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QPE studies

Responsible Machine Learning

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**Project**

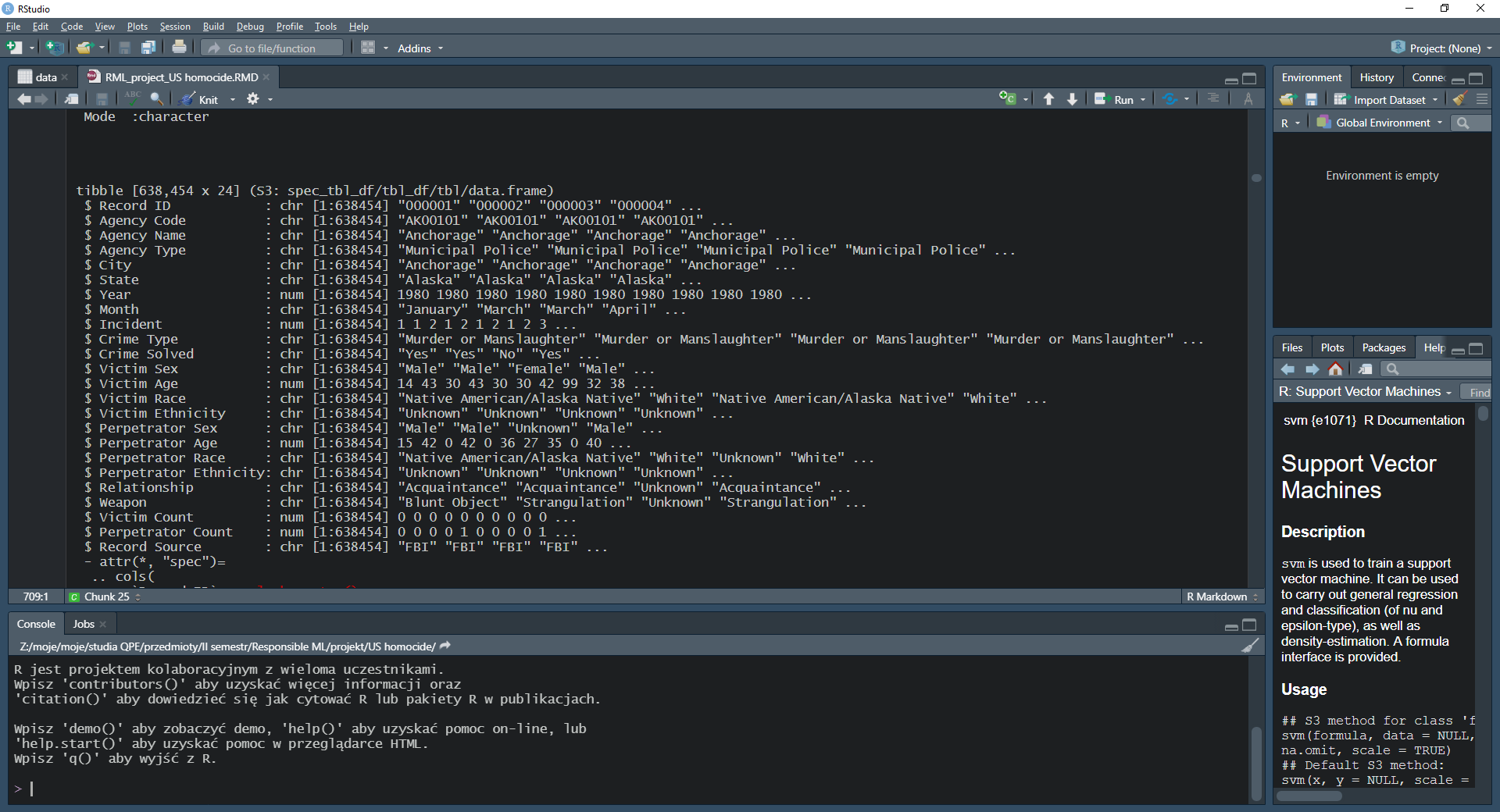
**Introduction**

**Data**

The Murder Accountability Project is the most complete database of homicides in the United States currently available. This dataset includes murders from the FBI's Supplementary Homicide Report from 1976 to the present.

Dataset comes from Kaggle (https://www.kaggle.com/murderaccountability/homicide-reports).

The dataset consists of nearly 640,000 crime cases. They are described by 24 variables, for example City, State, Year, Crime Type, Victim's Age, Perpetrator's Age and Weapon Used.



**Stakeholder**

A stakeholder could be associated with a public authority aiming at ensuring that – in a case of a murder – identical effort is put into investigation with no regard for the victim’s race, sex or age. As a result similar crimes should be solved (alternatively not solved) independent of the victim’s race, sex and age.

The stakeholder is thus interested in evaluating the model’s general performance. Their goal is to analyze whether there is some bias in police investigations towards certain social groups, which effectively results in a lower rate of solved crimes for those groups.

**Target variable**

* Crime Solved

**Explanatory variables**

* Agency Type (e.g. County Police, State Police, etc.)
* Victim’s Sex (Female, Male)
* Victim’s Race (e.g. Black, White, Native, etc.)
* Victim’s Age ( continuous 18-100 years old)
* Weapon (e.g. Knife, Gun, Poison, etc.)
* Victim’s Count ( how many additional victims there were – integral 0 – 10 people)

**Protected variables**

* Victim’s Sex
* Victim’s Race
* Victim’s Age

**ML algorithms and variables**

I plan to use two machine learning algorithms:

1. LogisticRegression
2. Random Forest

Below I present some initial results.

1. Logistic regression

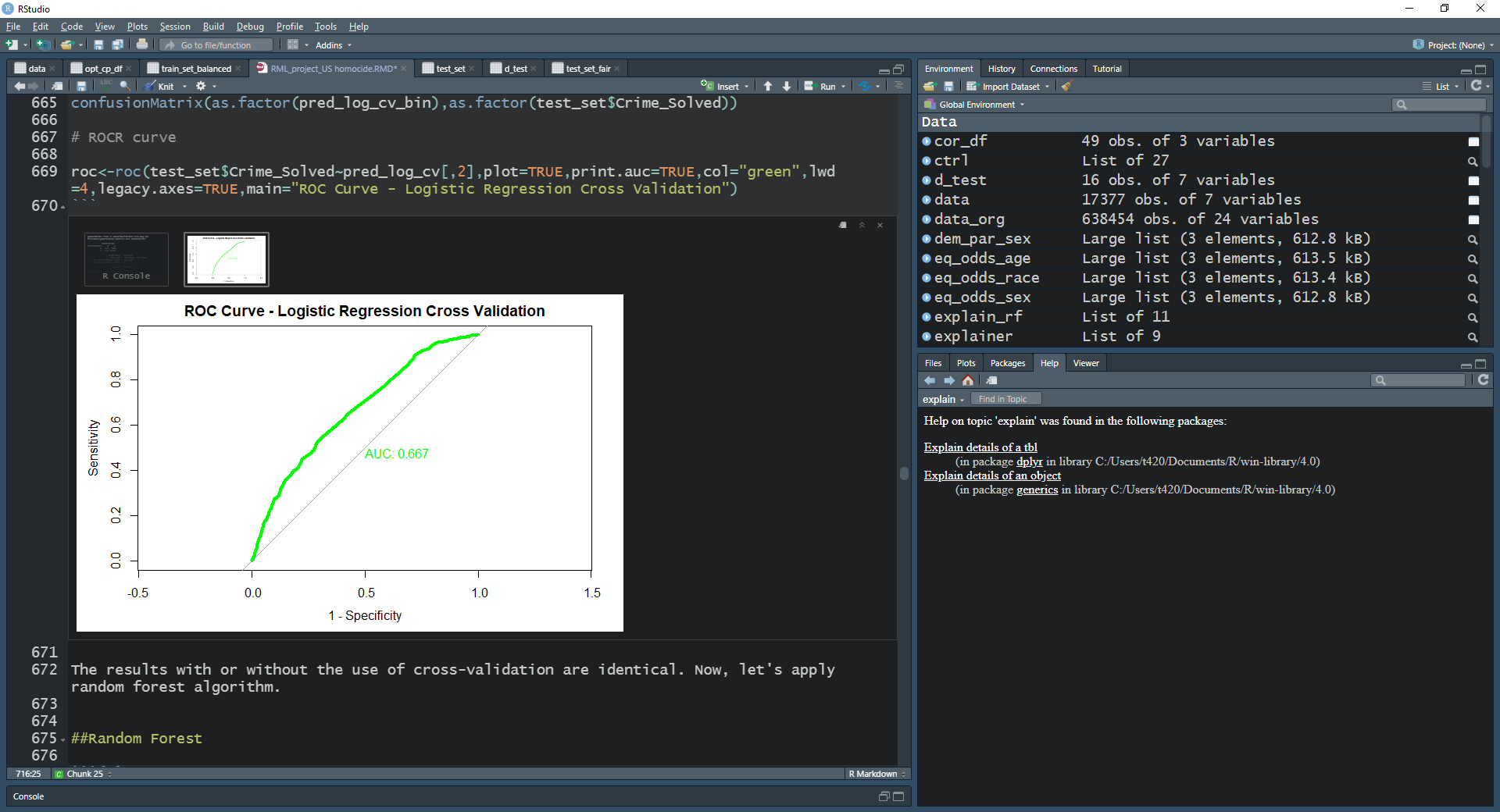
Obraz zawierający tekst

Opis wygenerowany automatycznieI received the following confusion matrix ( in a confusion matrix -1 denotes that crime was solved and 0 denotes that crime was not solved).

Obraz zawierający tekst

Opis wygenerowany automatycznie

… and ROC plot.



I tried to improve the results by running 10-fold cross validation on the training set, but the results were the same as with the simple logistic regression.

1. **Random Forest**

I have run the following analysis**.**

Obraz zawierający tekst

Opis wygenerowany automatycznie

I used 100 trees in the random forest formula, as error rates are stable then.

Obraz zawierający tekst, monitor, komputer, zrzut ekranu

Opis wygenerowany automatycznie

Out-of-bag error depending on the number of variables evaluated at each step of random forest (from 1 variable to max 6 variables). Error rate does not improve almost at all after 2 variables.

Obraz zawierający tekst, zrzut ekranu, monitor, computer

Opis wygenerowany automatycznie

Variable importance plot below.

Obraz zawierający tekst, zrzut ekranu, monitor, komputer

Opis wygenerowany automatycznie

Confusion matrix for random forest.

Obraz zawierający tekst, computer, komputer, monitor

Opis wygenerowany automatycznie

ROC plot is the same as for logistic regression with similar results as for logistic regression.

Obraz zawierający tekst, monitor, komputer, zrzut ekranu

Opis wygenerowany automatycznie

**Methods to analyze explainability and fairness**

For explainability and fairness analysis I will use random forest model, as its accuracy is only slightly worse than logistic regression, but it performs much better in terms of identifying true positives ( in our case “0” – i.e. crime unsolved is associated with positive results -> sensitivity for random forest is at 75% compared to 40% for logistic regression.

In order to analyze explainability and fairness of the model I intent to use the following methods:

**Explainability:**

**Global level (model)**

* Feature Importance Plots
* Partial Dependence Plots

**Local level (instance)**

* Shapley Values
* LIME

**Fairness:**

* Predictive rate parity
* Demographic parity
* Proportional parity
* Equalized odds