# Alzheimers-Detection

August 31, 2023

Alzheimers detection dataset obtained from https://www.kaggle.com/datasets/taeefnajib/handwriting-data-to-detect-alzheimers-disease.

[ ]:
```
# Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

[ ]:
```
# Loading data
alz = pd.read_csv("alzheimers.csv")
```

## 1 Exploratory Data Analysis

[ ]:
```
# First 5 rows of data
alz.head(5)
```

[ ]:

| | ID | air_time1 | disp_index1 | gmrt_in_air1 | gmrt_on_paper1 | \ |
|---|---|---|---|---|---|---|
| 0 | id_1 | 5160 | 0.000013 | 120.804174 | 86.853334 | |
| 1 | id_2 | 51980 | 0.000016 | 115.318238 | 83.448681 | |
| 2 | id_3 | 2600 | 0.000010 | 229.933997 | 172.761858 | |
| 3 | id_4 | 2130 | 0.000010 | 369.403342 | 183.193104 | |
| 4 | id_5 | 2310 | 0.000007 | 257.997131 | 111.275889 | |

| | max_x_extension1 | max_y_extension1 | mean_acc_in_air1 | mean_acc_on_paper1 | \ |
|---|---|---|---|---|---|
| 0 | 957 | 6601 | 0.361800 | 0.217459 | |
| 1 | 1694 | 6998 | 0.272513 | 0.144880 | |
| 2 | 2333 | 5802 | 0.387020 | 0.181342 | |
| 3 | 1756 | 8159 | 0.556879 | 0.164502 | |
| 4 | 987 | 4732 | 0.266077 | 0.145104 | |

| | mean_gmrt1 | … | mean_jerk_in_air25 | mean_jerk_on_paper25 | \ |
|---|---|---|---|---|---|
| 0 | 103.828754 | … | 0.141434 | 0.024471 | |
| 1 | 99.383459 | … | 0.049663 | 0.018368 | |
| 2 | 201.347928 | … | 0.178194 | 0.017174 | |
| 3 | 276.298223 | … | 0.113905 | 0.019860 | |
| 4 | 184.636510 | … | 0.121782 | 0.020872 | |

```
   mean_speed_in_air25  mean_speed_on_paper25  num_of_pendown25  paper_time25  \
0             5.596487               3.184589                71         40120
1             1.665973               0.950249               129        126700
2             4.000781               2.392521                74         45480
3             4.206746               1.613522               123         67945
4             3.319036               1.680629                92         37285

   pressure_mean25  pressure_var25  total_time25  class
0      1749.278166     296102.7676        144605      P
1      1504.768272     278744.2850        298640      P
2      1431.443492     144411.7055         79025      P
3      1465.843329     230184.7154        181220      P
4      1841.702561     158290.0255         72575      P

[5 rows x 452 columns]
```

[ ]:
```
# Shape of data
alz.shape
```

[ ]:
```
(174, 452)
```

[ ]:
```
# Data information
alz.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 174 entries, 0 to 173
Columns: 452 entries, ID to class
dtypes: float64(300), int64(150), object(2)
memory usage: 614.6+ KB
```

[ ]:
```
# Checking for object column names
alz.select_dtypes(include = "object").columns.tolist()
```

[ ]:
```
['ID', 'class']
```

[ ]:
```
# Checking for missing values
alz.isna().sum() # No NA values
```

[ ]:
```
ID                0
air_time1         0
disp_index1       0
gmrt_in_air1      0
gmrt_on_paper1    0
                 ..
paper_time25      0
pressure_mean25   0
pressure_var25    0
```

```
total_time25       0
class              0
Length: 452, dtype: int64
```

## 2 Feature Engineering

[ ]:
```
# Removing ID column
alz = alz.drop("ID", axis = 1)
alz.head(5)
```

[ ]:

| | air_time1 | disp_index1 | gmrt_in_air1 | gmrt_on_paper1 | max_x_extension1 | \ |
|---|---|---|---|---|---|---|
| 0 | 5160 | 0.000013 | 120.804174 | 86.853334 | 957 | |
| 1 | 51980 | 0.000016 | 115.318238 | 83.448681 | 1694 | |
| 2 | 2600 | 0.000010 | 229.933997 | 172.761858 | 2333 | |
| 3 | 2130 | 0.000010 | 369.403342 | 183.193104 | 1756 | |
| 4 | 2310 | 0.000007 | 257.997131 | 111.275889 | 987 | |

| | max_y_extension1 | mean_acc_in_air1 | mean_acc_on_paper1 | mean_gmrt1 | \ |
|---|---|---|---|---|---|
| 0 | 6601 | 0.361800 | 0.217459 | 103.828754 | |
| 1 | 6998 | 0.272513 | 0.144880 | 99.383459 | |
| 2 | 5802 | 0.387020 | 0.181342 | 201.347928 | |
| 3 | 8159 | 0.556879 | 0.164502 | 276.298223 | |
| 4 | 4732 | 0.266077 | 0.145104 | 184.636510 | |

| | mean_jerk_in_air1 | … | mean_jerk_in_air25 | mean_jerk_on_paper25 | \ |
|---|---|---|---|---|---|
| 0 | 0.051836 | … | 0.141434 | 0.024471 | |
| 1 | 0.039827 | … | 0.049663 | 0.018368 | |
| 2 | 0.064220 | … | 0.178194 | 0.017174 | |
| 3 | 0.090408 | … | 0.113905 | 0.019860 | |
| 4 | 0.037528 | … | 0.121782 | 0.020872 | |

| | mean_speed_in_air25 | mean_speed_on_paper25 | num_of_pendown25 | paper_time25 | \ |
|---|---|---|---|---|---|
| 0 | 5.596487 | 3.184589 | 71 | 40120 | |
| 1 | 1.665973 | 0.950249 | 129 | 126700 | |
| 2 | 4.000781 | 2.392521 | 74 | 45480 | |
| 3 | 4.206746 | 1.613522 | 123 | 67945 | |
| 4 | 3.319036 | 1.680629 | 92 | 37285 | |

| | pressure_mean25 | pressure_var25 | total_time25 | class |
|---|---|---|---|---|
| 0 | 1749.278166 | 296102.7676 | 144605 | P |
| 1 | 1504.768272 | 278744.2850 | 298640 | P |
| 2 | 1431.443492 | 144411.7055 | 79025 | P |
| 3 | 1465.843329 | 230184.7154 | 181220 | P |
| 4 | 1841.702561 | 158290.0255 | 72575 | P |

[5 rows x 451 columns]

[ ]:
```
# Converting class to numeric
alz["class"] = alz["class"].replace({'P': 1, 'H': 0})
alz["class"]
```

[ ]:
```
0      1
1      1
2      1
3      1
4      1
      ..
169    0
170    0
171    0
172    0
173    0
Name: class, Length: 174, dtype: int64
```

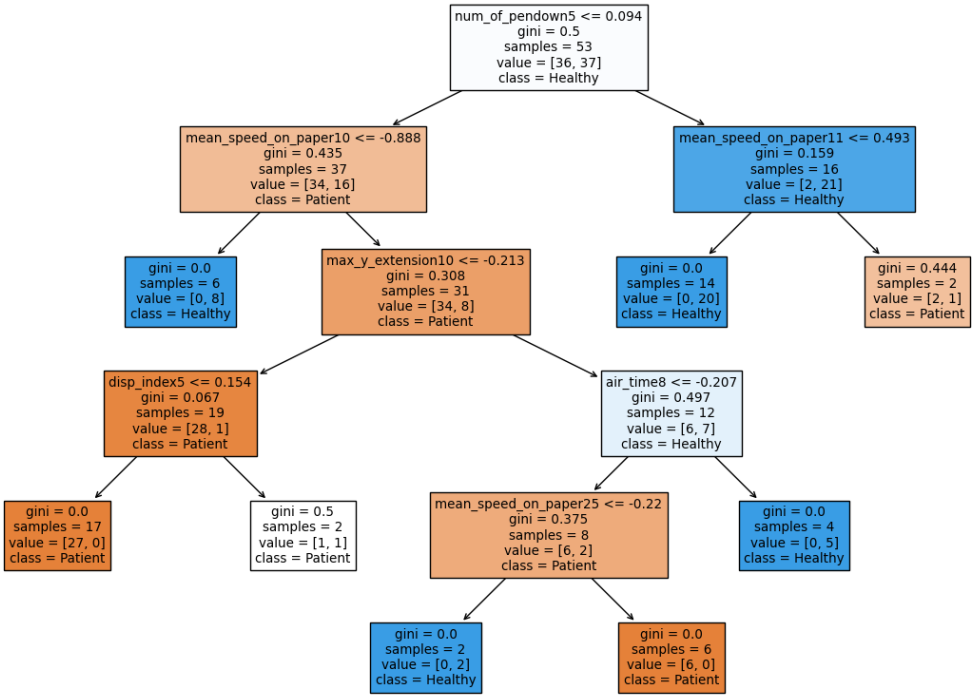
## 3 Model Training

[ ]:
```
from sklearn.model_selection import train_test_split

# Separating features from target
X = alz.drop(columns=["class"])
y = alz["class"]

# Training data with a 70/30 split
X_train, X_test, y_train, y_test = train_test_split(X, y, train_size = 0.7,␣
 ↪random_state = 42)
```

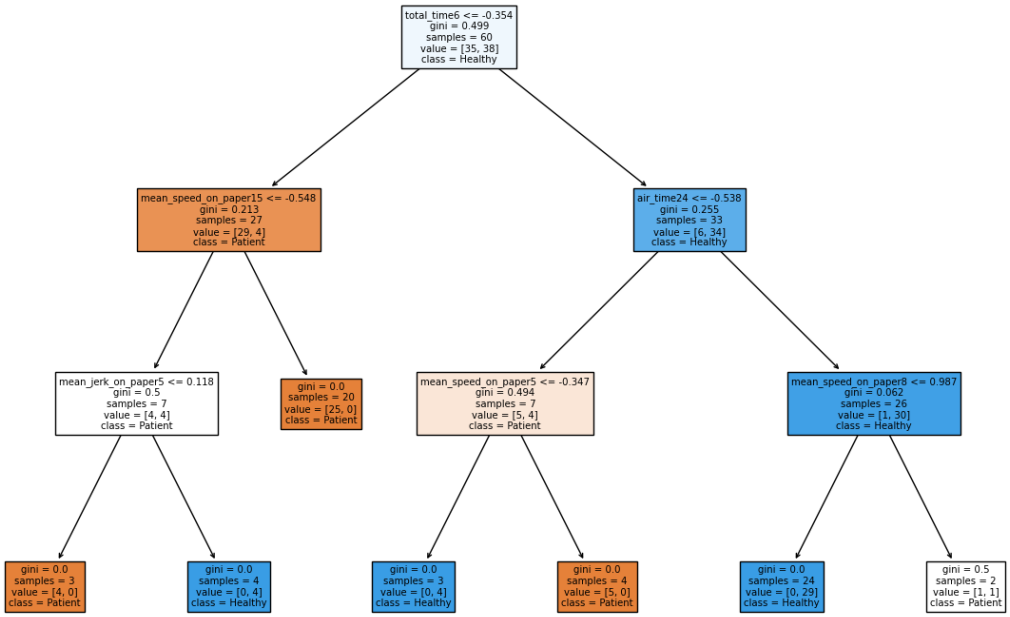
[ ]:
```
# Random Forest
from sklearn.ensemble import RandomForestClassifier
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.tree import plot_tree

# Creating random forest pipeline with scaled data
pipe = Pipeline([
    ('scaler', StandardScaler()),
    ('classifier', RandomForestClassifier(random_state = 42, max_samples = 0.6,␣
 ↪min_samples_leaf = 2))
])

# Fitting pipeline
pipe.fit(X_train, y_train)

# Predicting target values
```

```
y_pred = pipe.predict(X_test)
```

[ ]:
```
# Plotting first tree in the random forest
tree_viz = pipe.named_steps['classifier'].estimators_[0]

fig, ax = plt.subplots(figsize = (15, 10))

plot_tree(tree_viz, feature_names = alz.columns.tolist(), class_names =␣
 ↪["Patient", "Healthy"], filled = True)

plt.show()
```




[ ]:
```
# Plotting fiftieth tree in the random forest
tree_viz = pipe.named_steps['classifier'].estimators_[49]

fig, ax = plt.subplots(figsize = (15, 10))

plot_tree(tree_viz, feature_names = alz.columns.tolist(), class_names =␣
 ↪["Patient", "Healthy"], filled = True)

plt.show()
```



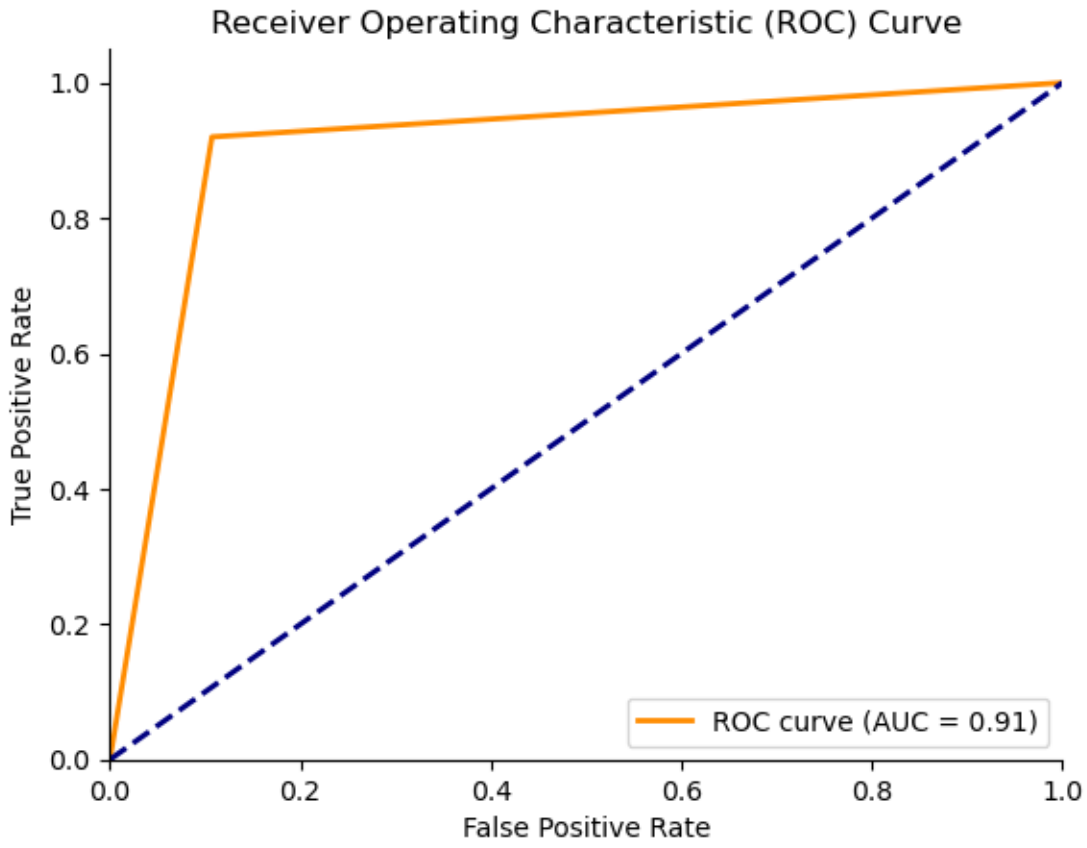

# 4 Results

[ ]:
```
from sklearn.metrics import f1_score

# F1 score is high so this random forest model is a good predictor of the target
f1 = f1_score(y_test, y_pred)
print("F1 Score:", f1)
```

```
F1 Score: 0.9019607843137256
```

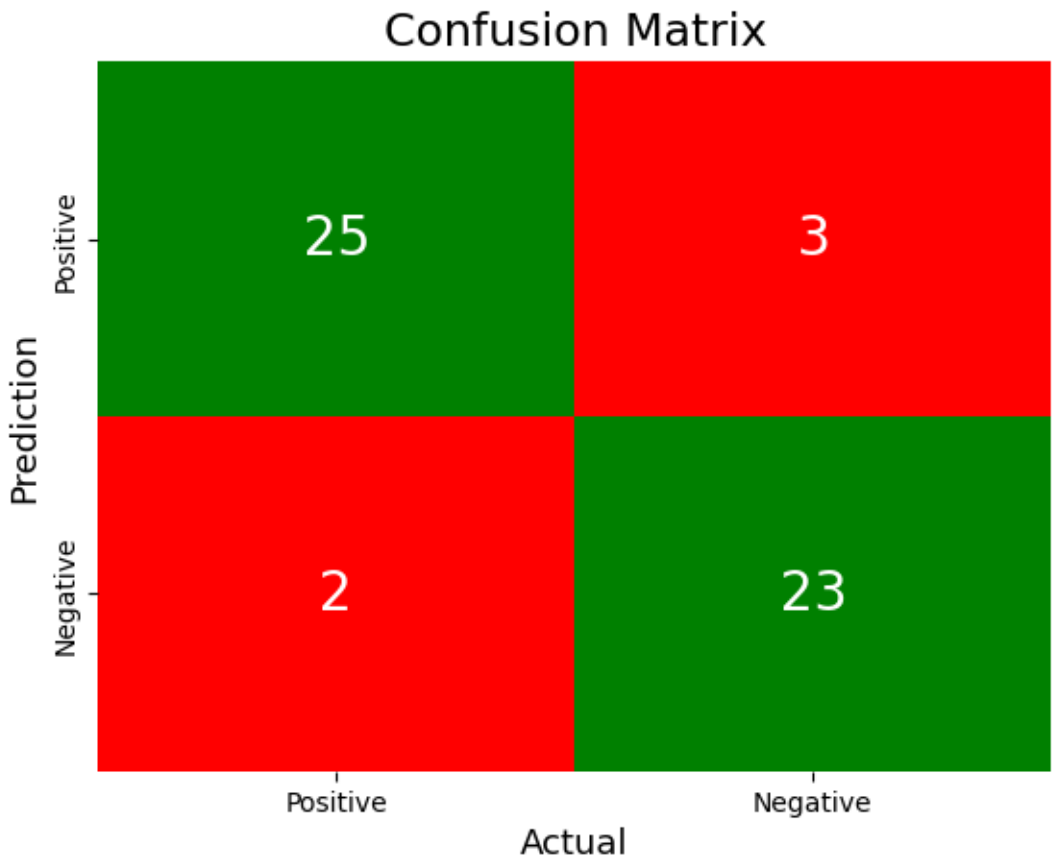
[ ]:
```
from sklearn.metrics import roc_auc_score, roc_curve

# False positive and true positive rates
fpr, tpr, _ = roc_curve(y_test, y_pred)

# AUC
auc = roc_auc_score(y_test, y_pred)

# Plotting ROC curve
fig, ax = plt.subplots()

ax.plot(fpr, tpr, color = 'darkorange', lw = 2, label = 'ROC curve (AUC = {:.
↪2f})'.format(auc))
```

```
ax.plot([0, 1], [0, 1], color = 'navy', lw = 2, linestyle = '--')

ax.set_xlim([0.0, 1.0])
ax.set_ylim([0.0, 1.05])
ax.set_xlabel('False Positive Rate')
ax.set_ylabel('True Positive Rate')
ax.set_title('Receiver Operating Characteristic (ROC) Curve')
ax.legend(loc = "lower right")

sns.despine()

plt.show()
```




[ ]:
```
from sklearn.metrics import confusion_matrix

# Creating confusion matrix
conf_matrix = confusion_matrix(y_test,y_pred)

# Plotting confusion matrix
fig, ax = plt.subplots()
```

```
sns.heatmap(conf_matrix,
            annot = True,
            fmt = 'g',
            xticklabels = ['Positive', 'Negative'],
            yticklabels = ['Positive', 'Negative'],
            cmap = ["Red", "Green", "Red", "Green"],
            cbar = False,
            annot_kws = {"size": 20},
            ax = ax)

ax.set_title('Confusion Matrix', fontsize = 17)
ax.set_ylabel('Prediction', fontsize = 13)
ax.set_xlabel('Actual', fontsize = 13)

plt.show()
```




[ ]:
```
# Creating TP/FP/TN/FN
TP = conf_matrix[1, 1]
```

```
FN = conf_matrix[1, 0]
TN = conf_matrix[0, 0]
FP = conf_matrix[0, 1]

# Printing results of predictions
accuracy = (TP + TN) / (TP + TN + FP + FN)
precision = (TP) / (TP + FP)
sensitivity = TP / (TP + FN)
specificity = TN / (TN + FP)

print("Accuracy:", accuracy)
print("Precision:", precision)
print("Sensitivity:", sensitivity)
print("Specificity:", specificity)
```

```
Accuracy: 0.9056603773584906
Precision: 0.8846153846153846
Sensitivity: 0.92
Specificity: 0.8928571428571429
```