Solution for Exercise M4.01

Contents

The aim of this exercise is two-fold:

- understand the parametrization of a linear model;
- quantify the fitting accuracy of a set of such models.

We will reuse part of the code of the course to:

- load data;
- create the function representing a linear model.

Prerequisites

Data loading

Note

If you want a deeper overview regarding this dataset, you can refer to the Appendix - Datasets description section at the end of this MOOC.

```
import pandas as pd

penguins = pd.read_csv("../datasets/penguins_regression.csv")
feature_name = "Flipper Length (
target_name = "Body Mass (g)"
data, target = penguins[[feature_name]], penguins[target_name]
```

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Model definition

```
def linear_model_flipper_mass(
    flipper_length, weight_flipper_length, intercept_body_mass
):
    """Linear model of the form y = a * x + b"""
    body_mass = weight_flipper_length * flipper_length + intercept_body_mass
    return body_mass
```

Main exercise

Define a vector `weights = [...]` and a vector `intercepts = [...]` of the same length. Each pair of entries `(weights[i], intercepts[i])` tags a different model. Use these vectors along with the vector `flipper_length_range` to plot several linear models that could possibly fit our data. Use the above helper function to visualize both the models and the real samples.

```
import numpy as np

flipper_length_range = np.linspace(data.min(), data.max(), num=300)
```

```
# solution
import matplotlib.pyplot as plt
import seaborn as sns

weights = [-40, 45, 90]
intercepts = [15000, -5000, -14000]

ax = sns.scatterplot(
    data=penguins, x=feature_name, y=target_name, color="black", alpha=0.5
)

label = "{0:.2f} (g / mm) * flipper length + {1:.2f} (g)"
for weight, intercept in zip(weights, intercepts):
    predicted_body_mass = linear_model_flipper_mass(
        flipper_length_range, weight, intercept
    )

    ax.plot(
        flipper_length_range,
        predicted_body_mass,
        label=label.format(weight, intercept),
    )
_ = ax.legend(loc="center left", bbox_to_anchor=(-0.25, 1.25), ncol=1)
```

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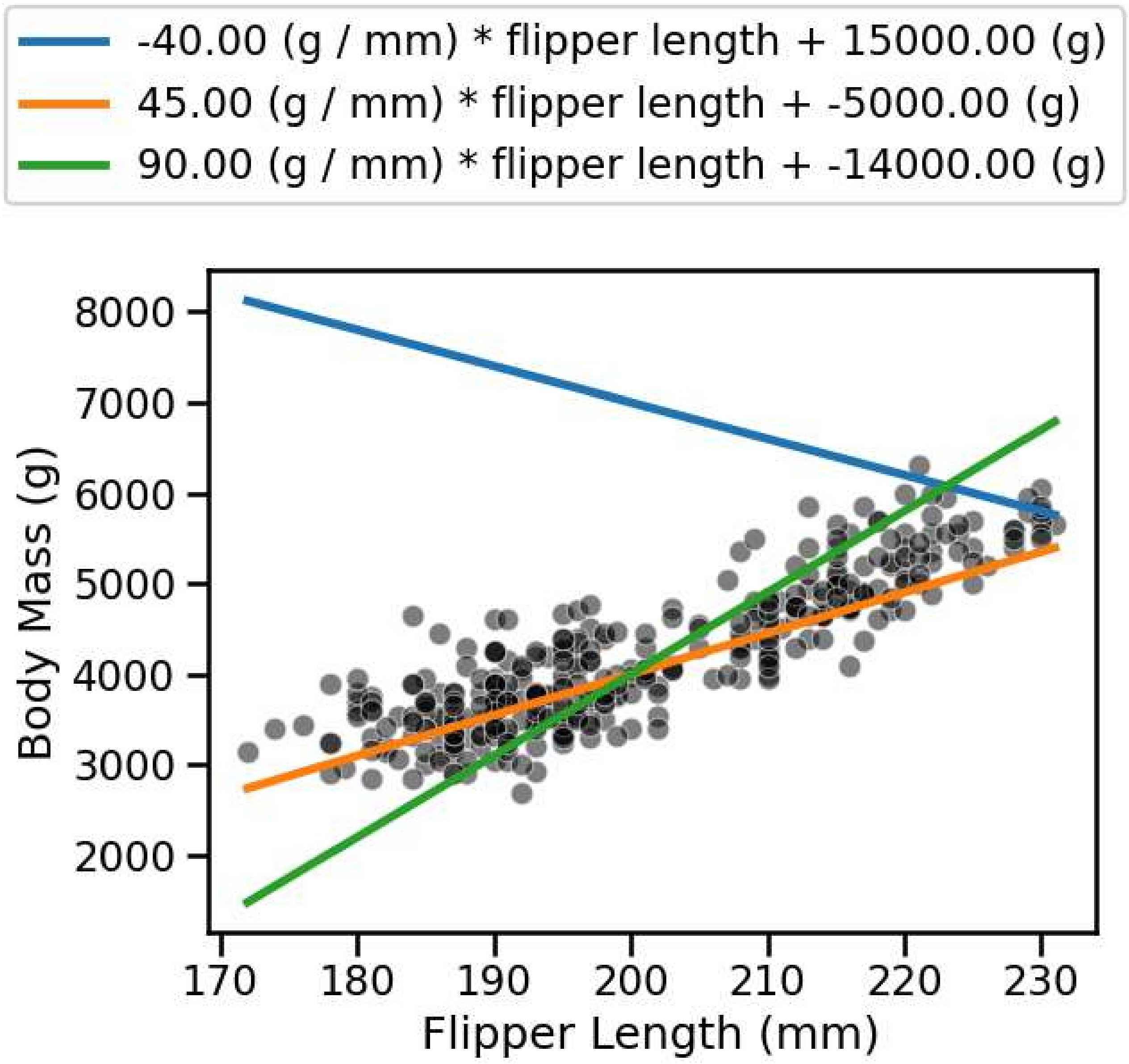

In the previous question, you were asked to create several linear models. The visualization allowed you to qualitatively assess if a model was better than another.

Now, you should come up with a quantitative measure which indicates the goodness of fit of each linear model and allows you to select the best model. Define a function `goodness_fit_measure(true_values, predictions)` that takes as inputs the true target values and the predictions and returns a single scalar as output.

```
# solution
def goodness_fit_measure(true_values, predictions):
    # we compute the error between the true values and the predictions of our
    # model
    errors = np.ravel(true_values) - np.ravel(predictions)
    # We have several possible strategies to reduce all errors to a single value.
```

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```
    # reduce the mean error. Therefore, we can either square each
    # error or take the absolute value: these metrics are known as mean
    # squared error (MSE) and mean absolute error (MAE). Let's use the MAE here
    # as an example.
    return np.mean(np.abs(errors))
```

You can now copy and paste the code below to show the goodness of fit for each model.

```
for model_idx, (weight, intercept) in enumerate(zip(weights, intercepts)):
    target_predicted = linear_model_flipper_mass(data, weight, intercept)
    print(f"Model #{model_idx}:")
    print(f"{weight:.2f} (g / mm) * flipper length + {intercept:.2f} (g)")
    print(f"Error: {goodness_fit_measure(target, target_predicted):.3f}\n")
```

```
# solution
for model_idx, (weight, intercept) in enumerate(zip(weights, intercepts)):
    target_predicted = linear_model_flipper_mass(data, weight, intercept)
    print(f"Model #{model_idx}:")
    print(f"{weight:.2f} (g / mm) * flipper length + {intercept:.2f} (g)")
    print(f"Error: {goodness_fit_measure(target, target_predicted):.3f}\n")
```

```
Model #0:
-40.00 (g / mm) * flipper length + 15000.00 (g)
Error: 2764.854

Model #1:
45.00 (g / mm) * flipper length + -5000.00 (g)
Error: 338.523

Model #2:
90.00 (g / mm) * flipper length + -14000.00 (g)
Error: 573.041
```