IN THE NAME OF **ALLAH**

Linear Regression

Implementing a linear regression for a real data set (body measurements) with scikit-learn (sklearn) library in python

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Numerical Computing Methods

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By theMHD

Introduction

What is the linear regression?

Linear regression analysis is used to predict value of a variable (dependent variable) based on the value of another variables (independent variables) in a data set.

Linear regression model takes this form:

$$y_i = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \ldots + a_nx_n + \varepsilon_i = a_0 + \sum_{i=[1,n]} a_ix_i + \varepsilon_i$$

y → dependent variable / x → independent variable / a_1 to a_n → coefficients of independent variables / a_0 → intercept of linear equation / ε_i → error of prediction

The goal of this project is to predict a person' age using his/her body measurements (with a real data set) …

```
print("\n||| ---------- Step 1: General file inf
print('1) The first 5 rows ---------------------------')
print(body_measures.head())
print('\n2) File information --------------------------')
print(body_measures.info())
print('\n3) Statistical information -------------------')
print(body_measures.describe())
```

```
||| ---------- Step 1: General file information ---------- |||
1) The first 5 rows ---------------------------
   Gender  Age  HeadCircumference  ...  WaistToKnee  LegLength  TotalHeight
0       1   30                 22  ...           25         22           52
1       1   28                 19  ...           25         20           56
2       2   27                 21  ...           14         18           53
3       1   29                 20  ...           20         21           45
4       2   28                 16  ...           32         13           47

[5 rows x 13 columns]
```

Let's go code!

Step 1

Get some general information from our data set file (part1)

.head() method and it's results (it shows the first 5 rows of data set file as it's header)

5 rows and 13 columns

More with code! …

```
2) File information -------------------------
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 716 entries, 0 to 715
Data columns (total 13 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Gender             716 non-null    int64
 1   Age                716 non-null    int64
 2   HeadCircumference  716 non-null    int64
 3   ShoulderWidth      716 non-null    int64
 4   ChestWidth         716 non-null    int64
 5   Belly              716 non-null    int64
 6   Waist              716 non-null    int64
 7   Hips               716 non-null    int64
 8   ArmLength          716 non-null    int64
 9   ShoulderToWaist    716 non-null    int64
 10  WaistToKnee        716 non-null    int64
 11  LegLength          716 non-null    int64
 12  TotalHeight        716 non-null    int64
dtypes: int64(13)
memory usage: 72.8 KB
None
```

Step 2 (.info())
Get some general information from our data set file (part2)

```
3) Statistical information ------------------
            Gender         Age  ...   LegLength  TotalHeight
count   716.000000  716.000000  ...  716.000000   716.000000
mean      1.452514   15.340782  ...   26.833799    48.118715
std       0.498088   11.831501  ...    7.925988    12.156722
min       1.000000    1.000000  ...    9.000000    19.000000
25%       1.000000    7.000000  ...   21.000000    40.000000
50%       1.000000   11.000000  ...   26.000000    48.000000
75%       2.000000   21.000000  ...   32.000000    55.000000
max       2.000000   68.000000  ...   50.000000    89.000000

[8 rows x 13 columns]
```

Step 3 (.describe())
Get some statistical information about our data set file …
Such as mean, std (root of variance), min, max and …

```python
print("\n||| ---------------------- Step 2: Make regression line ---------------------- |||")
x_list = body_measures[
    ["Gender", "HeadCircumference", "ShoulderWidth", "ChestWidth", "Belly", "Waist", "Hips",
     "ArmLength", "ShoulderToWaist", "WaistToKnee", "LegLength", "TotalHeight"]]
y_list = body_measures["Age"]
reg_res = LinearRegression()
reg_res.fit(x_list, y_list)

i = 0  # index of coefficients
print("The coefficient of variables are shown in bottom...")
for header in body_measures.columns:
    if header != "Age":
        print(f"{header}: {reg_res.coef_[i]}")
        i += 1
print("-----------------------------------")
print("Intercept of regression line is: ", reg_res.intercept_)

# Predict Ages and calculate error ----------------------------------------------
predicted_y = reg_res.predict(x_list)  # predicated y list (y is list Ages)
rmse = np.sqrt(np.mean(np.square(predicted_y - y_list)))  # root mean square error
print("Average prediction error: ", rmse, " ~= ", round(rmse))
```

With .coef_ attribute, we gain the coefficients of independent variables (x's) and with .intercept_ attribute, we gain the intercept of our regression line

…

Ok; the regression line is created for our dependent variable (Age → y) and independent variables (other body measurements → x_0 to x_{11}).

Create regression line

To create regression line, at first, we should consider one of variables as dependent variable (y) and other variables as independent variables (x)

…

In this project, Age is y and other variables considered as x

…

LinearRegression() class, prerforms the regression operation for us;

With fit() method, we can fit our x's and y for regression operation as dependent and independent variables.

```
||| ---------------------- Step 2: Make regression line ---------------------- |||
The coefficient of variables are shown in bottom...
Gender: -2.1600681758606353
HeadCircumference: -0.29175212771841047
ShoulderWidth: 0.4913502191932724
ChestWidth: -0.2637862587951137
Belly: -0.043528822433128
Waist: 0.15838333238679603
Hips: 0.1655076168425505
ArmLength: 0.23630518352852511
ShoulderToWaist: 0.5897866941413992
WaistToKnee: 0.34539183792808575
LegLength: -0.06615631219156848
TotalHeight: 0.12851226045314823
---------------------------------
Intercept of regression line is:  -9.222430674200167
Average prediction error:  8.365045897383036  ~=  8
```

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$$

Create regression line (results)

The results obtained from performing linear regression operations to predict age;

…

Coefficients of independent variables and intercept of regression line.

…

With predict() method, we can predict our desired option (which is Age here) based on the different independent variables;
(shown in the previous slide)

…

To calculate error of our prediction, we use RMSE formula;
<< Root mean square error >>
← It's formula (predicted Ages – actual Ages)
N is the number of y's (from first age to the last).

Solve an example

In this part, we solve an example to check our prediction using the created equation (to predict age of a person with his/her body measurements);

…

In general we want to check obtained result of linear regression.

☺

```python
print("\n||| ------------------------- Step 3: Solve an example ------------------------- |||")
# You can use this numbers for example: 1, 20, 25, 24, 25, 36, 17, 23, 12, 9, 19, 48
x_for_predict = [[]]
for header in x_list:
    x_for_predict[0].append(int(input(f"Enter a number for input var <{header}>: ")))
predicted_example = reg_res.predict(x_for_predict)[0]
print("An example to prediction: ", abs(predicted_example), " ~= ", round(abs(predicted_example)), "years old")
```

```
||| ------------------------- Step 3: Solve an example ------------------------- |||
Enter a number for input var <Gender>: 1
Enter a number for input var <HeadCircumference>: 20
Enter a number for input var <ShoulderWidth>: 25
Enter a number for input var <ChestWidth>: 24
Enter a number for input var <Belly>: 25
Enter a number for input var <Waist>: 36
Enter a number for input var <Hips>: 17
Enter a number for input var <ArmLength>: 23
Enter a number for input var <ShoulderToWaist>: 12
Enter a number for input var <WaistToKnee>: 9
Enter a number for input var <LegLength>: 19
Enter a number for input var <TotalHeight>: 48
An example to prediction:  16.695157418056837  ~=  17 years old
```

Let's go to draw the plots

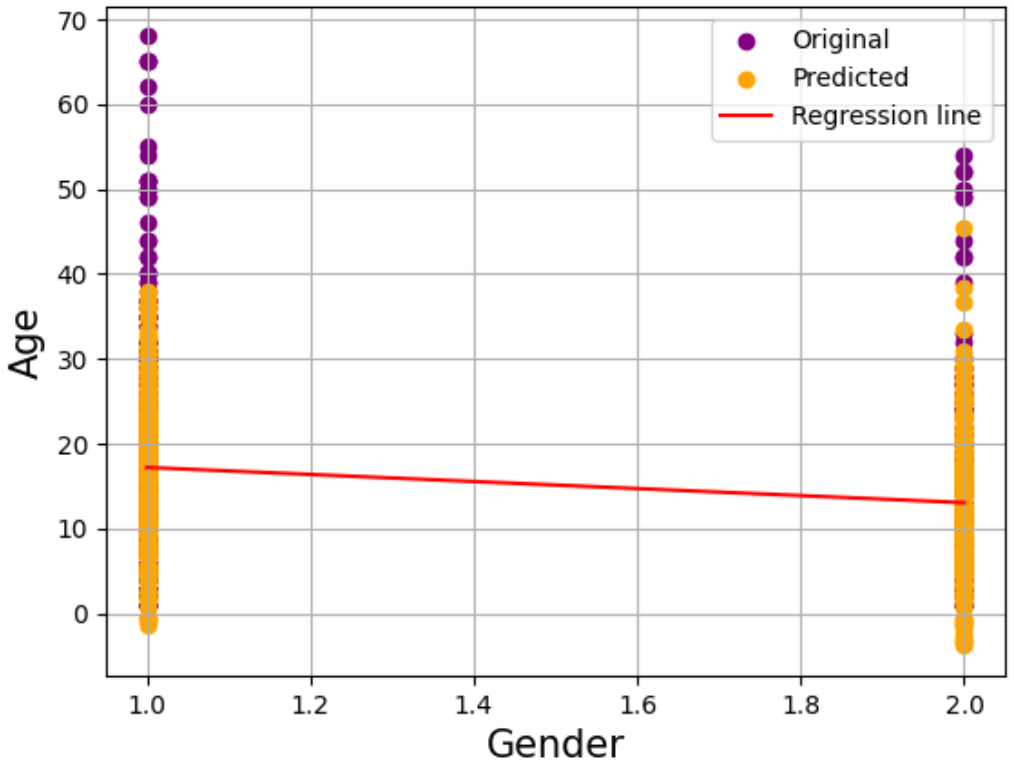
…

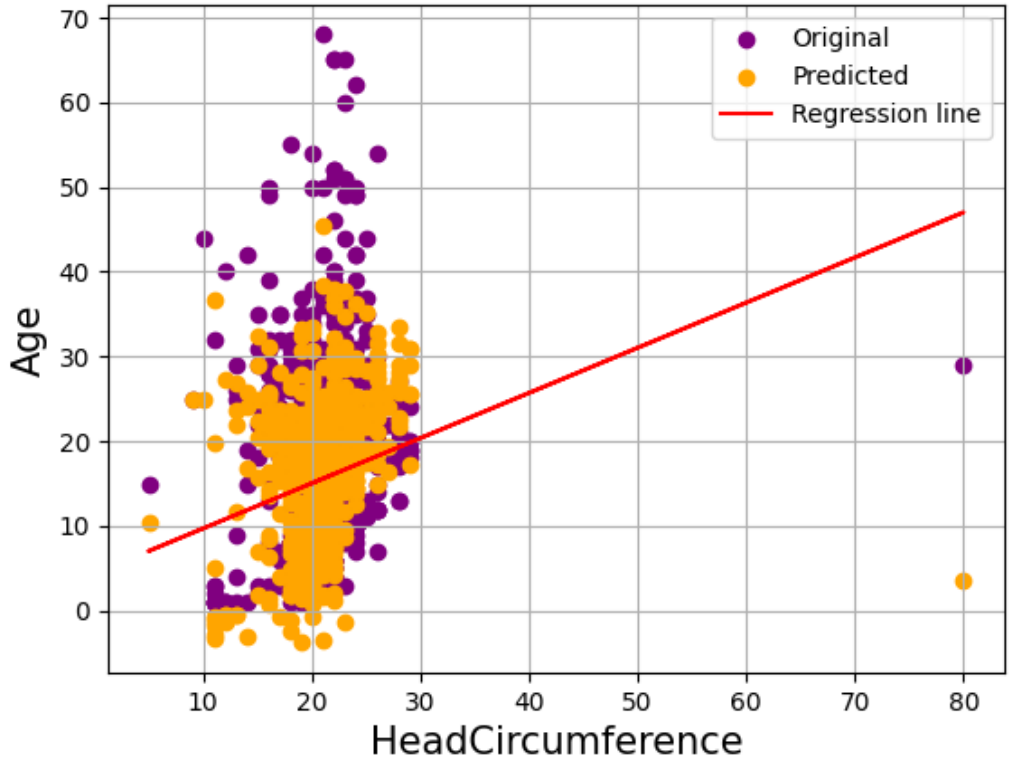
Here is the code for the charts that will be shown in the next slides;

Note: the regression line in the graphs, created for Age based on **one** variable; that is, **Age based on the per independent variables**; also actual age values and predicted values (that obtained from regression operation (with all independent variables) will be show along with the regression line.

The Charts and Plots ☺

```
print("\n||| ------------------------- Step 4: Draw the plots ------------------------- |||")
for header in x_list:
    plt.grid()
    # New regression for per input
    reg_res = LinearRegression()
    reg_input = x_list[header].values.reshape(-1, 1)
    reg_res.fit(reg_input, y_list)
    y_reg_line = reg_res.coef_ * x_list[header] + reg_res.intercept_
    # The plot inputs
    plt.scatter(x_list[header], y_list, color="purple")
    plt.scatter(x_list[header], predicted_y, color="orange")
    plt.plot(x_list[header], y_reg_line, color="red")
    # The plot styles
    plt.xlabel(header, fontsize=15)
    plt.ylabel("Age", fontsize=15)
    plt.legend(["Original", "Predicted", "Regression line"])
    plt.show()
```





Age based on the Gender

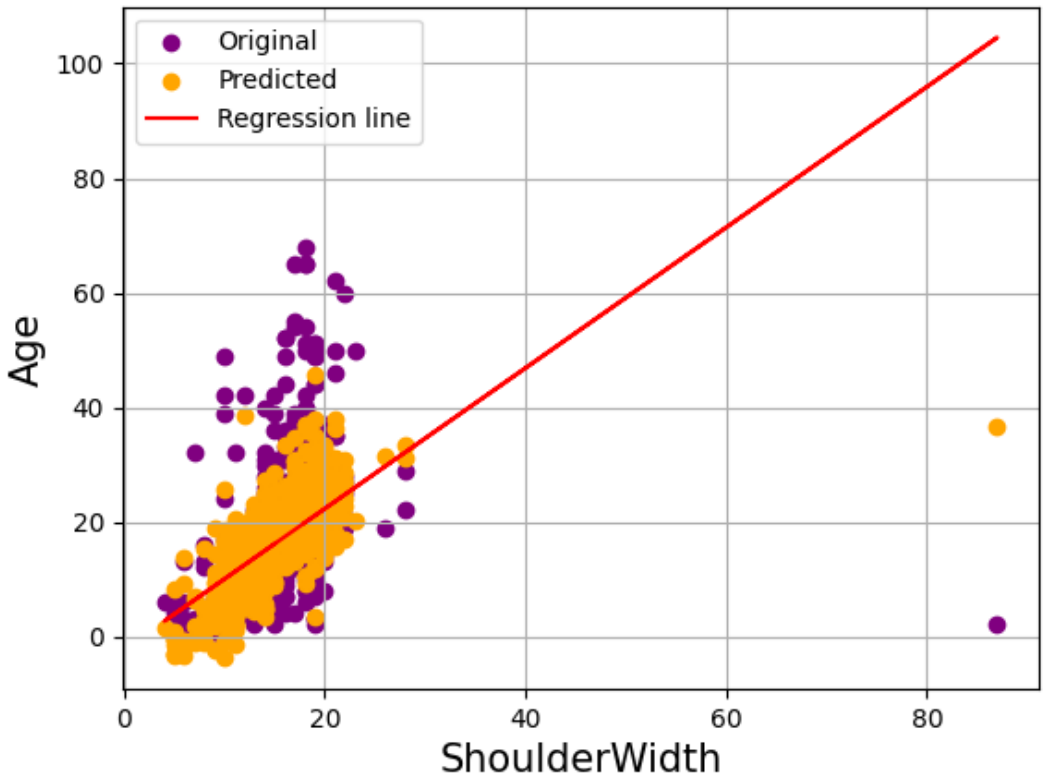
Type of relation: indirect

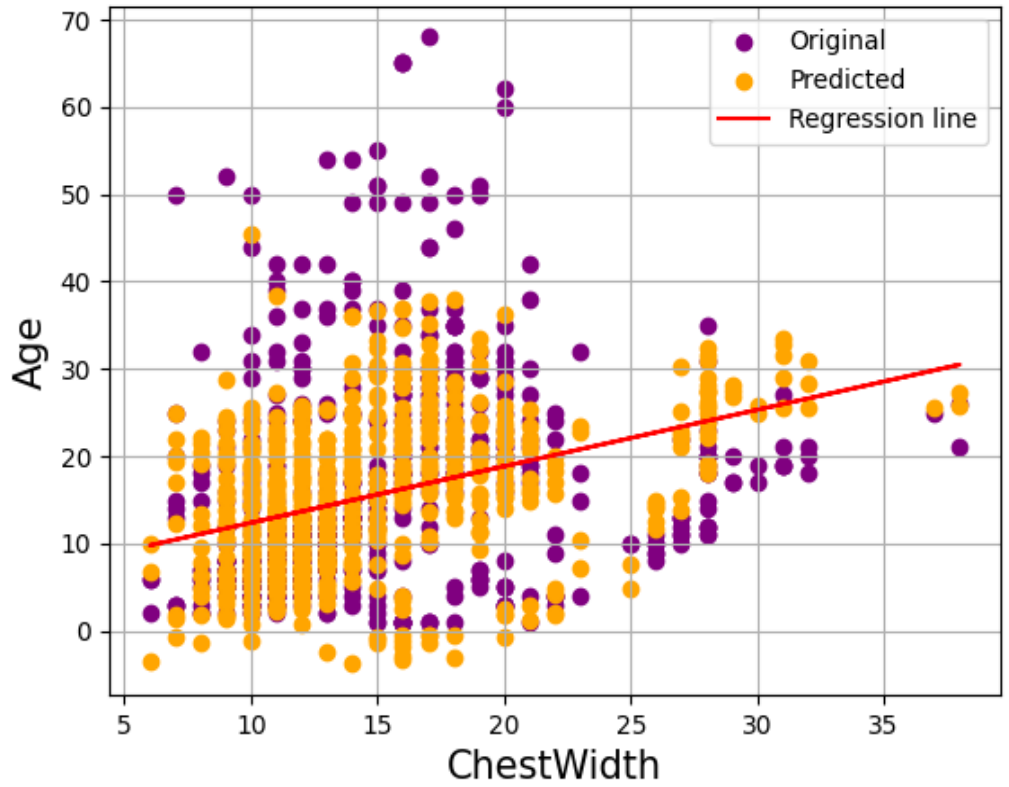
Gender 1 is male / Gender 2 is female

Age based on the Head circumference

Type of relation: direct

The highest density is between 10 and 30





Age based on the Shoulder width

Type of relation: direct

The highest density is almost between 4 and 25

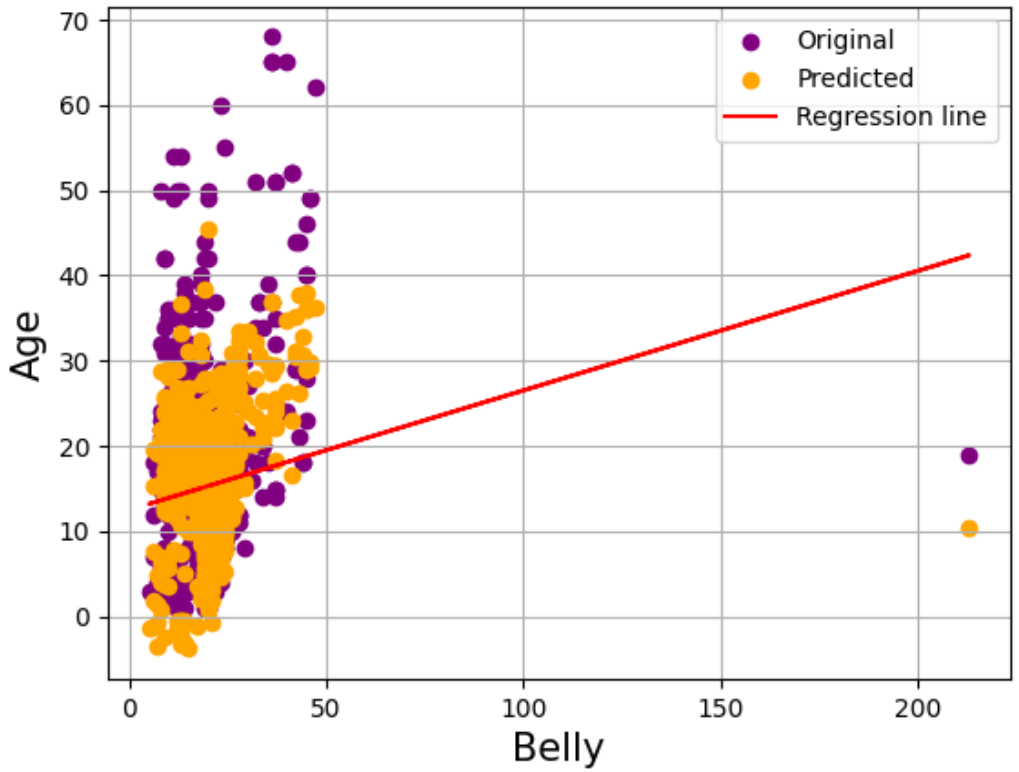
Age based on the Head Chest width

Type of relation: direct

The highest density is between 5 and 25

(and a weaker density between 25 and 35)

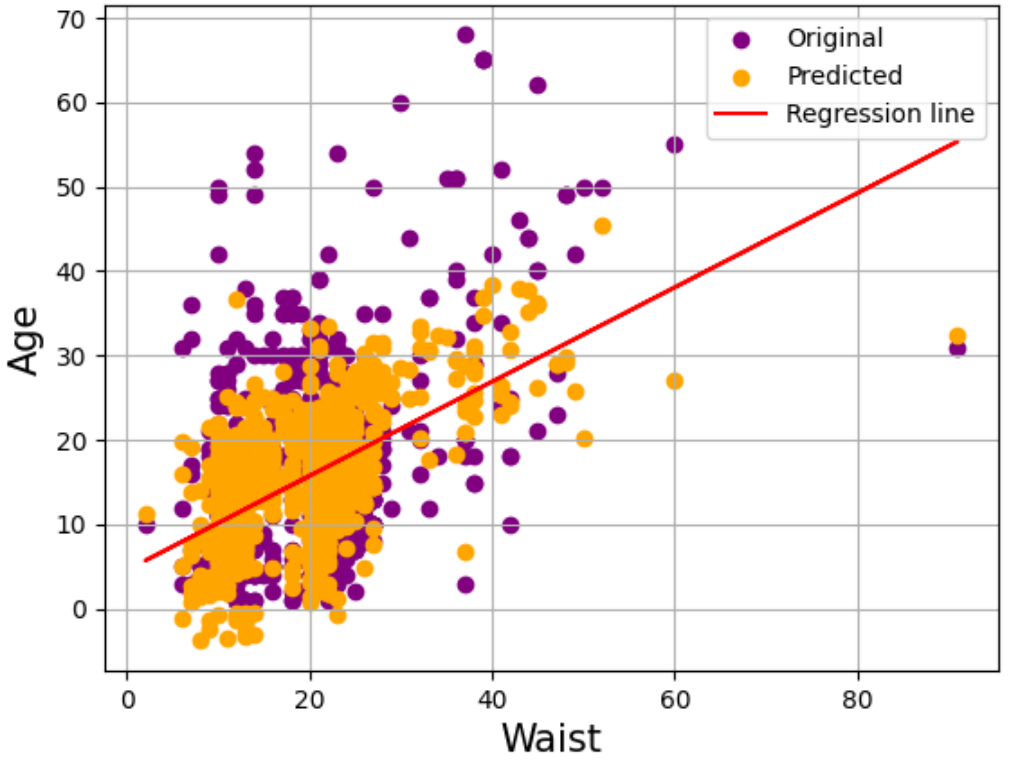
In general the density is a little weak in this chart.



Age based on the Belly

Type of relation: direct

The highest density is between 0 and 50

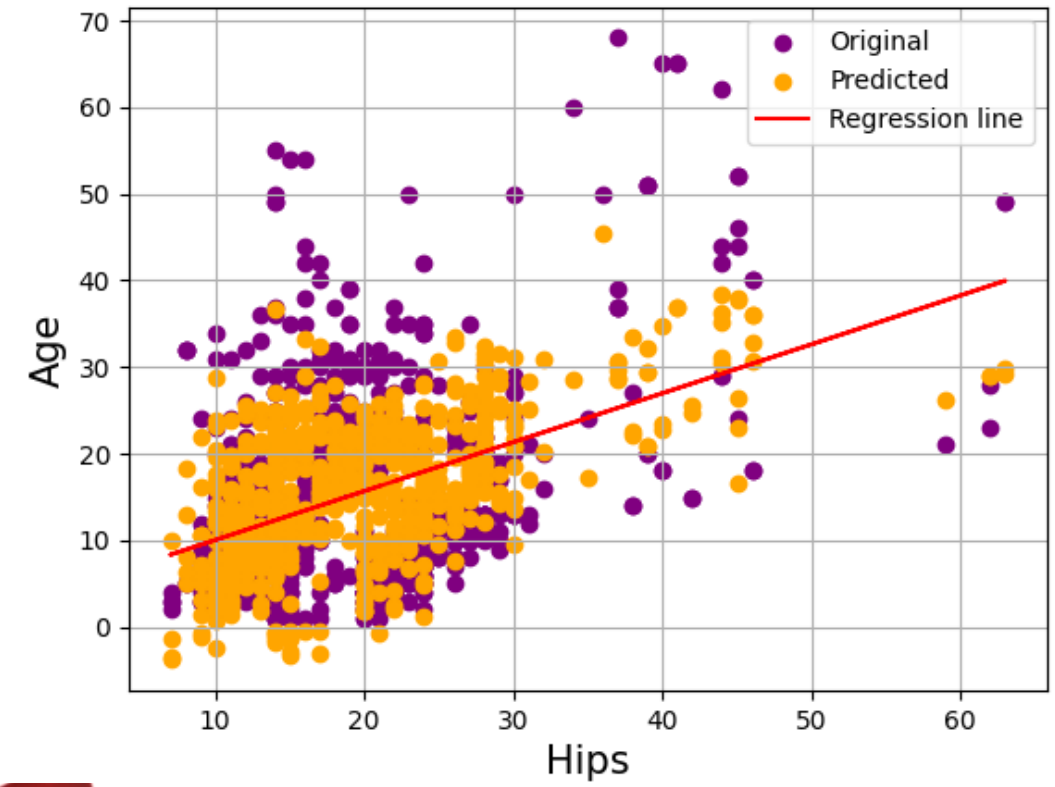


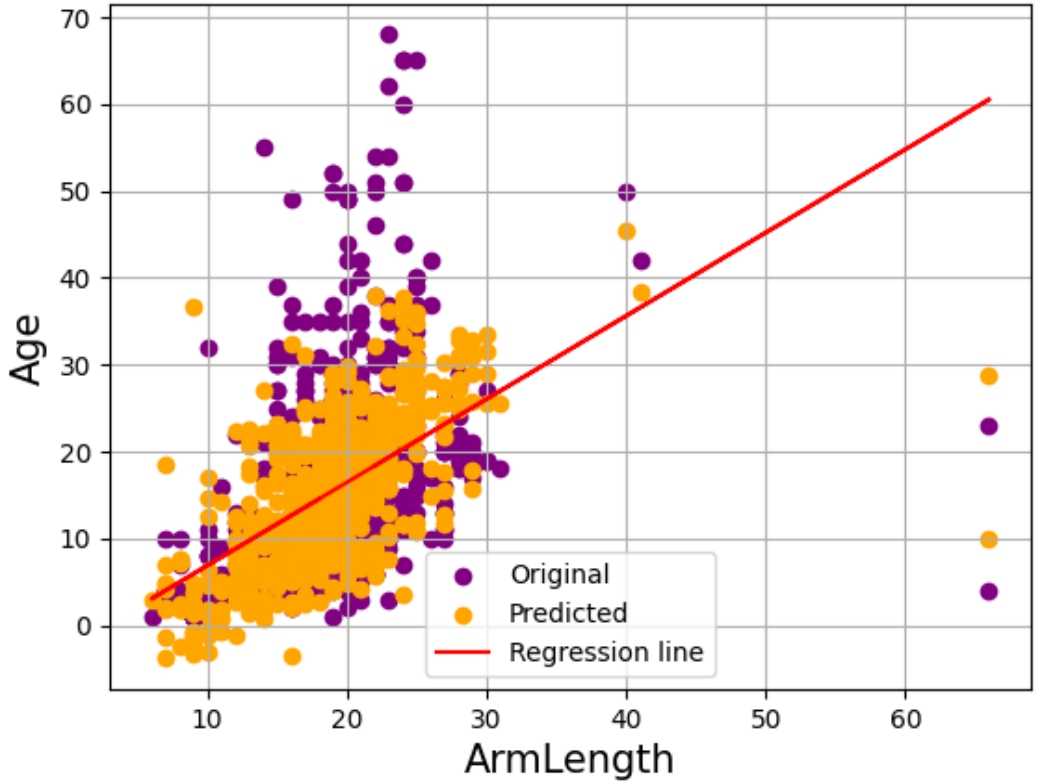
Age based on the Waist

Type of relation: direct

The highest density is between 0 and 25

(with weaker density between 25 and 50)





Age based on the Hips

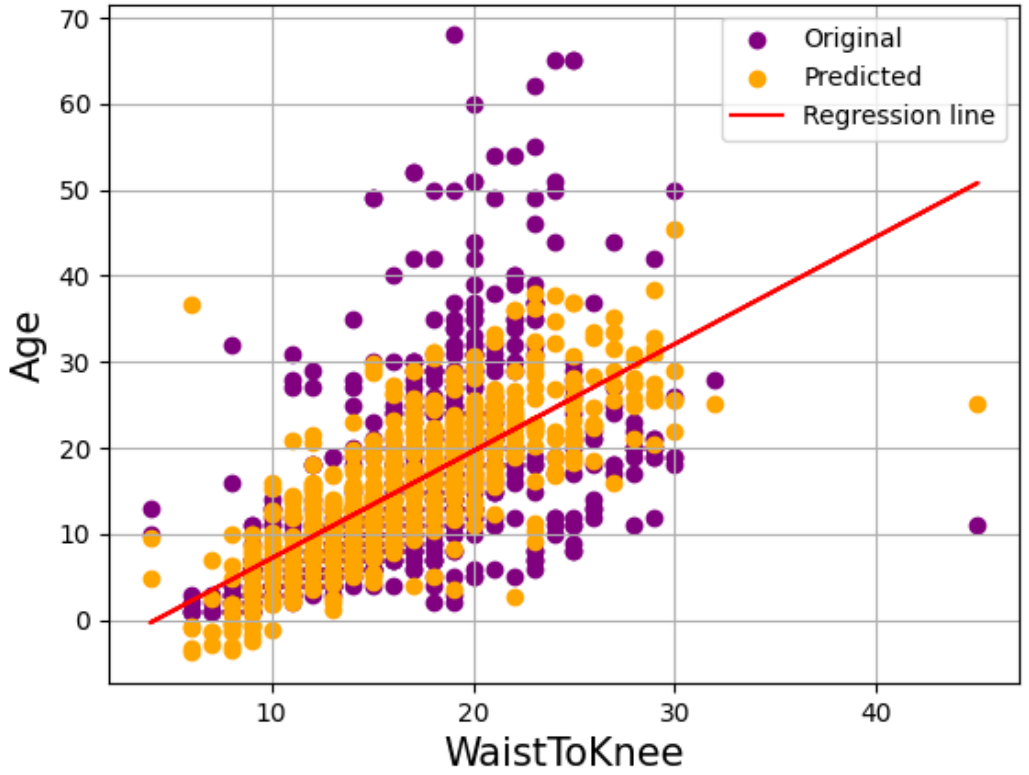
Type of relation: direct

The highest density is between 4 and 30 (to 33)

Age based on the Head Arm length

Type of relation: direct

The highest density is between 4 and 30 (to 32)



Age based on the Shoulder to waist

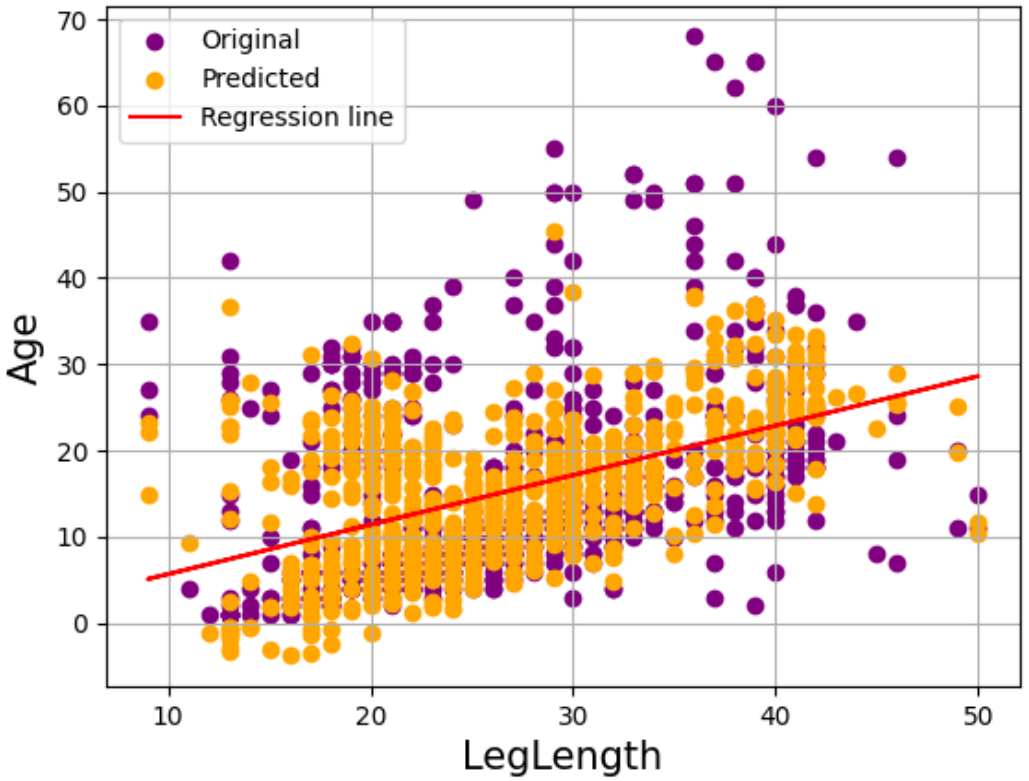
Type of relation: direct

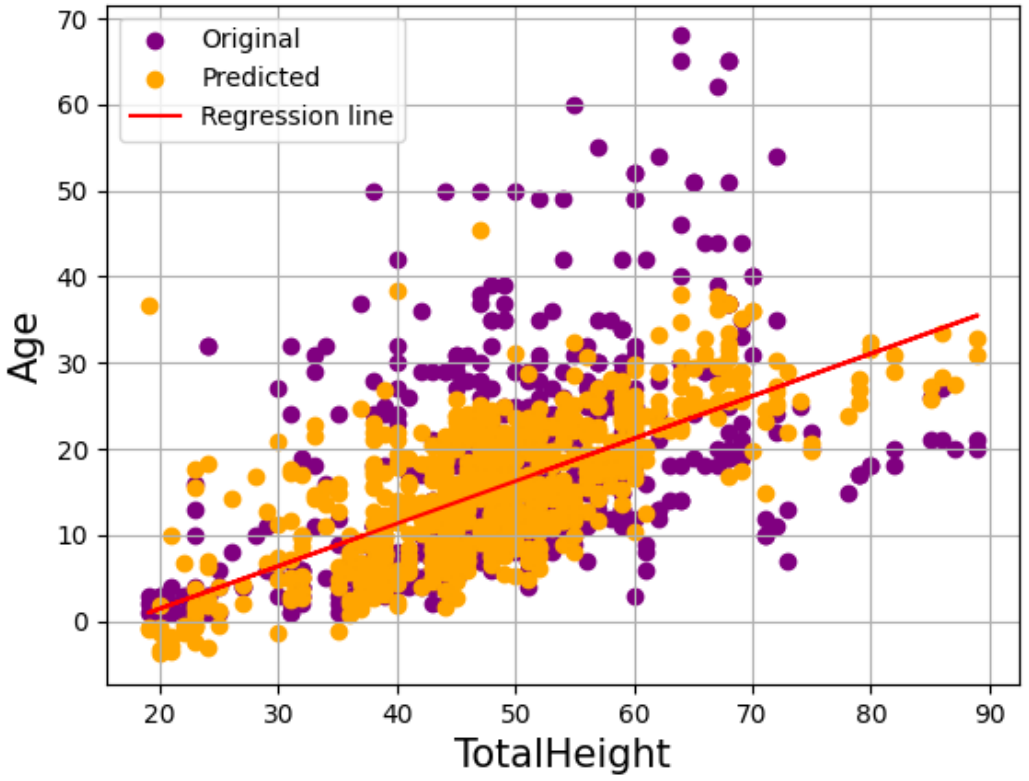
The highest density is between 5 (~6) and 30 (~28)

Age based on the Head Waist to knee

Type of relation: direct

The highest density is between 4 and 30 (~31)





Age based on the Leg length

Type of relation: indirect

The highest density is between 10(~11) and 43

(with very weaker density to 50)

Age based on the Total height

Type of relation: direct

The highest density is almost between 15 and 75

(with very weaker density to 90)

The End

خدایا چنان کن سرانجام کار تو خشنود باشی و ما رستگار

By theMHD