DAT565/DIT407 Assignment 4

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This paper is addressing the assignment 3 study queries within the *Introduction to Data Science & AI* course, DIT407 at the University of Gothenburg and DAT565 at Chalmers. The main source of information for this project is derived from the lectures and Skiena [1]. Assignment 4 is about correlation and linear regression.

Problem 1: Splitting the data

Problem 2: Single-variable model

Problem 3: Non-linear relationship

Problem 4: Mulitple linear regression

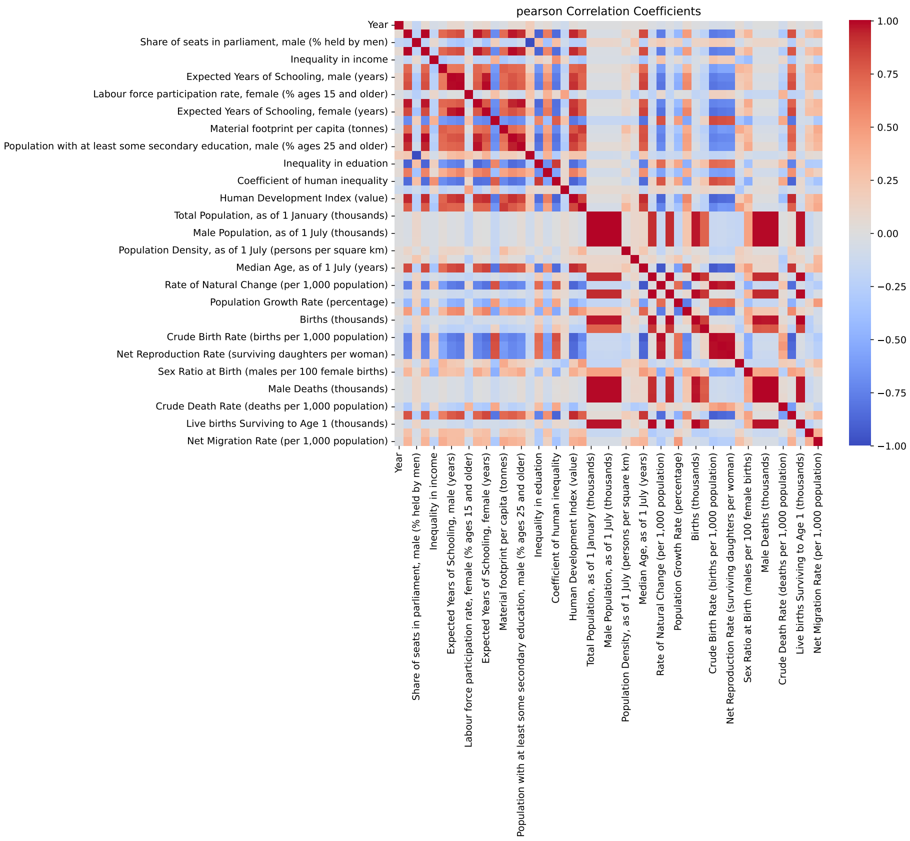


Figure 1: Correlation Pearson

References

[1] Steven S Skiena. *The Data Science Design Manual*. Retrieved 2024-01-20. 2024. URL: https://ebookcentral.proquest.com/lib/gu/detail.action?docID=6312797.

Appendix: Source Code

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

def calculate_correlation(data, variable, method):
    # Compute Pearson correlation coefficients
    correlation_matrix = data.corr(method = method)

```

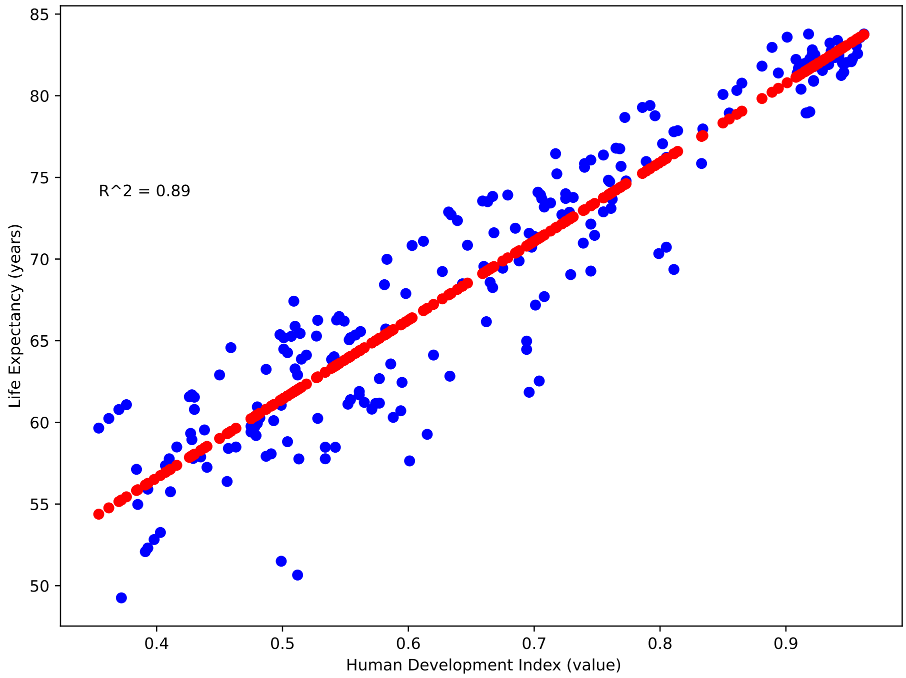


Figure 2: Linear Regression Human Development Index (value)

```
    # Extract correlation coefficients of the target variable (life expectancy)
    correlation_with_life_expectancy = correlation_matrix[variable]
    # Remove the target variable from the correlation coefficients
    correlation_without_life_expectancy = correlation_with_life_expectancy.drop(variable)

    # Find the variable with the highest absolute correlation coefficient
    strongest_correlation_variable = correlation_without_life_expectancy.abs().idxmax()
    strongest_correlation_coefficient = correlation_without_life_expectancy.abs().max()

    print(f"The variable '{strongest_correlation_variable}' has the strongest " + method + f" correlation with a coefficient of {strongest_correlation_coefficient:.2f}.")

    fig, ax = pyplot.subplots(figsize=(10, 8))
    sns.heatmap(correlation_matrix, annot=False, cmap='coolwarm')
    ax.set_title(method + ' Correlation Coefficients')
    fig.savefig(method + "_correlation.pdf", bbox_inches='tight')

    return strongest_correlation_variable, correlation_matrix


def train_linear_regression_model(X_train, X_test, y_train, y_test, variables, prefix = ''):
    # Train a linear regression model using the variable with the
```

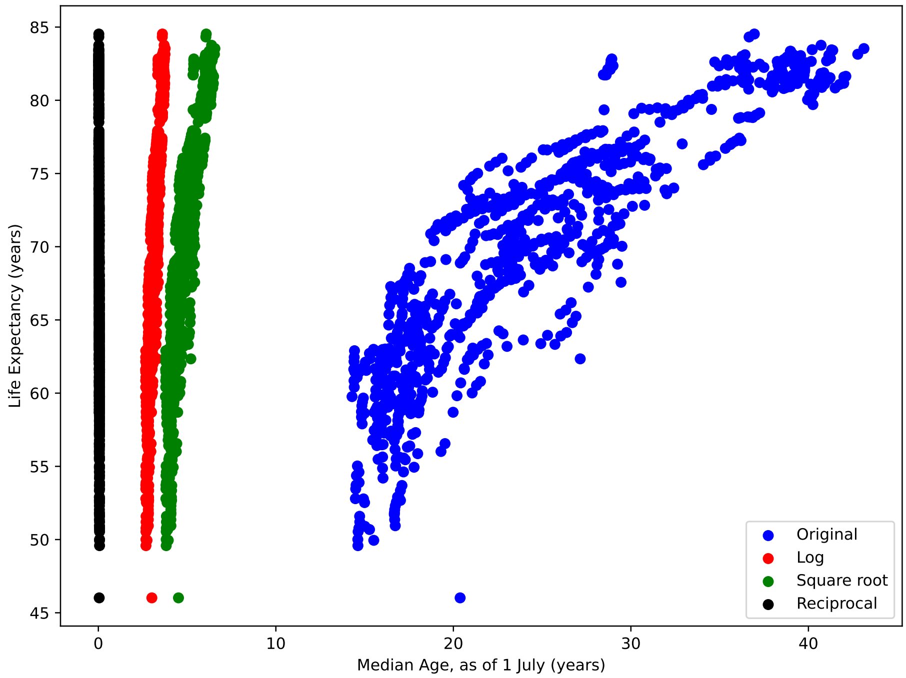
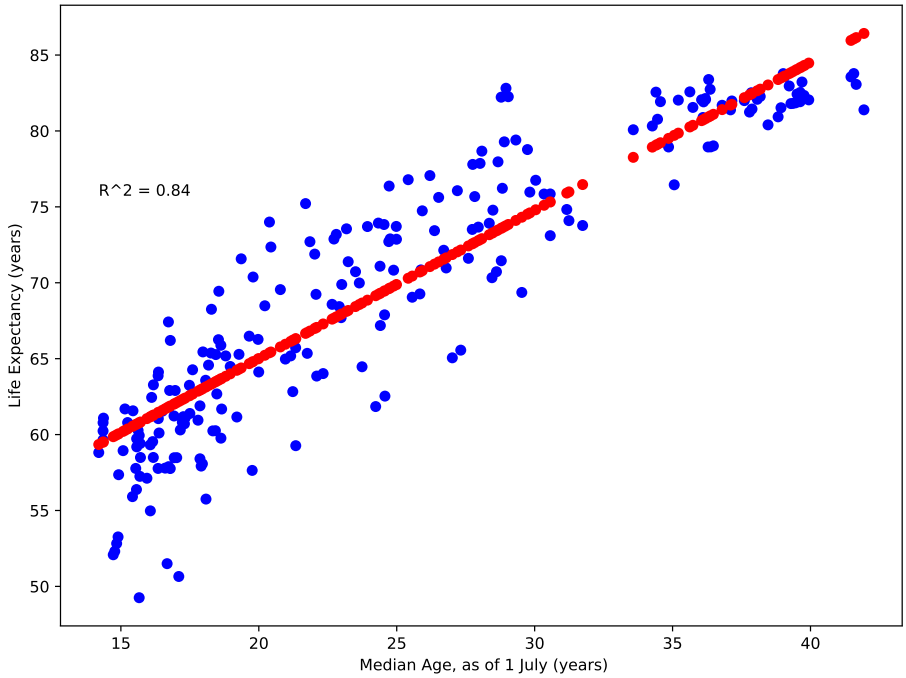
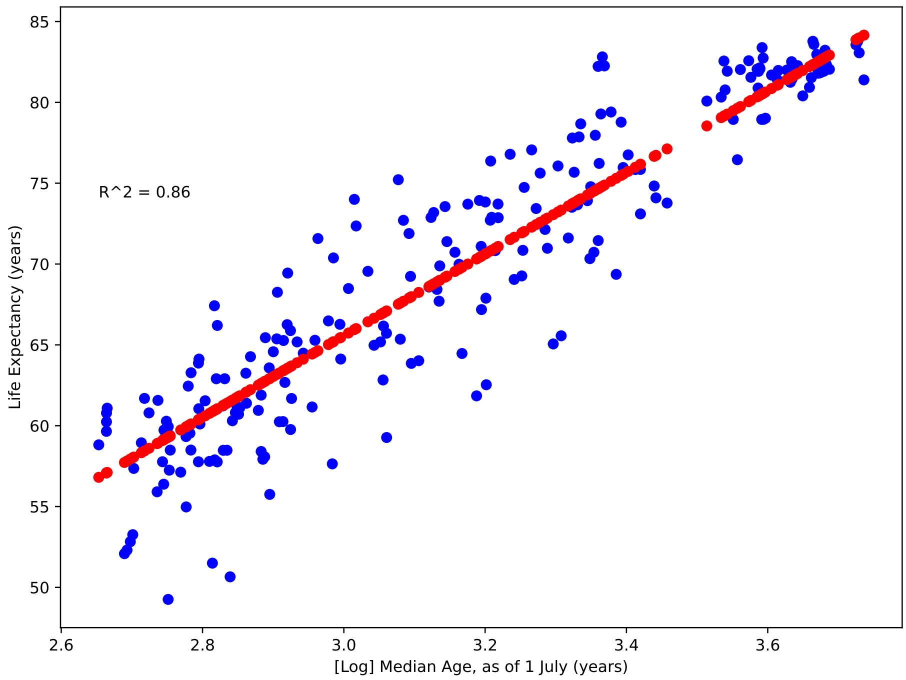


Figure 3: Linear transformation

```
        strongest correlation
    model = LinearRegression().fit(X_train, y_train)
    # Make predictions
    y_pred = model.predict(X_test)
    r2 = r2_score(y_test, y_pred)
    _, rows = X_test.shape
    if rows == 1:
        fig, ax = pyplot.subplots(figsize=(8, 6), layout='constrained')
        ax.scatter(X_test, y_test, color='blue')
        ax.scatter(X_test, y_pred, color='red')
        ax.set_xlabel(prefix + " " + variables)
        ax.set_ylabel('Life Expectancy (years)')
        ax.text(0.1, 0.7, f'R^2 = {r2:.2f}', ha='center', va='center', transform=ax.transAxes)
        filename = prefix + "_linear_regression_" + variables + ".pdf"
        filename = filename.replace(' ', '_').lower()
        fig.savefig(filename, bbox_inches='tight')


    mse = mean_squared_error(y_test, y_pred)
    print("Trained model with the following variables " + prefix + ": ", variables)
    print(f"The mean squared error for is {mse:.2f}.")

def transform_variable(X_train, y_train, correlation_variable):
    pd.options.mode.chained_assignment = None

    X_train_selected = X_train[[correlation_variable]]
```



(a) Linear Regression Median Age (original)



(b) Linear Regression Median Age (log)

Figure 4: Linear Regression Median Age

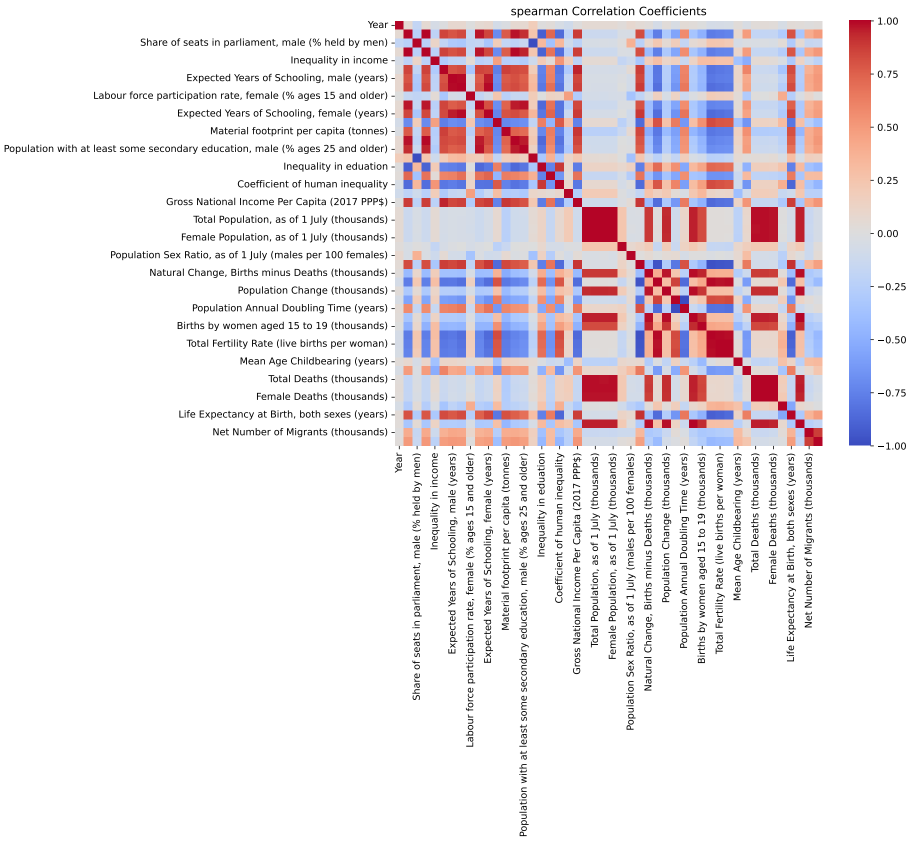


Figure 5: Correlation Spearman

```
    X_train_selected['log'] = np.log(X_train[[correlation_variable]])
    X_train_selected['sqrt'] = np.sqrt(X_train[[correlation_variable]])
    X_train_selected['reciprocal'] = 1/(X_train[[correlation_variable]])

    fig, ax = pyplot.subplots(figsize=(8, 6), layout='constrained')
    ax.scatter(X_train_selected.iloc[:, 0], y_train, color='blue', label='Original')
    ax.scatter(X_train_selected['log'], y_train, color='red', label='Log')
    ax.scatter(X_train_selected['sqrt'], y_train, color='green', label='Square root')
    ax.scatter(X_train_selected['reciprocal'], y_train, color='black', label='Reciprocal')
    ax.set_ylabel('Life Expectancy (years)')
    ax.set_xlabel(correlation_variable)

    ax.legend()
    fig.savefig("linear_transformation.pdf", bbox_inches='tight')
```

```python
file_path = "../life_expectancy.csv"
life_expectancy = pd.read_csv(file_path, sep=',',).dropna()
LEB = 'Life Expectancy at Birth, both sexes (years)'
life_expectancy.set_index('Country', inplace=True)

life_expectancy_train, life_expectancy_test = train_test_split(life_expectancy, test_size=0.2)

X_train = life_expectancy_train.drop(LEB, axis=1)
X_test =  life_expectancy_test.drop(LEB, axis=1)
y_train = life_expectancy_train[LEB]
y_test = life_expectancy_test[LEB]



strongest_pearson_correlation_variable, correlation_pearson = calculate_correlation(life_expectancy_train, LEB, 'pearson')
train_linear_regression_model(X_train[[strongest_pearson_correlation_variable]], X_test[[strongest_pearson_correlation_variable]], y_train, y_test, strongest_pearson_correlation_variable)

strongest_spearman_correlation_variable, correlation_spearman = calculate_correlation(life_expectancy_train.drop(strongest_pearson_correlation_variable, axis=1), LEB, 'spearman')
train_linear_regression_model(X_train[[strongest_spearman_correlation_variable]], X_test[[strongest_spearman_correlation_variable]], y_train, y_test, strongest_spearman_correlation_variable)
transform_variable(X_train, y_train, strongest_spearman_correlation_variable)
train_linear_regression_model(np.log(X_train[[strongest_spearman_correlation_variable]]), np.log(X_test[[strongest_spearman_correlation_variable]]), y_train, y_test,  strongest_spearman_correlation_variable, "[Log]")
train_linear_regression_model(np.sqrt(X_train[[strongest_spearman_correlation_variable]]), np.sqrt(X_test[[strongest_spearman_correlation_variable]]), y_train, y_test,  strongest_spearman_correlation_variable, "[Sqrt]")
train_linear_regression_model(1/(X_train[[strongest_spearman_correlation_variable]]), 1/(X_test[[strongest_spearman_correlation_variable]]), y_train, y_test,  strongest_spearman_correlation_variable, "[Reciprocal]")

threshold = 0.85
correlation_spearman_no_LEB = correlation_spearman.drop([LEB])

relevant_variables = correlation_spearman_no_LEB[abs(correlation_spearman_no_LEB['Life Expectancy at Birth, both sexes (years)']) > threshold].index.tolist()
train_linear_regression_model(X_train[relevant_variables], X_test[relevant_variables], y_train, y_test, relevant_variables)
```