403

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Epoch: 1000 - Prediction: 3.8312476177839514
Epoch: 1000 - Prediction: 2.630080955476997
Epoch: 1000 - Prediction: 4.664481792191601
Epoch: 1000 - Prediction: 3.0162081696351177
Epoch: 1000 - Prediction: 3.234404764783468
Epoch: 1000 - Prediction: 2.6493377174005994
Epoch: 1000 - Prediction: 3.329603185410454
Epoch: 1000 - Prediction: 3.290027625898462
Epoch: 1000 - Prediction: 2.707108003171408
Epoch: 1000 - Prediction: 3.312493848142666
Epoch: 1000 - Prediction: 2.1637172333038652
Epoch: 1000 - Prediction: 1.635335082700778
Epoch: 1000 - Prediction: 4.959705435034363
Epoch: 1000 - Prediction: 2.915652864031716
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Epoch: 1000 - Prediction: 1.4310383644996163
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Epoch: 1000 - Prediction: 2.4760502134144153
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Epoch: 1000 - Prediction: 1.9904530826439213
Epoch: 1000 - Prediction: 5.433526760187242
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Epoch: 1000 - Prediction: 2.4022559793668457
Epoch: 1000 - Prediction: 3.565994506817621
Epoch: 1000 - Prediction: 5.158621914932869
Epoch: 1000 - Prediction: 2.409736935672833
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Epoch: 1000 - Prediction: 1.8342749159255256
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Epoch: 1000 - Prediction: 3.7371345861479917
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Epoch: 1000 - Prediction: 4.518994042099793
Epoch: 1000 - Prediction: 3.1135306615916774
Epoch: 1000 - Prediction: 2.5327351101941966
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Epoch: 1000 - Prediction: 2.707108003171408
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Epoch: 1000 - Prediction: 1.8867116700461604
Epoch: 1000 - Prediction: 4.42273358580802
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Epoch: 1000 - Prediction: 4.066553550200091
Epoch: 1000 - Prediction: 4.020582423373138
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Epoch: 1000 - Prediction: 5.068780379282297
Epoch: 1000 - Prediction: 5.35008079185163
Epoch: 1000 - Prediction: 4.193846574033081
Epoch: 1000 - Prediction: 3.3574029393048312
Epoch: 1000 - Prediction: 1.685624412165599
Epoch: 1000 - Prediction: 1.711276741404162
Epoch: 1000 - Prediction: 2.2728388842042806
Epoch: 1000 - Prediction: 5.602519414861797
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Epoch: 1000 - Prediction: 5.4581170537610175
Epoch: 1000 - Prediction: 2.6151190428650217
Epoch: 1000 - Prediction: 4.055863133573502
Epoch: 1000 - Prediction: 2.707084649845168
Epoch: 1000 - Prediction: 3.8729472486255165
Epoch: 1000 - Prediction: 2.4183032809698477
Epoch: 1000 - Prediction: 4.390662335928256
Epoch: 1000 - Prediction: 5.418541494249025
Epoch: 1000 - Prediction: 1.385043884346423
Epoch: 1000 - Prediction: 5.515887339531826
Epoch: 1000 - Prediction: 2.4407695032140513
Epoch: 1000 - Prediction: 3.017293558626145
Epoch: 1000 - Prediction: 5.738378783991804
Epoch: 1000 - Prediction: 4.940425319784519
Epoch: 1000 - Prediction: 4.766099133459789
Epoch: 1000 - Prediction: 3.1627579553917116
```

```
Epoch: 1000 - Prediction: 1.7882804357723328
Epoch: 1000 - Prediction: 2.0717282729974786
Epoch: 1000 - Prediction: 4.333954085822235
Epoch: 1000 - Prediction: 3.430135137687615
Epoch: 1000 - Prediction: 1.343320900178617
Epoch: 1000 - Prediction: 3.13278742351528
Epoch: 1000 - Prediction: 2.849339586290134
Epoch: 1000 - Prediction: 3.6515411931565653
Epoch: 1000 - Prediction: 5.221749085680091
Epoch: 1000 - Prediction: 2.5733727053709754
Epoch: 1000 - Prediction: 4.232360097880287
Epoch: 1000 - Prediction: 5.096580133176674
Epoch: 1000 - Prediction: 5.001405065875928
Epoch: 1000 - Prediction: 5.460264478416831
Epoch: 1000 - Prediction: 1.7904278604281465
Epoch: 1000 - Prediction: 3.6879306456741983
R2 score:  0.6390213809134486
Mean squared error:  0.6441302478980424
Mean absolute error:  0.625612067711276
Root mean squared error:  0.8025772535388992
```

### 0.0.3 Sonuçların yorumlanması

Ne kadar epoch yapılmasını kontrol etmek için 1'den 1000e kadar epoch sayısını değiştirerek model döngü içinde eğitilmiştir ve her epoch değeri için loss ve accuracy değerleri hem train hem test verileri için dizilere kaydedilmiştir.

```python
# bu hücre 1 dakika 15 saniye kadar sürmektedir.
loss_train = []
accuracy_train = []
loss_test = []
accuracy_test = []
epoch = [x for x in range(10, 1001, 10)]
for i in epoch:
    if i % 10 == 0:
        lr = LinearRegression(learning_rate=0.000005, num_epochs=i)
        lr.fit(height, weight, y_train)
        new_height = [row[0]for row in X_test]
        new_weight = [row[1]for row in X_test]
        y_pred_test = lr.predict(new_height, new_weight)
        y_pred_train = lr.predict(height, weight)
        loss_train.append(mean_squared_error(y_train, y_pred_train))
        accuracy_train.append(r2_score(y_train, y_pred_train))
        loss_test.append(mean_squared_error(y_test, y_pred_test))
        accuracy_test.append(r2_score(y_test, y_pred_test))
```

```
Epoch: 500 - Prediction: 3.545711266936934
Epoch: 500 - Prediction: 1.7924473887243806
```

```
Epoch: 500 - Prediction: 2.9497772638429542
Epoch: 500 - Prediction: 3.3198587240276987
Epoch: 500 - Prediction: 5.158527532768586
Epoch: 500 - Prediction: 6.417854058471067
Epoch: 500 - Prediction: 5.442395191112874
Epoch: 500 - Prediction: 6.0720584539641145
Epoch: 500 - Prediction: 2.3719211975957903
Epoch: 500 - Prediction: 6.454687277643816
Epoch: 500 - Prediction: 3.4453323589772737
Epoch: 500 - Prediction: 3.3097379744691113
Epoch: 500 - Prediction: 1.3384472148025448
Epoch: 500 - Prediction: 4.539925416621061
Epoch: 500 - Prediction: 4.694406609288163
Epoch: 500 - Prediction: 1.59411618674143
Epoch: 500 - Prediction: 6.388846500753541
Epoch: 500 - Prediction: 4.619931299630541
Epoch: 500 - Prediction: 2.990523313743315
Epoch: 500 - Prediction: 4.815967413510127
Epoch: 500 - Prediction: 1.1275686493246366
Epoch: 500 - Prediction: 6.114422246488721
Epoch: 500 - Prediction: 1.0883088162155177
Epoch: 500 - Prediction: 4.330533067934394
Epoch: 500 - Prediction: 3.549624097664546
Epoch: 500 - Prediction: 5.227603794907354
Epoch: 500 - Prediction: 5.582033932181653
Epoch: 500 - Prediction: 6.522145797158338
Epoch: 500 - Prediction: 3.74174738081652
Epoch: 500 - Prediction: 1.053093339667015
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Epoch: 1000 - Prediction: 5.653870779991405
Epoch: 1000 - Prediction: 2.716713030806969
Epoch: 1000 - Prediction: 5.203577712747516
Epoch: 1000 - Prediction: 4.740400097568744
Epoch: 1000 - Prediction: 3.7938194829277725
Epoch: 1000 - Prediction: 3.772415296348356
Epoch: 1000 - Prediction: 2.687827887921565
Epoch: 1000 - Prediction: 1.43318578915543
Epoch: 1000 - Prediction: 3.099630784644489
Epoch: 1000 - Prediction: 2.410798971337619
Epoch: 1000 - Prediction: 4.146790058215102
Epoch: 1000 - Prediction: 2.941351899922761
Epoch: 1000 - Prediction: 3.6697359194153822
```

```
Epoch: 1000 - Prediction: 2.904985800731369
Epoch: 1000 - Prediction: 5.024933323784917
Epoch: 1000 - Prediction: 4.627030304009182
Epoch: 1000 - Prediction: 4.354272883410625
Epoch: 1000 - Prediction: 3.597003721032598
Epoch: 1000 - Prediction: 1.4909560749262385
Epoch: 1000 - Prediction: 2.830082824366531
Epoch: 1000 - Prediction: 2.2984912134428437
Epoch: 1000 - Prediction: 2.941351899922761
Epoch: 1000 - Prediction: 5.5597577483554455
Epoch: 1000 - Prediction: 1.8396318009019403
Epoch: 1000 - Prediction: 2.4354126182376366
Epoch: 1000 - Prediction: 2.9552517768699493
Epoch: 1000 - Prediction: 5.544772482417231
Epoch: 1000 - Prediction: 1.5476409717060198
Epoch: 1000 - Prediction: 4.538250804023396
Epoch: 1000 - Prediction: 3.1199495822328784
Epoch: 1000 - Prediction: 3.205519621898064
Epoch: 1000 - Prediction: 5.215330165038891
Epoch: 1000 - Prediction: 5.422812990234412
Epoch: 1000 - Prediction: 3.8237666614779635
Epoch: 1000 - Prediction: 3.598065756697385
Epoch: 1000 - Prediction: 2.846153479295774
Epoch: 1000 - Prediction: 1.8749358644285452
Epoch: 1000 - Prediction: 1.5144843328352284
Epoch: 1000 - Prediction: 4.723314113627196
Epoch: 1000 - Prediction: 3.5991511456884124
Epoch: 1000 - Prediction: 2.764854935615976
Epoch: 1000 - Prediction: 1.7262620073423778
Epoch: 1000 - Prediction: 3.742468117798165
Epoch: 1000 - Prediction: 2.2771103801896677
Epoch: 1000 - Prediction: 1.3369019795374162
Epoch: 1000 - Prediction: 5.578991156952808
Epoch: 1000 - Prediction: 5.461326514081618
Epoch: 1000 - Prediction: 4.047320141602729
Epoch: 1000 - Prediction: 5.085913069876326
Epoch: 1000 - Prediction: 5.5597343950292055
Epoch: 1000 - Prediction: 3.9553078279701013
Epoch: 1000 - Prediction: 5.185359633162459
Epoch: 1000 - Prediction: 4.797108347674766
Epoch: 1000 - Prediction: 4.455890224678812
Epoch: 1000 - Prediction: 5.258091831545243
Epoch: 1000 - Prediction: 5.023871288120131
Epoch: 1000 - Prediction: 3.246180570401083
Epoch: 1000 - Prediction: 4.191699149377268
Epoch: 1000 - Prediction: 2.7338223680747578
Epoch: 1000 - Prediction: 2.556263368103186
Epoch: 1000 - Prediction: 2.2375348206776757
```

```
Epoch: 1000 - Prediction: 2.3263143206634616
Epoch: 1000 - Prediction: 3.999178236793721
Epoch: 1000 - Prediction: 2.653609213385987
Epoch: 1000 - Prediction: 5.0313522444261185
Epoch: 1000 - Prediction: 5.399308085651663
Epoch: 1000 - Prediction: 2.070666237332692
Epoch: 1000 - Prediction: 5.220663696689065
Epoch: 1000 - Prediction: 3.272894935304433
Epoch: 1000 - Prediction: 3.930717534396325
Epoch: 1000 - Prediction: 5.283790867436287
Epoch: 1000 - Prediction: 3.4568962092434457
Epoch: 1000 - Prediction: 2.2107737491218447
Epoch: 1000 - Prediction: 2.748807634012974
Epoch: 1000 - Prediction: 5.571510200646821
Epoch: 1000 - Prediction: 2.703875189524567
Epoch: 1000 - Prediction: 4.221669681253699
Epoch: 1000 - Prediction: 2.0952565309064686
Epoch: 1000 - Prediction: 4.005597157434923
Epoch: 1000 - Prediction: 4.955410585722735
Epoch: 1000 - Prediction: 1.602201797156228
Epoch: 1000 - Prediction: 5.2538203355598565
Epoch: 1000 - Prediction: 1.3625776621022199
Epoch: 1000 - Prediction: 1.774380558825144
Epoch: 1000 - Prediction: 4.158565863832718
Epoch: 1000 - Prediction: 2.7049605785155943
Epoch: 1000 - Prediction: 5.799335176756973
Epoch: 1000 - Prediction: 1.4577760827292068
Epoch: 1000 - Prediction: 3.308198998831038
Epoch: 1000 - Prediction: 4.221646327927459
Epoch: 1000 - Prediction: 4.622758808023795
Epoch: 1000 - Prediction: 3.8430234234015663
Epoch: 1000 - Prediction: 4.779999010406977
Epoch: 1000 - Prediction: 4.052653673252902
Epoch: 1000 - Prediction: 5.792916256115771
Epoch: 1000 - Prediction: 4.673048137488616
Epoch: 1000 - Prediction: 4.883740423004737
Epoch: 1000 - Prediction: 5.707346216450587
Epoch: 1000 - Prediction: 5.611085760158813
```

Önceki kısımda kaydedilen loss ve accuracy değerleri görselleştirilmiştir. Grafiklerden de anlaşılacağı üzere 500 epoch'dan sonra anlamlı bir iyileşme meydana gelmemektedir. Hesaplama kolaylığı ve model doğruluğu arasındaki ödünleşme sonucunda eğitimi 500 epoch ile yapmak daha isabetli olacaktır. Ayrıca train ve test için ayrı ayrı çizilmesine rağmen birbirlerini oldukça iyi takip etmişlerdir, birbirleriyle tutarlı sonuç vermişlerdir. Bunu sebebi train datası ile test datasının birbirleriyle oldukça uyum içinde olmalarıdır.

```python
fig, ax= plt.subplots(1,3, figsize=(15,8))
fig.suptitle('Learning Rate = 0.000005')
```

```
ax[0].plot(epoch, loss_train, label='Train')
ax[0].plot(epoch, loss_test, label='Test')
ax[0].set_ylim([0, 100])
ax[0].axvline(x=500, color='r', linestyle='--')
ax[0].set_xlabel('Epoch')
ax[0].set_ylabel('Loss')
ax[0].legend()
ax[1].plot(epoch, accuracy_train, label='Train')
ax[1].plot(epoch, accuracy_test, label='Test')
ax[1].set_ylim([-100, 1])
ax[1].axvline(x=500, color='r', linestyle='--')
ax[1].set_xlabel('Epoch')
ax[1].set_ylabel('Accuracy')
ax[1].legend()
ax[2].plot(epoch, loss_train, label='Train')
ax[2].plot(epoch, loss_test, label='Test')
ax[2].plot(epoch, accuracy_train, label='Train')
ax[2].plot(epoch, accuracy_test, label='Test')
ax[2].set_ylim([-100, 100])
ax[2].axvline(x=500, color='r', linestyle='--')
ax[2].set_xlabel('Epoch')
ax[2].set_ylabel('Loss & Accuracy')
ax[2].legend()
plt.show()
```

Learning Rate = 0.000005