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Факультет «Информатика и системы управления»
Кафедра «Системы обработки информации и управления»


**Отчет**

**Лабораторная работа №4**

**По курсу Технологии машинного обучения»**

**ИСПОЛНИТЕЛЬ:**
Кожуро Б.Е.
Группа ИУ5-65Б

**ПРЕПОДАВАТЕЛЬ:**
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"__"_____2021 г.

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# Lab4

May 22, 2021

[1]:
```
import pandas as pd
from sklearn.preprocessing import LabelEncoder, StandardScaler
from sklearn.model_selection import train_test_split
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
sns.set(style="ticks")
import numpy as np
from typing import Dict, Tuple

from sklearn.metrics import mean_absolute_error, mean_squared_error,␣
 ↪mean_squared_log_error, median_absolute_error, r2_score
from sklearn.metrics import classification_report
from sklearn.metrics import plot_roc_curve, plot_precision_recall_curve
from sklearn.model_selection import cross_validate, KFold, StratifiedKFold
from sklearn.model_selection import GridSearchCV, RandomizedSearchCV
from scipy.stats import uniform, randint
from sklearn.model_selection import validation_curve, learning_curve

from sklearn.linear_model import ElasticNet
from sklearn.svm import SVR
from sklearn.tree import DecisionTreeRegressor, export_graphviz
from IPython.display import Image
from io import StringIO

import graphviz
import pydotplus
```

[2]:
```
data = pd.read_csv('data/Admission_Predict_Ver1.1.csv', sep=',')
```

[3]:
```
data.shape
```

[3]:
```
(500, 9)
```

[4]:
```
data.info()
data.drop(columns=data.columns[0], inplace=True)
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 500 entries, 0 to 499
Data columns (total 9 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   Serial No.         500 non-null    int64  
 1   GRE Score          500 non-null    int64  
 2   TOEFL Score        500 non-null    int64  
 3   University Rating  500 non-null    int64  
 4   SOP                500 non-null    float64
 5   LOR                500 non-null    float64
 6   CGPA               500 non-null    float64
 7   Research           500 non-null    int64  
 8   Chance of Admit    500 non-null    float64
dtypes: float64(4), int64(5)
memory usage: 35.3 KB
```

[5]:
```
data.duplicated().sum()
```

[5]:
```
0
```

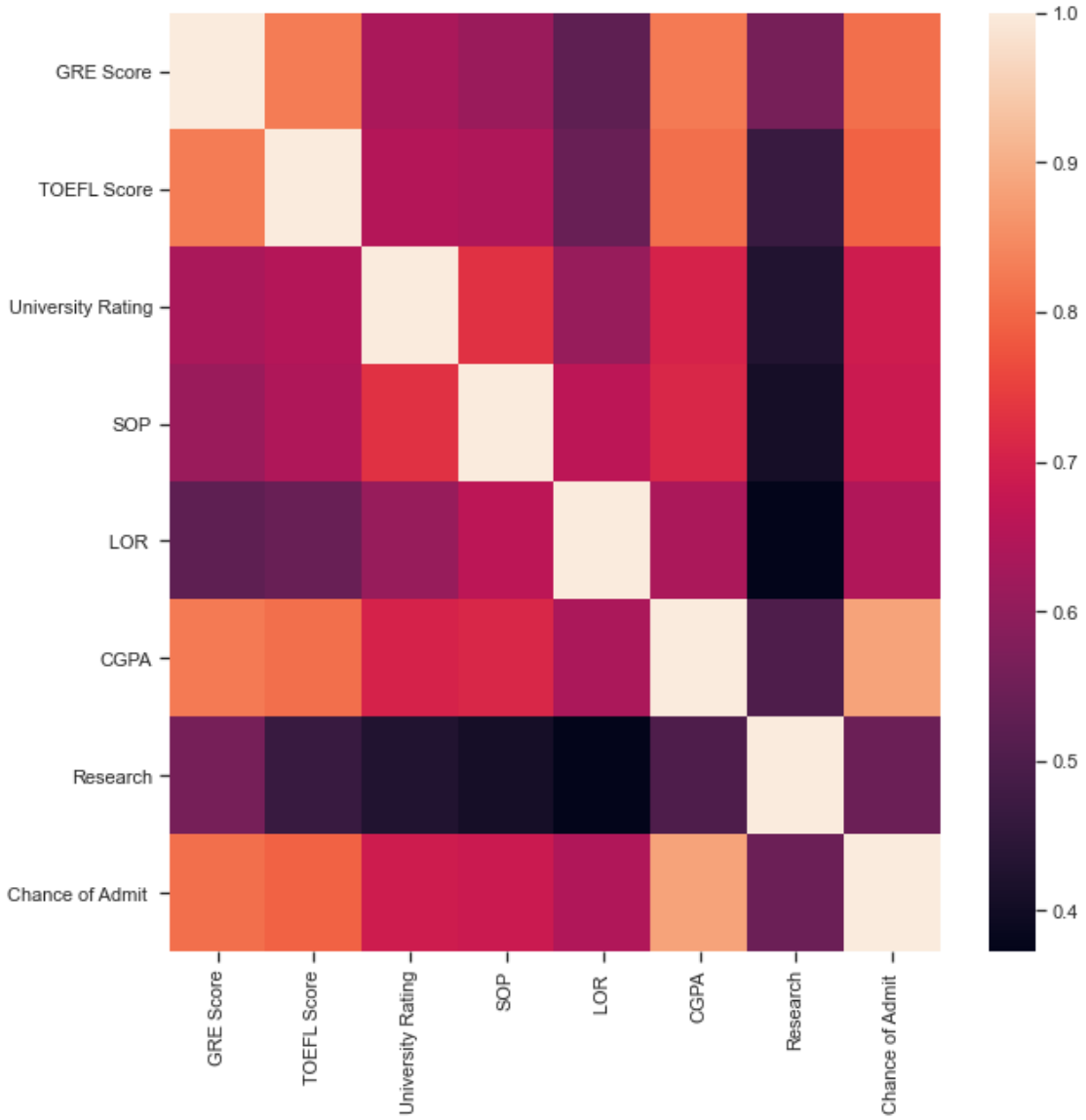
[6]:
```
col_num = data.dtypes[data.dtypes!=object].index.values.tolist()
col_num.remove("Chance of Admit ")
se = StandardScaler()
data[col_num] = se.fit_transform(data[col_num])
```

[7]:
```
data.head()
```

[7]:

| | GRE Score | TOEFL Score | University Rating | SOP | LOR | CGPA | Research | Chance of Admit |
|---|---|---|---|---|---|---|---|---|
| 0 | 1.819238 | 1.778865 | 0.775582 | 1.137360 | 1.098944 | 1.776806 | 0.886405 | 0.92 |
| 1 | 0.667148 | -0.031601 | 0.775582 | 0.632315 | 1.098944 | 0.485859 | 0.886405 | 0.76 |
| 2 | -0.041830 | -0.525364 | -0.099793 | -0.377773 | 0.017306 | -0.954043 | 0.886405 | 0.72 |
| 3 | 0.489904 | 0.462163 | -0.099793 | 0.127271 | -1.064332 | 0.154847 | 0.886405 | 0.80 |
| 4 | -0.219074 | -0.689952 | -0.975168 | -1.387862 | -0.523513 | -0.606480 | -1.128152 | 0.65 |

[8]:
```
plt.figure(figsize=(10,10))
g = sns.heatmap(data.corr())
```




[9]:
```
data.corr()["TOEFL Score"].sort_values(ascending=False)
```

[9]:
```
TOEFL Score          1.000000
GRE Score            0.827200
CGPA                 0.810574
Chance of Admit      0.792228
University Rating    0.649799
SOP                  0.644410
LOR                  0.541563
Research             0.467012
Name: TOEFL Score, dtype: float64
```

[10]:
```
data.corr()["GRE Score"].sort_values(ascending=False)
```

[10]:
```
GRE Score            1.000000
TOEFL Score          0.827200
CGPA                 0.825878
Chance of Admit      0.810351
University Rating    0.635376
SOP                  0.613498
Research             0.563398
LOR                  0.524679
Name: GRE Score, dtype: float64
```

[11]:
```
data.corr()["CGPA"].sort_values(ascending=False)
```

[11]:
```
CGPA                 1.000000
Chance of Admit      0.882413
GRE Score            0.825878
TOEFL Score          0.810574
SOP                  0.712154
University Rating    0.705254
LOR                  0.637469
Research             0.501311
Name: CGPA, dtype: float64
```

3

,

[12]:
```
TEST_SIZE = 0.3
RANDOM_STATE = 0
SPLITS_DEFAULT = 5
CROSS_VAL = StratifiedKFold(n_splits=SPLITS_DEFAULT)
```

[13]:
```
data_deleted1 = data.drop(columns='TOEFL Score')
data_deleted2 = data.drop(columns= ["TOEFL Score", "GRE Score"])
```

[14]:
```
data_X = data.drop(columns='Chance of Admit ')
data_Y = data['Chance of Admit ']
data_d1_X = data_deleted1.drop(columns='Chance of Admit ')
data_d1_Y = data_deleted1['Chance of Admit ']
data_d2_X = data_deleted2.drop(columns='Chance of Admit ')
data_d2_Y = data_deleted2['Chance of Admit ']
```

[15]:
```
data_X_train, data_X_test, data_Y_train, data_Y_test = train_test_split \
(data_X, data_Y, test_size = TEST_SIZE, random_state = RANDOM_STATE)
data_d1_X_train, data_d1_X_test, data_d1_Y_train, data_d1_Y_test =␣
 ↪train_test_split \
(data_d1_X, data_d1_Y, test_size = TEST_SIZE, random_state = RANDOM_STATE)
```

```
data_d2_X_train, data_d2_X_test, data_d2_Y_train, data_d2_Y_test =␣
↪train_test_split \
(data_d2_X, data_d2_Y, test_size = TEST_SIZE, random_state = RANDOM_STATE)
```

[16]:
```
def print_metrics(X_train, Y_train, X_test, Y_test, clf):
    clf.fit(X_train, Y_train)
    target = clf.predict(X_test)
    ret = (mean_squared_error(Y_test, target), median_absolute_error(Y_test,␣
↪target))
    print(f'RMSE: {ret[0]}, MedianAE: {ret[1]}')
    return ret
```

# 1

## 1.1

[17]:
```
from sklearn.linear_model import ElasticNet
from numpy import array
grid = RandomizedSearchCV(estimator=ElasticNet(),␣
↪param_distributions=[{'l1_ratio': uniform(loc=0, scale=1)}], cv=100,␣
↪scoring='neg_mean_squared_error')
grid.fit(data_X_train, data_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'l1_ratio': 0.018309914573411357}, score = -0.005650252003836783
```

[18]:
```
regression_full = print_metrics(data_X_train, data_Y_train,  data_X_test,␣
↪data_Y_test, ElasticNet(l1_ratio=grid.best_params_.get('l1_ratio')))
```

```
RMSE: 0.005271227890332877, MedianAE: 0.045644301907059426
```

## 1.2  1

[19]:
```
grid = RandomizedSearchCV(estimator=ElasticNet(),␣
↪param_distributions=[{'l1_ratio': uniform(loc=0, scale=1)}], cv=100,␣
↪scoring='neg_mean_squared_error')
grid.fit(data_X_train, data_Y_train)
grid.fit(data_d1_X_train, data_d1_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'l1_ratio': 0.47040556782174814}, score = -0.020902440142821548
```

[20]:
```
regression_d1 = print_metrics(data_d1_X_train, data_d1_Y_train, ␣
↪data_d1_X_test, data_d1_Y_test, ElasticNet(l1_ratio=grid.best_params_.
↪get('l1_ratio')))
```

```
RMSE: 0.018688403265306124, MedianAE: 0.08805714285714283
```

### 1.3 2

[21]:
```
grid = RandomizedSearchCV(estimator=ElasticNet(),␣
↪param_distributions=[{'l1_ratio': uniform(loc=0, scale=1)}], cv=100,␣
↪scoring='neg_mean_squared_error')
grid.fit(data_X_train, data_Y_train)
grid.fit(data_d2_X_train, data_d2_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'l1_ratio': 0.508462646612917}, score = -0.020902440142821548
```

[22]:
```
regression_d2 = print_metrics(data_d2_X_train, data_d2_Y_train, ␣
↪data_d2_X_test, data_d2_Y_test, ElasticNet(l1_ratio=grid.best_params_.
↪get('l1_ratio')))
```

```
RMSE: 0.018688403265306124, MedianAE: 0.08805714285714283
```

[23]:
```
print(f'    :{regression_full}')
print(f'  TOEFL :{regression_d1}')
print(f'  CGPA :{regression_d2}')
```

```
    :(0.005271227890332877, 0.045644301907059426)
  TOEFL :(0.018688403265306124, 0.08805714285714283)
  CGPA :(0.018688403265306124, 0.08805714285714283)
```

## 2 SVR

### 2.1

[24]:
```
grid = GridSearchCV(estimator=SVR(kernel='poly'), param_grid=[{'degree':␣
↪array([1, 2, 3, 4])}], cv=10, scoring='neg_mean_squared_error')
grid.fit(data_X_train, data_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'degree': 1}, score = -0.004299519020403193
```

[25]:
```
SVR_full = print_metrics(data_X_train, data_Y_train,  data_X_test, data_Y_test,␣
↪SVR(kernel='poly', degree=grid.best_params_.get('degree')))
```

```
RMSE: 0.004670952294593802, MedianAE: 0.04886169568948162
```

### 2.2 1

[26]:
```
grid = GridSearchCV(estimator=SVR(kernel='poly'), param_grid=[{'degree':␣
↪array([1, 2, 3, 4])}], cv=10, scoring='neg_mean_squared_error')
grid.fit(data_d1_X_train, data_d1_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'degree': 1}, score = -0.004583961888149202
```

[27]:
```
SVR_d1 = print_metrics(data_d1_X_train, data_d1_Y_train,  data_d1_X_test,␣
↪data_d1_Y_test, SVR(kernel='poly', degree=grid.best_params_.get('degree')))
```

```
RMSE: 0.004856996757379799, MedianAE: 0.05145831076268981
```

### 2.3 2

[28]:
```
grid = GridSearchCV(estimator=SVR(kernel='poly'), param_grid=[{'degree':␣
↪array([1, 2, 3, 4])}], cv=10, scoring='neg_mean_squared_error')
grid.fit(data_d2_X_train, data_d2_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'degree': 1}, score = -0.004819888838668563
```

[29]:
```
SVR_d2 = print_metrics(data_d2_X_train, data_d2_Y_train,  data_d2_X_test,␣
↪data_d2_Y_test, SVR(kernel='poly', degree=grid.best_params_.get('degree')))
```

```
RMSE: 0.005274152109453729, MedianAE: 0.05562094598525846
```

[30]:
```
print(f'    :{SVR_full}')
print(f'  TOEFL :{SVR_d1}')
print(f'  CGPA :{SVR_d2}')
```

```
   :(0.004670952294593802, 0.04886169568948162)
  TOEFL :(0.004856996757379799, 0.05145831076268981)
  CGPA :(0.005274152109453729, 0.05562094598525846)
```

SVM

## 3

[31]:
```
def get_png_tree(tree_model_param, feature_names_param):
    dot_data = StringIO()
    export_graphviz(tree_model_param, out_file=dot_data,␣
↪feature_names=feature_names_param,
                    filled=True, rounded=True, special_characters=True)
    graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
    return graph.create_png()
```

[32]:
```
def show_feature_importance(importance, col_names):
    data = pd.DataFrame({'feature_names':np.
↪array(col_names),'feature_importance':np.array(importance)})
    data.sort_values(by=['feature_importance'], ascending=False,inplace=True)

    plt.figure(figsize=(10,7))
    sns.barplot(x=data['feature_importance'], y=data['feature_names'])
    plt.title('Feature importance using DecisionTreeClassifier')
    plt.xlabel('importance')
    plt.ylabel('name')
```

### 3.1

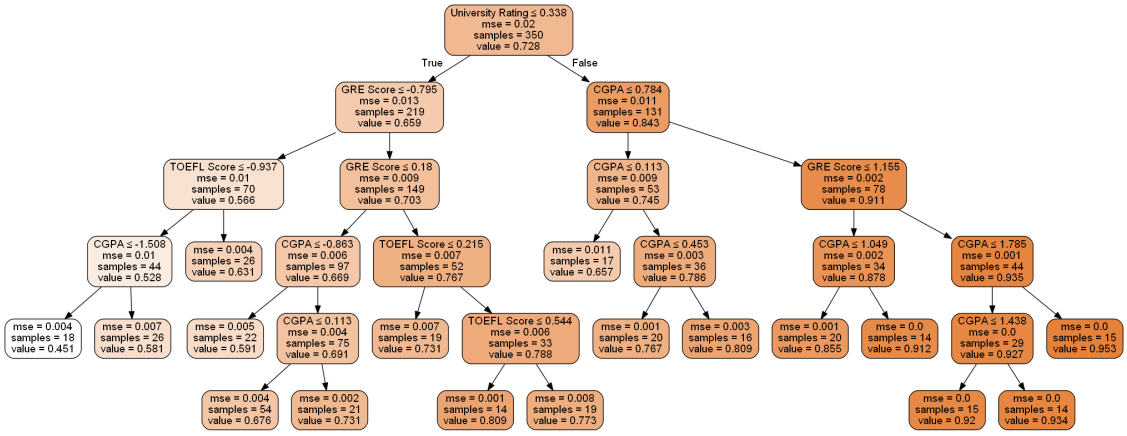
[33]:
```
params = {
    'max_depth': [3, 4, 5, 6],
    'min_samples_leaf': [0.04, 0.06, 0.08],
    'max_features': [0.2, 0.4, 0.6, 0.8]
}
```

[34]:
```
grid = GridSearchCV(estimator = DecisionTreeRegressor(random_state=1),␣
↪param_grid=params, cv=10, scoring='neg_mean_squared_error')
grid.fit(data_X_train, data_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
```

```
Best Param = {'max_depth': 5, 'max_features': 0.6, 'min_samples_leaf': 0.04},
score = -0.005291104228871576
```

[35]:
```
tree1 = DecisionTreeRegressor(random_state=1, \
                              max_depth = grid.best_params_.get('max_depth'),\
                              max_features = grid.best_params_.
↪get('max_features'),\
                              min_samples_leaf = grid.best_params_.
↪get('min_samples_leaf'))
tree1.fit(data_X_train, data_Y_train)
Image(get_png_tree(tree1, data_X_train.columns), height='100%')
```

[35]:




[36]:
```
tree_full = print_metrics(data_X_train, data_Y_train,  data_X_test,␣
↪data_Y_test, tree1)
```

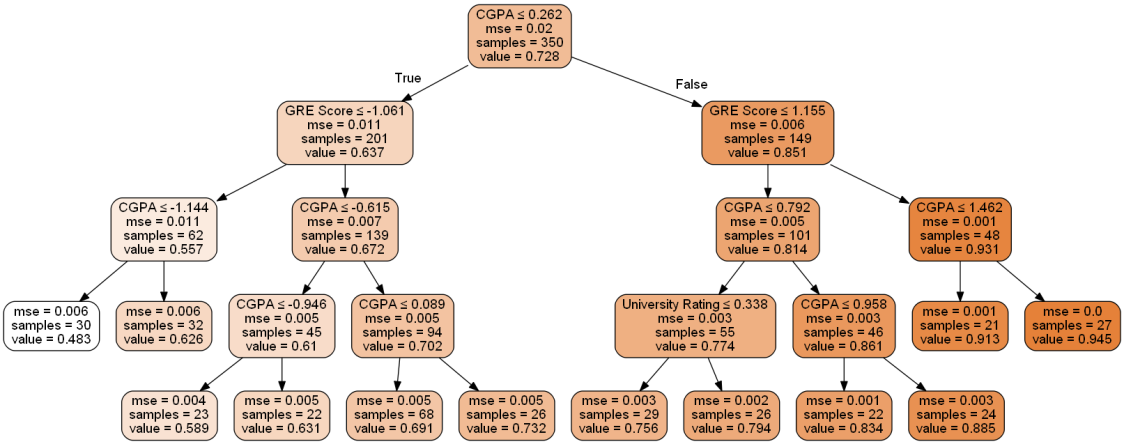
```
RMSE: 0.005205922348714913, MedianAE: 0.04076923076923067
```

### 3.2 1

[37]:
```
grid.fit(data_d1_X_train, data_d1_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
tree2 = DecisionTreeRegressor(random_state=1, \
                              max_depth = grid.best_params_.get('max_depth'),\
                              max_features = grid.best_params_.
 ↪get('max_features'),\
                              min_samples_leaf = grid.best_params_.
 ↪get('min_samples_leaf'))
tree2.fit(data_d1_X_train, data_d1_Y_train)
Image(get_png_tree(tree2, data_d1_X_train.columns), height='100%')
```

```
Best Param = {'max_depth': 4, 'max_features': 0.8, 'min_samples_leaf': 0.06},
score = -0.0049007423881750655
```

[37]:




[38]:
```
tree_d1 = print_metrics(data_d1_X_train, data_d1_Y_train,  data_d1_X_test,␣
 ↪data_d1_Y_test, tree2)
```

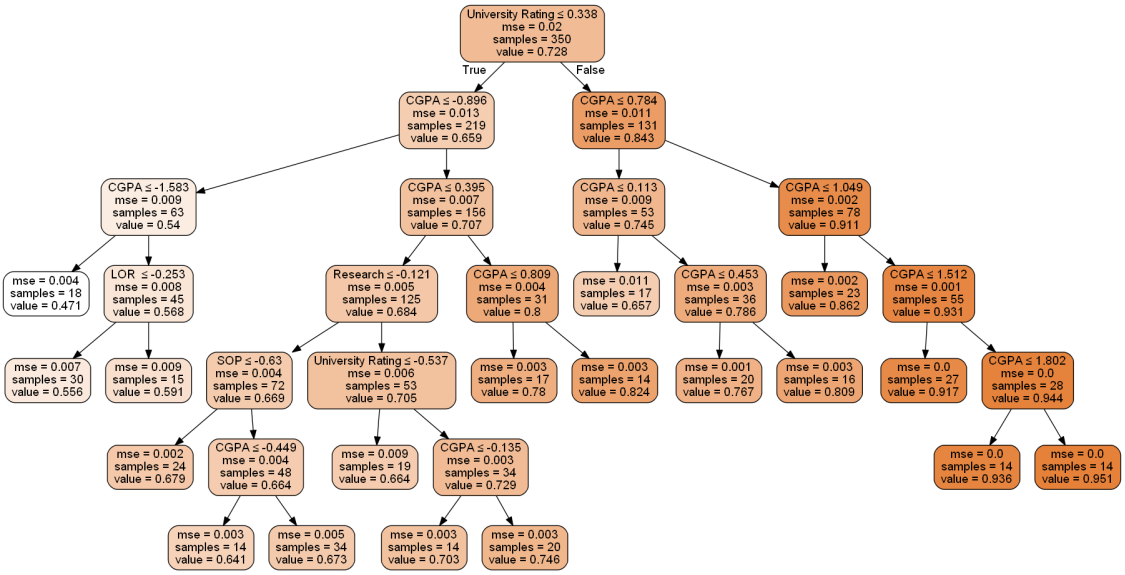
```
RMSE: 0.005302694813220191, MedianAE: 0.038950534759358224
```

### 3.3 2

[39]:
```
grid.fit(data_d2_X_train, data_d2_Y_train)
print(f'Best Param = {grid.best_params_}, score = {grid.best_score_}')
tree3 = DecisionTreeRegressor(random_state=1, \
                              max_depth = grid.best_params_.get('max_depth'),\
                              max_features = grid.best_params_.
 ↪get('max_features'),\
                              min_samples_leaf = grid.best_params_.
 ↪get('min_samples_leaf'))
tree3.fit(data_d2_X_train, data_d2_Y_train)
Image(get_png_tree(tree3, data_d2_X_train.columns), height='100%')
```

```
Best Param = {'max_depth': 6, 'max_features': 0.6, 'min_samples_leaf': 0.04},
score = -0.005260788113270196
```

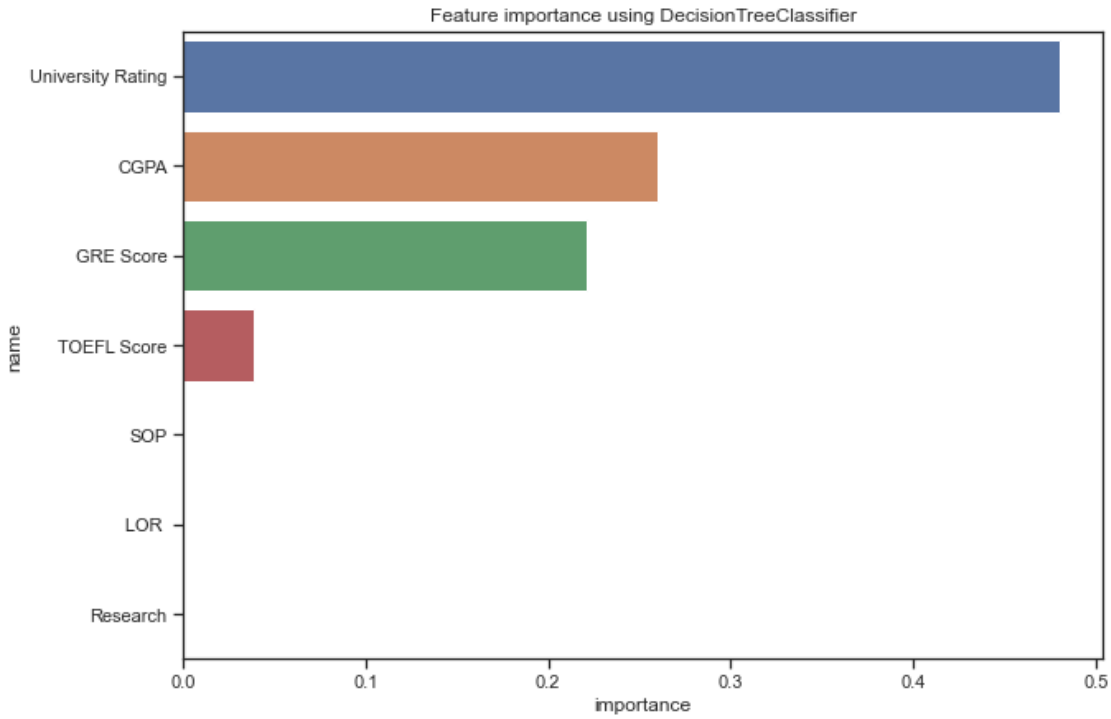
[39]:



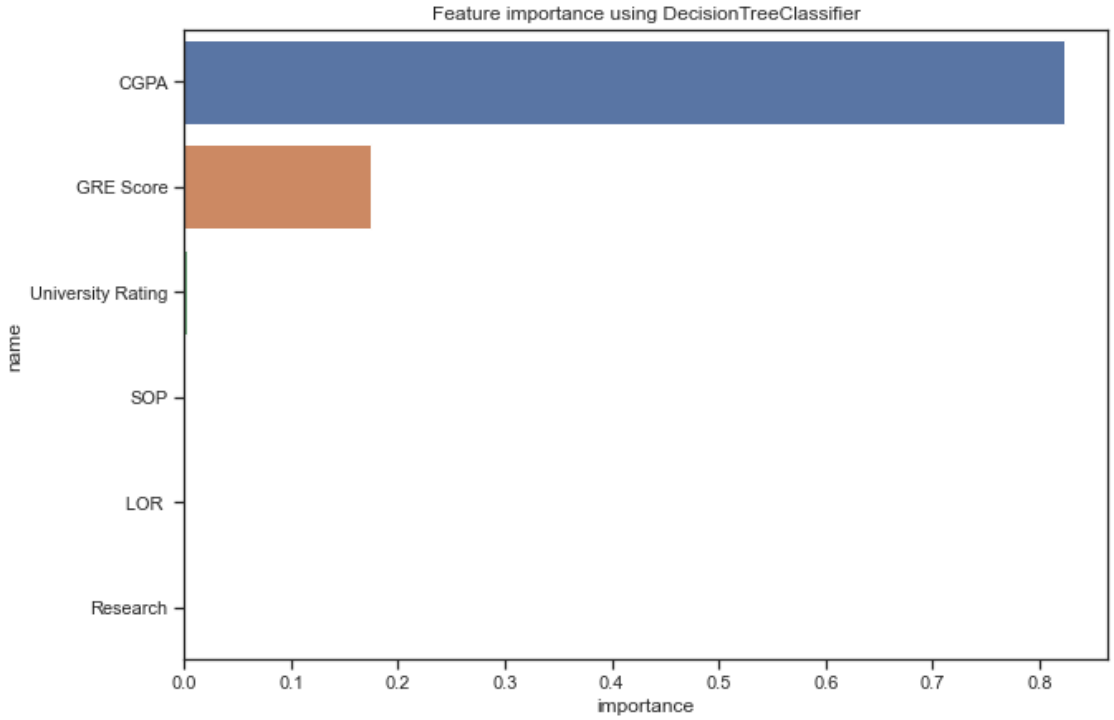

[40]:
```
tree_d2 = print_metrics(data_d2_X_train, data_d2_Y_train,  data_d2_X_test,␣
↪data_d2_Y_test, tree3)
```

```
RMSE: 0.004996184197120284, MedianAE: 0.036732804232804284
```

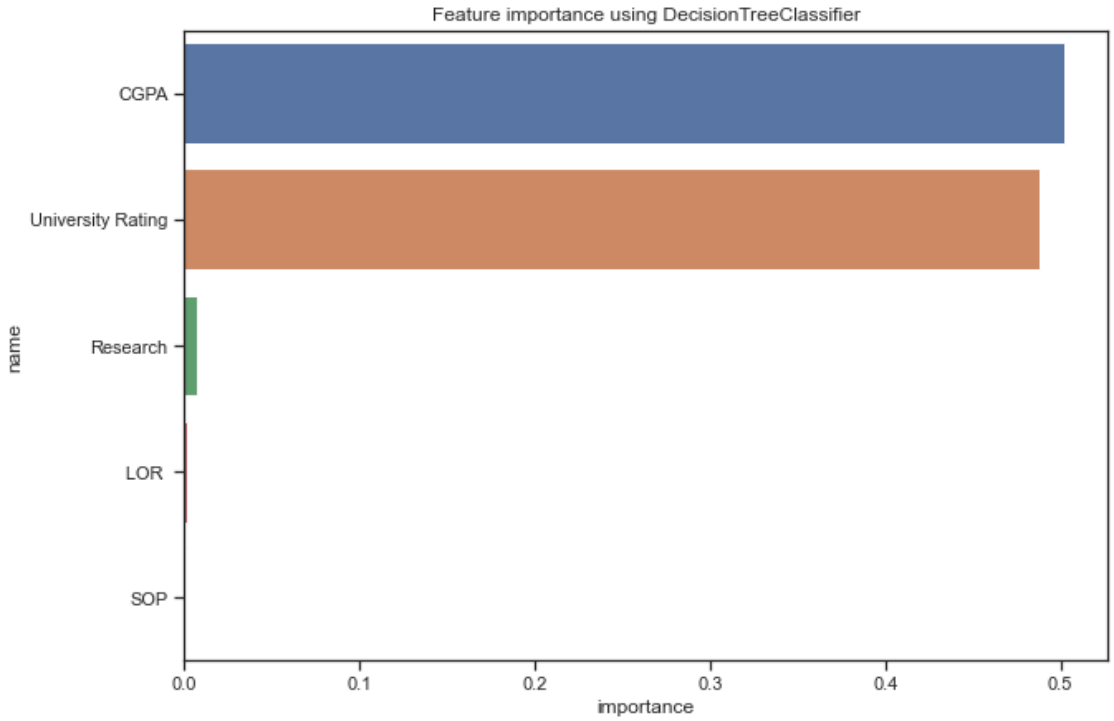
[41]:
```
show_feature_importance(tree1.feature_importances_, data_X_test.columns.
↪tolist())
```




[42]:
```
show_feature_importance(tree2.feature_importances_, data_d1_X_test.columns.
↪tolist())
```



[43]:
```
show_feature_importance(tree3.feature_importances_, data_d2_X_test.columns.
↪tolist())
```




[44]:
```
print(f'    :{tree_full}')
print(f'  TOEFL :{tree_d1}')
print(f'  CGPA :{tree_d2}')
```

```
   :(0.005205922348714913, 0.04076923076923067)
  TOEFL :(0.005302694813220191, 0.038950534759358224)
  CGPA :(0.004996184197120284, 0.036732804232804284)
```

## 4

[45]:
```
print('Linear')
print(f'    :{regression_full}')
print(f'  TOEFL :{regression_d1}')
print(f'  CGPA :{regression_d2}')
print('Vector')
print(f'    :{SVR_full}')
print(f'  TOEFL :{SVR_d1}')
print(f'  CGPA :{SVR_d2}')
```

```
print('tree')
print(f'    :{tree_full}')
print(f'  TOEFL :{tree_d1}')
print(f'  CGPA :{tree_d2}')
```

```
Linear
    :(0.005271227890332877, 0.045644301907059426)
  TOEFL :(0.018688403265306124, 0.08805714285714283)
  CGPA :(0.018688403265306124, 0.08805714285714283)
Vector
    :(0.004670952294593802, 0.04886169568948162)
  TOEFL :(0.004856996757379799, 0.05145831076268981)
  CGPA :(0.005274152109453729, 0.05562094598525846)
tree
    :(0.005205922348714913, 0.04076923076923067)
  TOEFL :(0.005302694813220191, 0.038950534759358224)
  CGPA :(0.004996184197120284, 0.036732804232804284)
```

RMSE SVR , MedianAbsoluteError DecTree 2 .

[ ]: