Regression and Classification Analysis Using Python

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1. Introduction

This project demonstrates the application of machine learning techniques on two real-world datasets. The primary objectives include:

- **Regression Analysis:** Predicting numerical outcomes using the Corona Virus dataset.
- **Classification Task:** Categorizing data using the Asthma dataset.

The project incorporates data preprocessing, pipelines, and model evaluation to ensure robust and efficient workflows. Both single test dataset evaluation and cross-validation methods are used to compare model performance.

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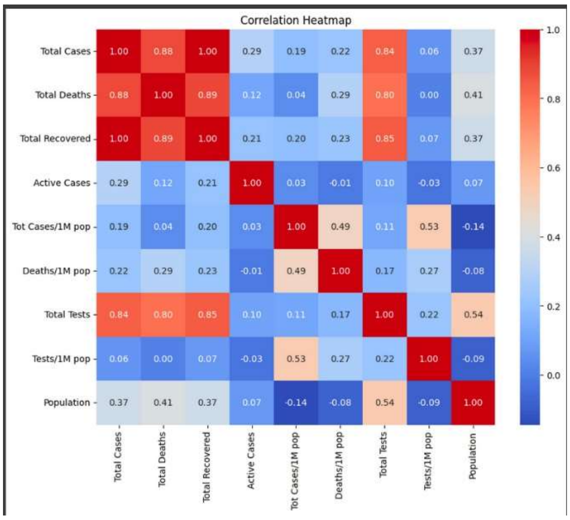
2. Dataset Description

We selected two datasets for this project:

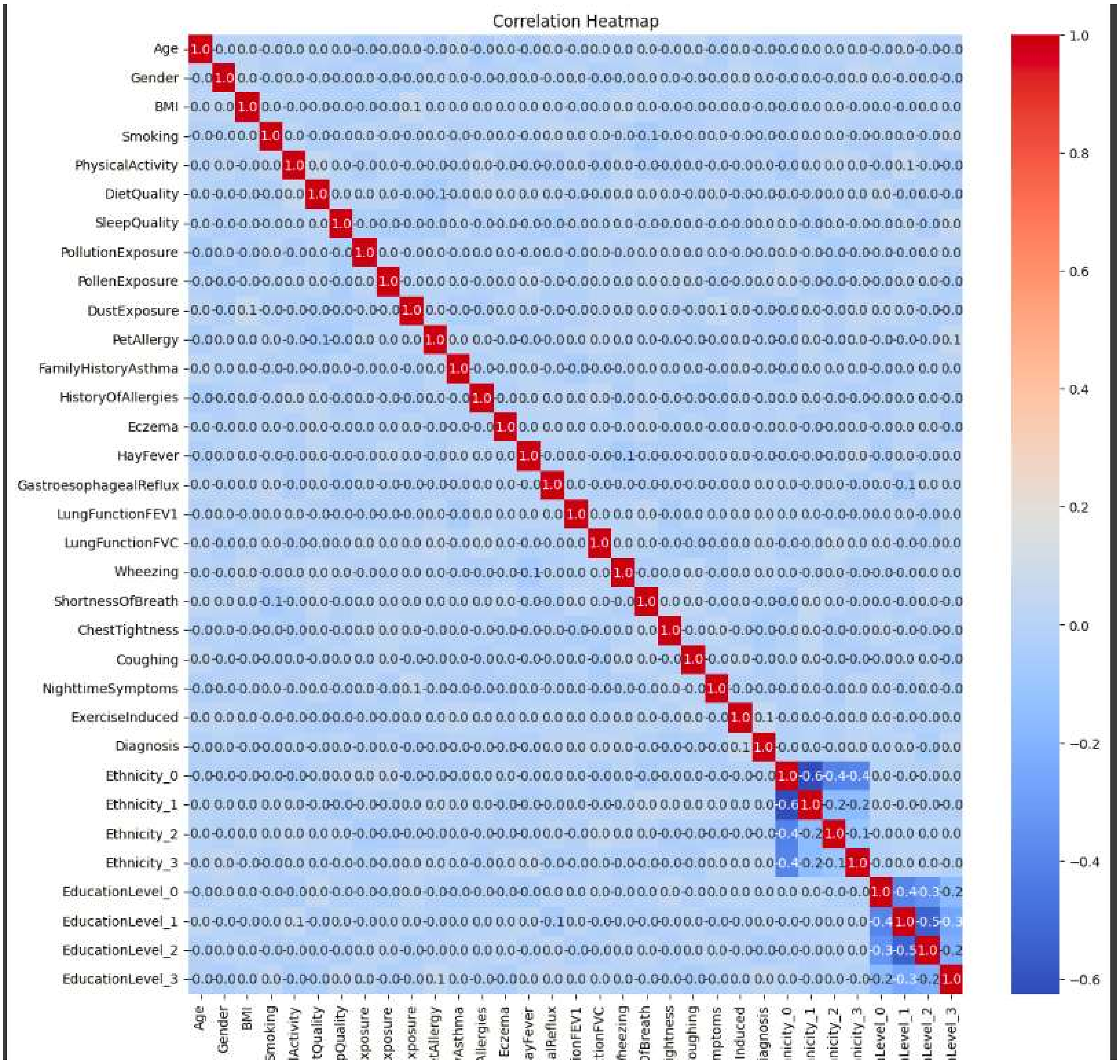
2.1 Regression Dataset

- **Dataset Name:** Corona Virus Dataset
- **Description:** This dataset includes features related to COVID-19 statistics, and the target variable is the total number of deaths.
- **Summary:**
    - Number of Rows: 232
    - Number of Columns: 13
    - Missing Values: 879
    - Data Types: Numerical



2.2 Classification Dataset

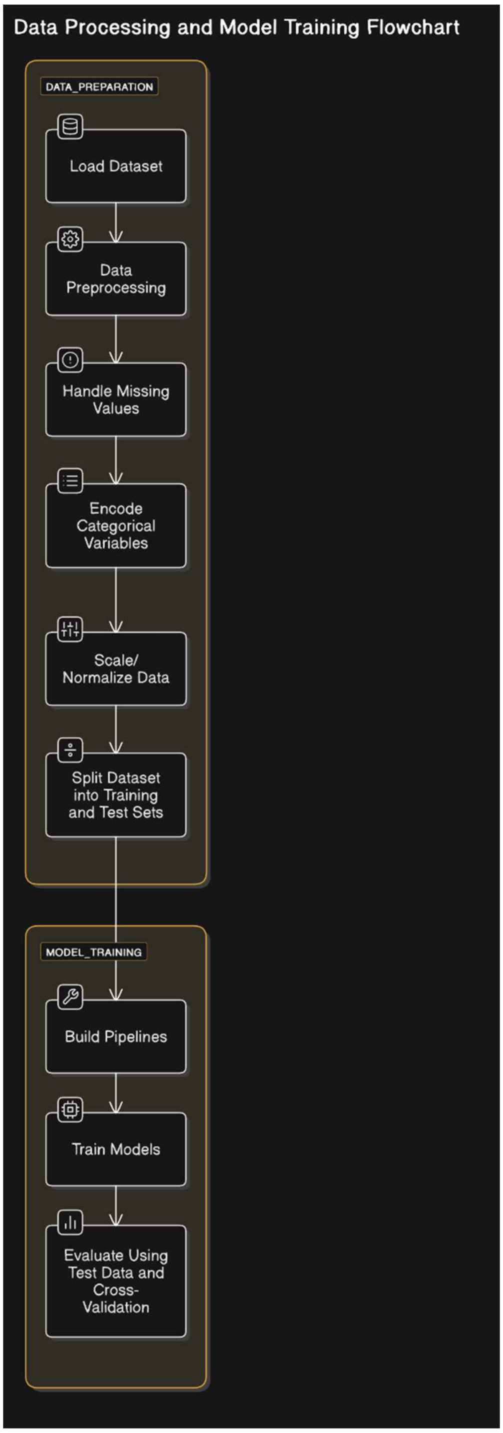
- **Dataset Name:** Asthma Dataset
- **Description:** This dataset contains features such as BMI, sleep quality, lung function metrics, and the target variable {Diagnosis} indicates whether a patient has asthma.
- **Summary:**
    - Number of Rows: 2392
    - Number of Columns: 29
    - Missing Values: 0
    - Data Types: Categorical, Numerical



3. Methodology

3.1 Flowchart

A flowchart of our approach is outlined below:


Data Processing and Model Training Flowchart
DATA_PREPARATION
Load Dataset
Data Preprocessing
Handle Missing Values
Encode Categorical Variables
Scale/ Normalize Data
Split Dataset into Training and Test Sets
MODEL_TRAINING
Build Pipelines
Train Models
Evaluate Using Test Data and Cross-Validation

3.2 Preprocessing

We applied the following preprocessing steps:

- **Handling Missing Values:** in the corona data set we dropped the columns that had more than 40% missing values.
- **Encoding Categorical Variables:** Used one-hot encoding for classification datasets.
- **Scaling/Normalization:** Applied Min-Max Scaling for regression and classification datasets to ensure model performance.

3.3 Models

We applied these models to each dataset:

- **Regression Models:**
    1. Linear Regression
    2. Decision Tree Regressor
    3. Random Forest Regressor
    4. SVR (support vector machine)
    5. K-nearest Neighbors
- **Classification Models:**
    1. Logistic Regression
    2. Support Vector Machine (SVC)
    3. K-Nearest Neighbors classifier
    4. Decision tree classifier
    5. Random forest classifier
    6. Naïve Bayes

3.4 Parameters

Default parameters were used initially.

4. Results

4.1 Regression Results

Model	Test R^2 Score	Mean Cross-Validation R^2
Linear Regression	1.0	1.0
Decision Tree Regressor	0.493	-0.5507
Random Forest Regressor	0.606	-11.25

4.2 Classification Results

Model	Test Accuracy	Mean Cross-Validation Accuracy
Logistic Regression	0.958	0.948
Support Vector Machine	0.9582	0.948
K-Nearest Neighbors	0.956	0.946

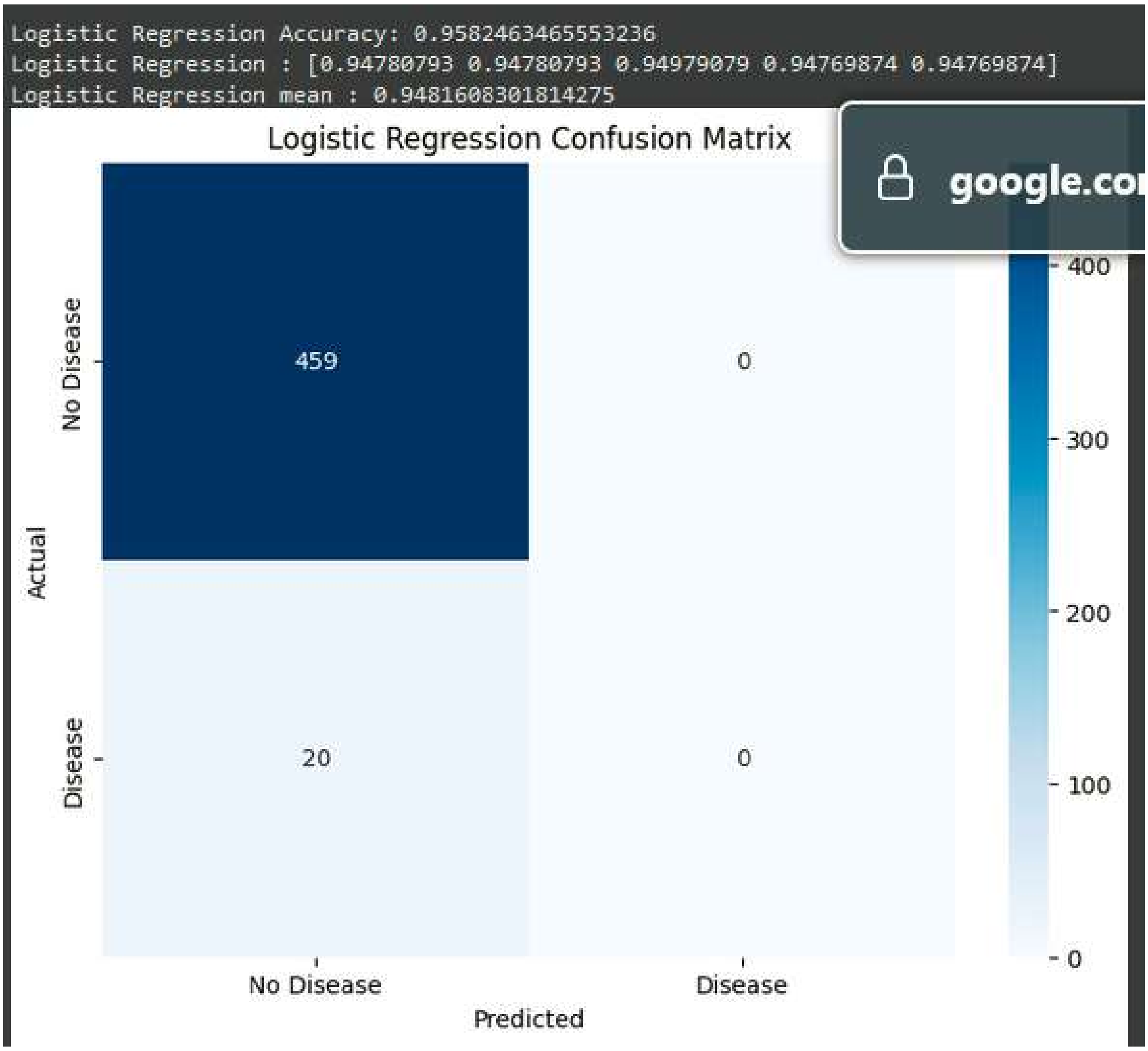
4.3 Discussion of Results

Regression:

- **Linear Regression performed excellently, with both test and cross-validation R^2 scores at 1.0, indicating a perfect fit for the data.**
- **Decision Tree Regressor and Random Forest Regressor showed poor performance, especially in cross-validation. The negative values in cross-validation R^2 for both models (e.g., Decision Tree: -0.5507 and Random Forest: -11.25) suggest that these models overfitted to the training data. In simple terms, they captured noise or irrelevant patterns in the data rather than the true underlying relationship.**
  - **The negative R^2 occurs when the model performs worse than a simple mean-based prediction. It indicates that the model is not generalizing well to unseen data, resulting in poor performance on cross-validation folds.**
  - **This issue could also be due to the high number of missing values in the Corona Virus dataset, which may lead to instability in tree-based models without proper handling of missing data or feature engineering.**

Classification:

- **Logistic Regression and SVM performed well with consistent results, while KNN showed slightly lower accuracy but was still strong.**
- **Random Forest and Decision Tree Classifiers performed reasonably well, but their results were slightly lower, suggesting that simpler models could perform just as well for this task.**



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Logistic Regression Accuracy: 0.9582463465553236
Logistic Regression : [0.94780793 0.94780793 0.94979079 0.94769874 0.94769874]
Logistic Regression mean : 0.9481608301814275
```

Cross-Validation:

Cross-validation highlighted the overfitting issue in regression models, where models like Decision Tree and Random Forest did well on the training data but failed to generalize, leading to negative R^2 scores.

5. Conclusion

The negative cross-validation scores in the regression task reflect overfitting, where complex models failed to generalize to unseen data. Linear Regression performed the best, while tree-based models (e.g., Decision Tree and Random Forest) need further tuning or preprocessing to improve generalization.

Code Co-Lab Link

Asthma model

https://colab.research.google.com/drive/1h6CCehtIw2vktLDyfbT1HhkeFzjBAFad?usp=sharing

coronavirus model

https://colab.research.google.com/drive/1FqMxzHnKtOzw7lITS47re8bq3bf4OnyQ?usp=sharing