8_wine_quality_prediction

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1 红酒质量预测

2 数据集字段

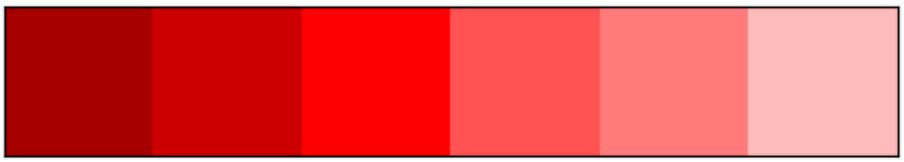
- 固定酸度: 固定酸度对应于一组低挥发性有机酸，例如苹果酸、乳酸、酒石酸或柠檬酸，并且是样品特性所固有的。
- 挥发性酸度：挥发性酸度是一个重要的感官参数，含量越高表明葡萄酒腐败。
- 柠檬酸：柠檬酸通常添加到葡萄酒中以增加酸度、补充特定风味或防止铁雾。它可以添加到成品葡萄酒中以增加酸度并赋予新鲜的风味。
- 残糖：残糖是酒精发酵完成后葡萄酒中残留的天然葡萄糖。
- 氯化物：它们是葡萄酒咸味的主要来源。
- 游离二氧化硫：二氧化硫 (SO2) 可以保存葡萄酒，防止氧化和褐变。
- 总二氧化硫：总二氧化硫 (TSO2) 是葡萄酒中游离 SO2 的部分加上与葡萄酒中其他化学物质（如醛、色素或糖）结合的部分。
- 密度：保持酒精含量恒定，密度对葡萄酒的质量影响很小，因为其他因素也会影响密度。
- pH 值：酿酒师使用 pH 值来衡量与酸度相关的成熟度。低 pH 值的葡萄酒尝起来又酸又脆，而高 pH 值的葡萄酒更容易受到细菌生长的影响。
- 硫酸盐：另一种硫酸盐的存在被认为有助于去除葡萄酒中的多种细菌（好细菌和坏细菌）。这似乎也会降低葡萄酒的质量，因为它会减弱葡萄酒的发酵过程。
- 酒精：酒精含量会影响葡萄酒的酒体，因为酒精比水更粘稠。酒精含量较高的葡萄酒，酒体会更加饱满、丰富，而酒精含量较低的葡萄酒，口感会更加清淡、细腻。
- 品质：葡萄酒的品质主要取决于酿造过程和葡萄的地理原产地，但也很大程度上取决于葡萄的品种组成。

[1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib.offsetbox import AnnotationBbox, OffsetImage
import matplotlib.image as mpimg

from sklearn.preprocessing import LabelEncoder, StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
```

```
from sklearn.ensemble import (
    RandomForestClassifier,
    GradientBoostingClassifier,
    AdaBoostClassifier,
)

from catboost import CatBoostClassifier
from xgboost import XGBClassifier

import lightgbm as lgbm

import sklearn.metrics as metrics
from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score

import optuna

import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras import Input
from tensorflow.keras.layers import Dense,Dropout,Conv2D,Flatten,MaxPooling2D
from tensorflow.keras.optimizers import Adam
from keras.callbacks import ReduceLROnPlateau
from tensorflow.keras.utils import plot_model

import warnings
warnings.filterwarnings('ignore')
```

```
/home/micuks/.conda/envs/tf2/lib/python3.10/site-packages/tqdm/auto.py:21:
TqdmWarning: IProgress not found. Please update jupyter and ipywidgets. See
https://ipywidgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
2023-08-01 18:30:53.223875: I tensorflow/core/platform/cpu_feature_guard.cc:193]
This TensorFlow binary is optimized with oneAPI Deep Neural Network Library
(oneDNN) to use the following CPU instructions in performance-critical
operations:  SSE4.1 SSE4.2 AVX AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate
compiler flags.
```

[2]:
```
# Set a color scheme
custom_colors=['#a70000','#cc0001','#ff0000','#ff5252','#ff7b7b','#ffbaba']
custom_palette=sns.set_palette(sns.color_palette(custom_colors))
sns.palplot(sns.color_palette(custom_colors),size=1)
plt.tick_params(axis='both',labelsize=0,length=0)
```



[3]:
```
# Reading the data
df=pd.read_csv('../dataset/winequality-red.csv')
df.head()
```

[3]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5
1	7.8	0.88	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	0.68	9.8	5
2	7.8	0.76	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	0.65	9.8	5
3	11.2	0.28	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	0.58	9.8	6
4	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5

[4]:
```
# Taking a look at the missing values of the dataset
print(df.isna().sum())
print('-'*10)
print('Total Missing Values = {}'.format(df.isna().sum().sum()))
print('-'*10)
```

```
fixed acidity           0
volatile acidity        0
citric acid             0
residual sugar          0
chlorides               0
free sulfur dioxide     0
total sulfur dioxide    0
density                 0
```

```
pH                    0
sulphates             0
alcohol               0
quality               0
dtype: int64
----------
Total Missing Values = 0
----------
```

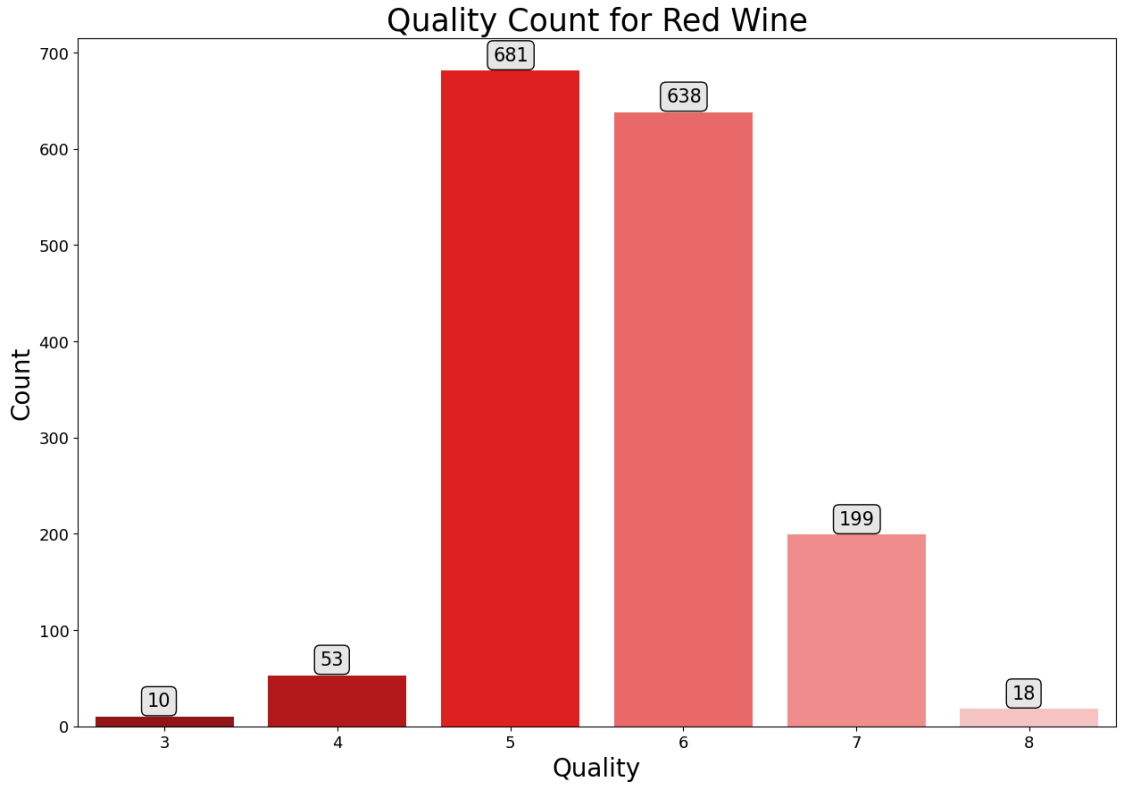
[5]:
```
# Taking a look at the statistical summary of the dataset
summary = pd.DataFrame(df.describe())
summary = (
    summary.style.background_gradient(cmap="Reds")
    .set_table_attributes('style="display: inline"')
    .set_caption("Statistics of the Dataset")
    .set_table_styles(
        [{"selector": "caption", "props": [("font-size", "16px")]}]
    )
)
summary
```

[5]: <pandas.io.formats.style.Styler at 0x7f8ee94c2410>

3 探索性数据分析 (EDA)

[6]:
```
plt.figure(figsize=(15, 10))
ax = sns.countplot(
    data=df,
    x="quality",
    palette=[
        custom_colors[0],
        custom_colors[1],
        custom_colors[2],
        custom_colors[3],
        custom_colors[4],
        custom_colors[5],
    ],
)

bbox_args = dict(boxstyle="round", fc="0.9")
for p in ax.patches:
    ax.annotate(
        "{:.0f}".format(p.get_height()),
        (p.get_x() + 0.3, p.get_height() + 10.5),
        color="black",
        bbox=bbox_args,
        fontsize=15,
```

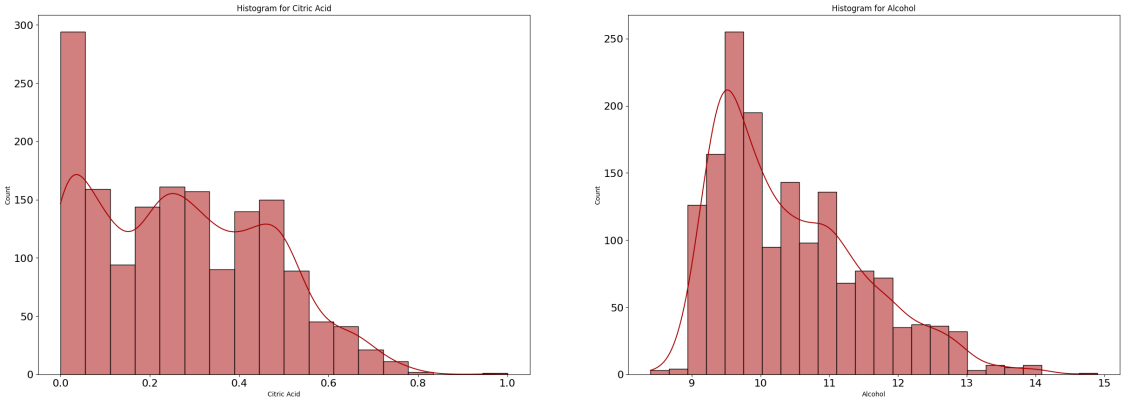
```
    )

plt.title("Quality Count for Red Wine", fontsize=25)
plt.xlabel("Quality", fontsize=20)
plt.ylabel("Count", fontsize=20)
plt.xticks(fontsize=13)
plt.yticks(fontsize=13)
plt.show()
```



观察: 质量为 **5** 的红酒是最多的, 质量为 **3** 的红酒是最少的. 在数据集中有**类不平衡**, 在开始训练机器学习模型之前需要对其进行修复

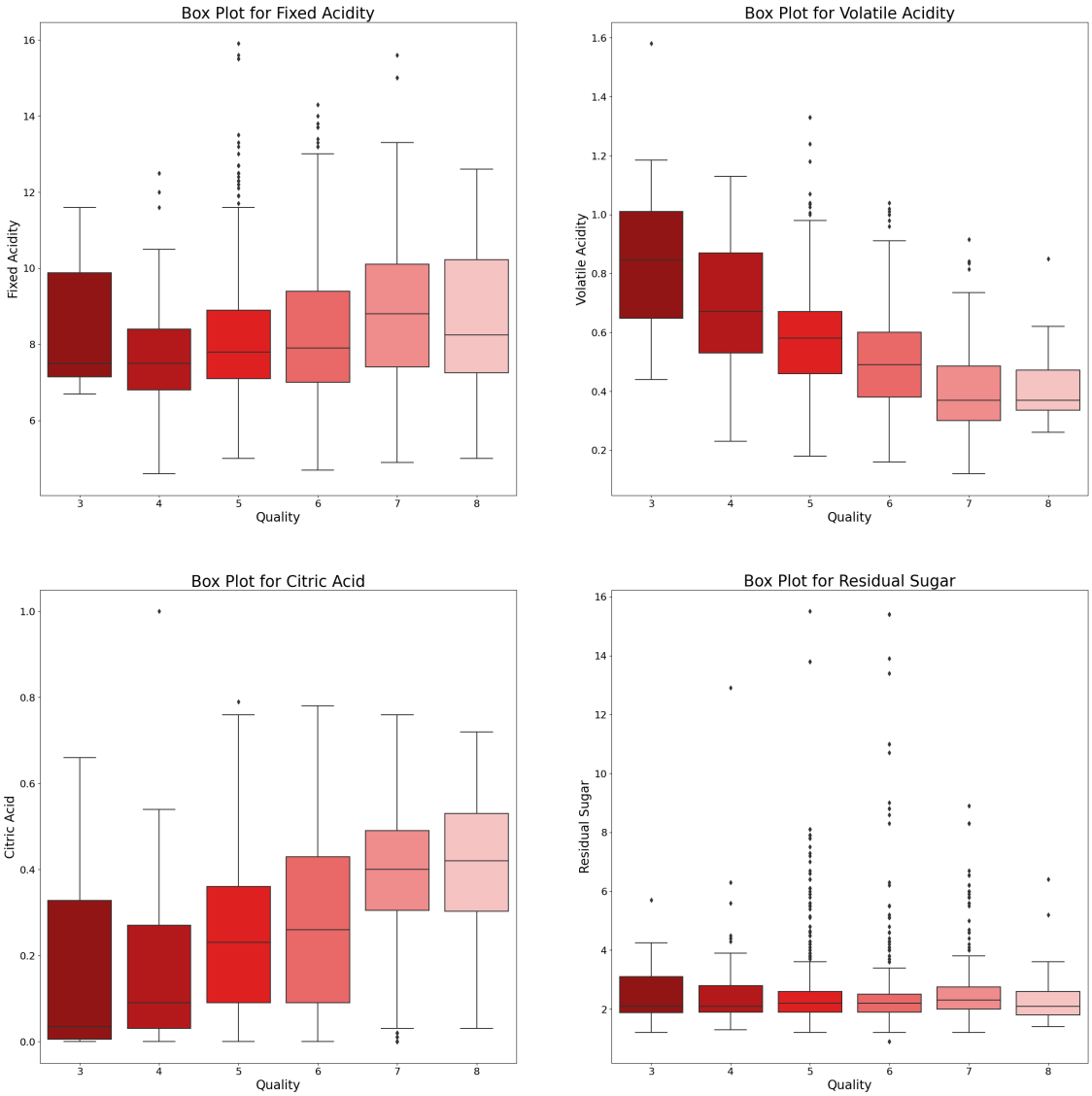
[7]:
```
fig, axes = plt.subplots(ncols=2, figsize=(30, 10))

sns.histplot(data=df, x="citric acid", kde=True, ax=axes[0])
axes[0].set_title("Histogram for Citric Acid")
axes[0].set_xlabel("Citric Acid")
axes[0].set_ylabel("Count")
axes[0].xaxis.set_tick_params(labelsize=16)
axes[0].yaxis.set_tick_params(labelsize=16)

sns.histplot(data=df, x="alcohol", kde=True, ax=axes[1])
```

```
axes[1].set_title("Histogram for Alcohol")
axes[1].set_xlabel("Alcohol")
axes[1].set_ylabel("Count")
axes[1].xaxis.set_tick_params(labelsize=16)
axes[1].yaxis.set_tick_params(labelsize=16)

plt.show()
```



观察: 绘制柠檬酸和酒精的直方图以查看其分布的偏度。酒精直方图呈现右偏态，其中众数 < 中值 < 平均值。

[8]:
```
# BoxPlots
plt.figure(figsize=(30,30))

def create_boxplot(feature):
    sns.boxplot(data=df,x=df['quality'],y=feature)
    plt.title('Box Plot for '+feature.title(),fontsize=25)
    plt.xlabel('Quality',fontsize=20)
    plt.ylabel(feature.title(),fontsize=20)
    plt.xticks(fontsize=16)
    plt.yticks(fontsize=16)

plt.subplot(221)
create_boxplot('fixed acidity')

plt.subplot(222)
create_boxplot('volatile acidity')

plt.subplot(223)
create_boxplot('citric acid')

plt.subplot(224)
create_boxplot('residual sugar')
```

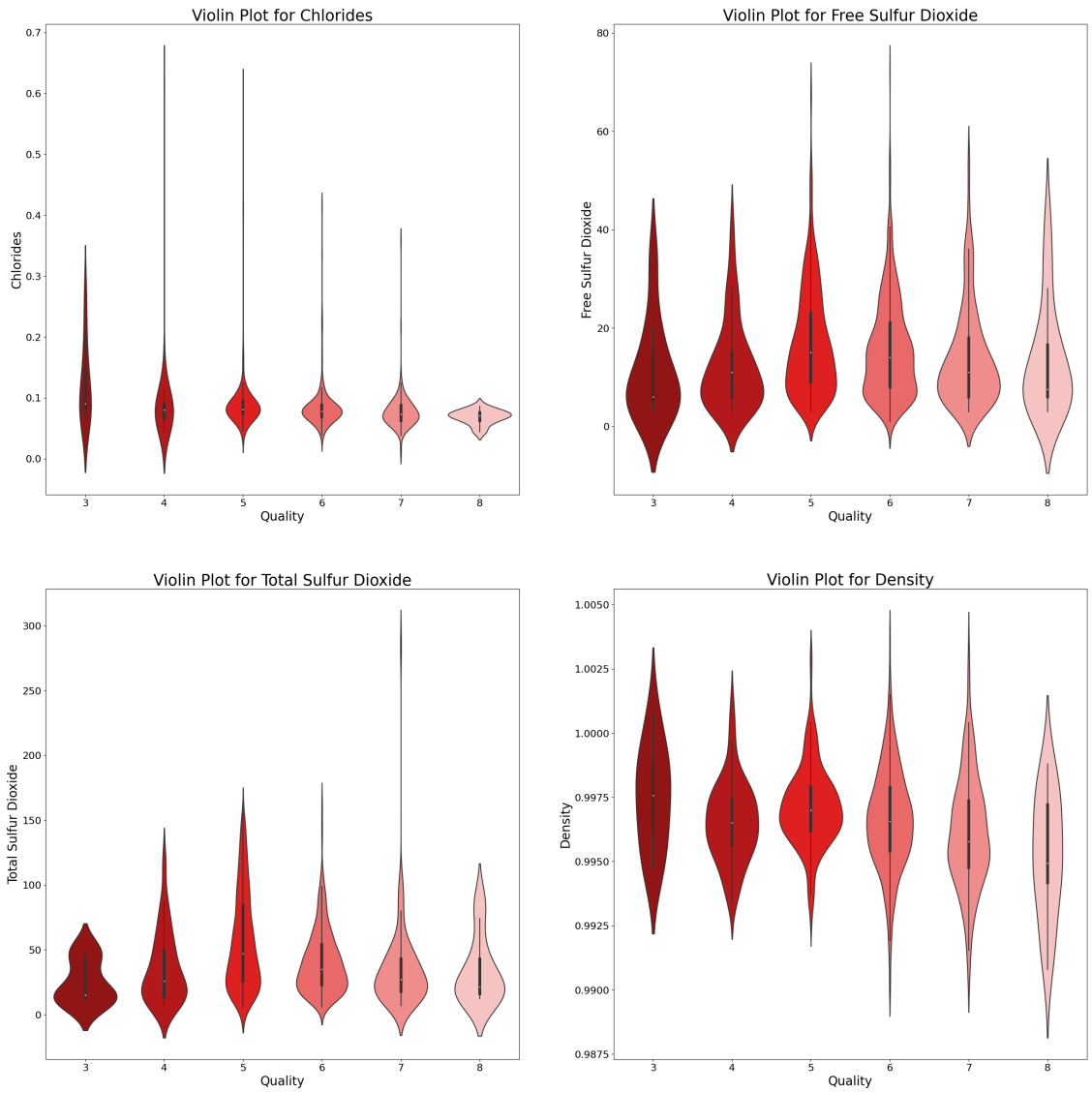


观察:

- 固定酸度：对于不同品质的葡萄酒，固定酸度的箱线图具有大致相同的中值。质量为 5 的葡萄酒的异常值最高。
- 挥发酸度：随着葡萄酒质量的提高，我们可以观察到葡萄酒挥发酸度的中值下降。
- 柠檬酸：随着葡萄酒质量的提高，我们可以观察到葡萄酒柠檬酸的中值增加。这与我们在分析葡萄酒的挥发酸度时获得的观察结果完全相反。
- 残糖：不同品质的葡萄酒，残糖的中值几乎相同。质量为 5 或 6 的葡萄酒的异常值数量最多。

[9]:
```
# Violin plots
plt.figure(figsize=(30,30))

def create_violinplot(feature):
    sns.violinplot(data=df,x=df['quality'],y=feature)
```

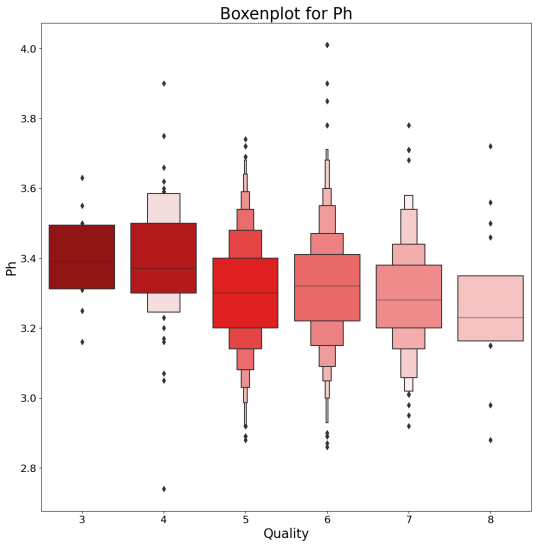
```
    plt.title('Violin Plot for '+feature.title(),fontsize=25)
    plt.xlabel('Quality',fontsize=20)
    plt.ylabel(feature.title(),fontsize=20)
    plt.xticks(fontsize=16)
    plt.yticks(fontsize=16)

plt.subplot(221)
create_violinplot('chlorides')

plt.subplot(222)
create_violinplot('free sulfur dioxide')

plt.subplot(223)
create_violinplot('total sulfur dioxide')

plt.subplot(224)
create_violinplot('density')
```

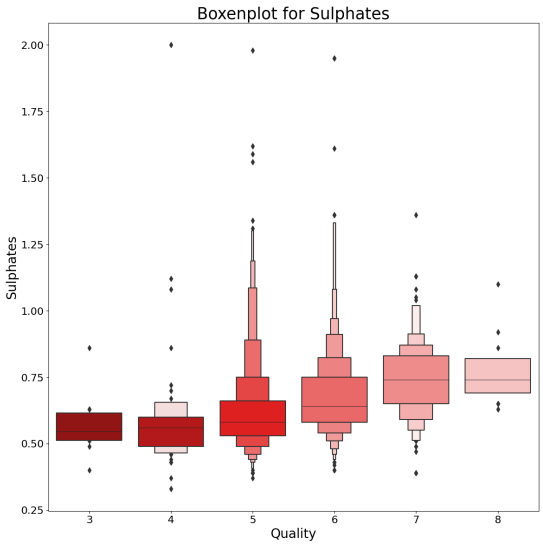


观察 - 氯化物：不同类型葡萄酒品质的氯化物中值是相同的。- 游离二氧化硫：品质为 5 的葡萄酒中游离二氧化硫的中值最高。- 总二氧化硫：总二氧化硫 IQR 最高的是品质为 5 的葡萄酒。- 密度：品质为 3 的葡萄酒具有最高的密度中值。

[10]:
```
# boxen plots
plt.figure(figsize=(30, 30))


def create_boxenplot(feature):
    sns.boxenplot(data=df, x=df["quality"], y=feature)
    plt.title("Boxenplot for " + feature.title(), fontsize=25)
    plt.xlabel("Quality", fontsize=20)
    plt.ylabel(feature.title(), fontsize=20)
```

```
    plt.xticks(fontsize=16)
    plt.yticks(fontsize=16)

plt.subplot(221)
create_boxenplot('pH')

plt.subplot(222)
create_boxenplot('sulphates')
```

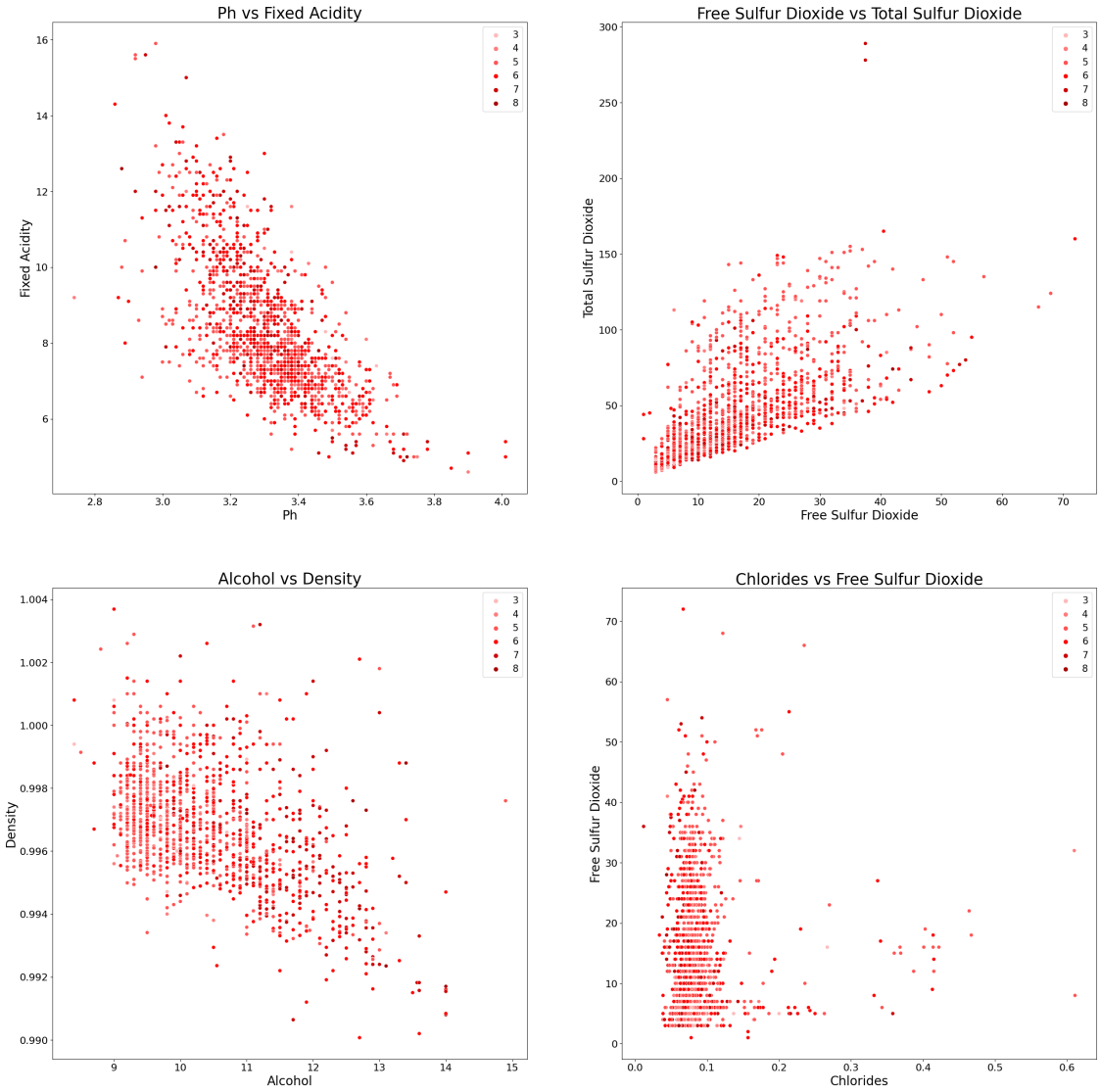




观察 - pH: pH 的中位数随着品质上升而下降. 具有质量 5 和 6 的红酒相比其他有更长的头和尾 - 硫酸盐: 随着品质上升, 硫酸盐含量上升. 和 pH 类似, 品质为 5 和 6 的红酒有更长的头和尾

[11]:
```
# scatter plots
plt.figure(figsize=(30, 30))


def create_scatterplot(feature1, feature2):
    sns.scatterplot(
        data=df,
        x=feature1,
        y=feature2,
        hue=df["quality"],
        palette=[
            custom_colors[-1],
            custom_colors[-2],
            custom_colors[-3],
            custom_colors[-4],
            custom_colors[-5],
            custom_colors[-6],
```

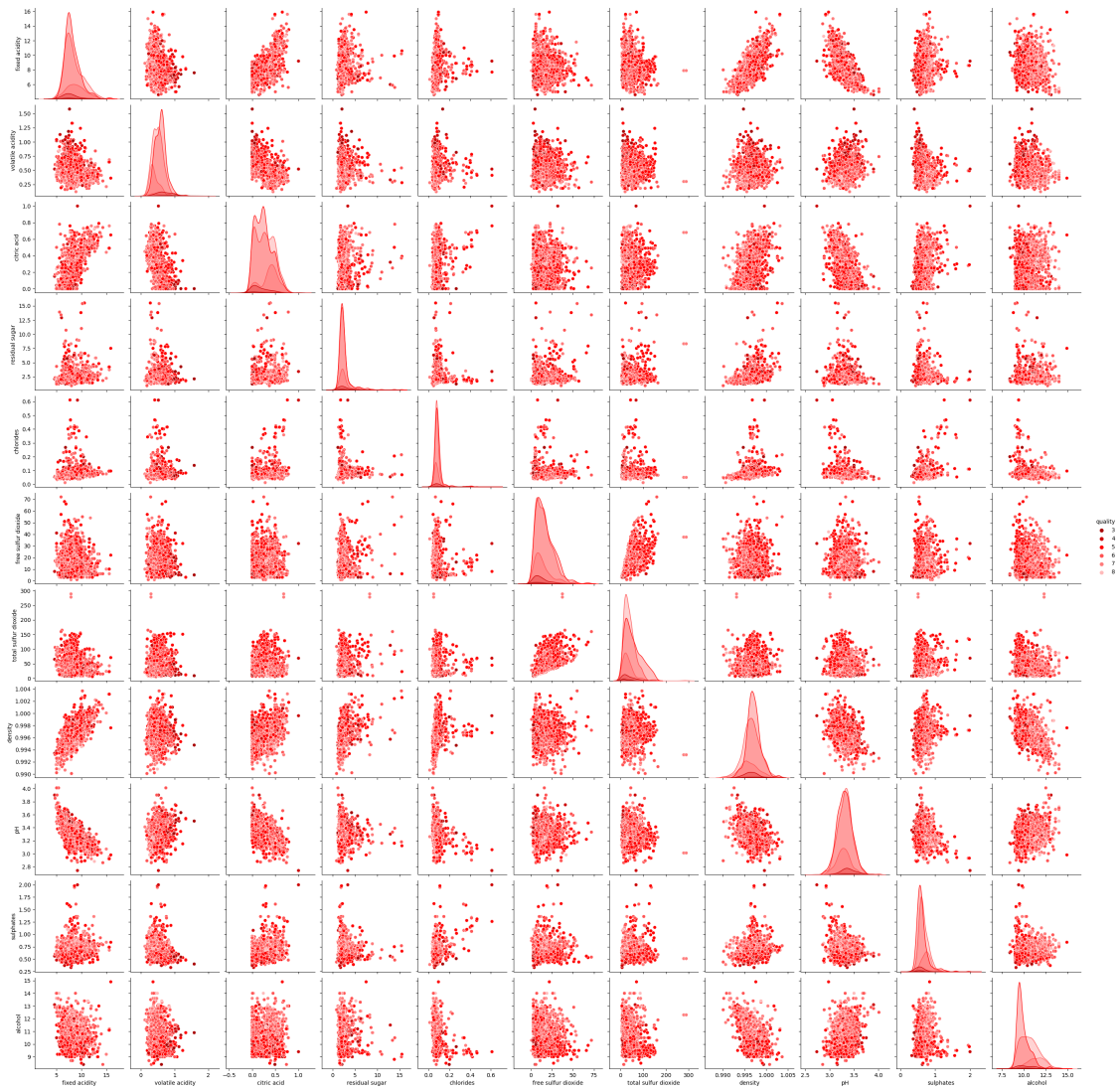
```
        ],
    )
    plt.title(feature1.title()+' vs '+feature2.title(),fontsize=25)
    plt.legend(fontsize=15)
    plt.xlabel(feature1.title(),fontsize=20)
    plt.ylabel(feature2.title(),fontsize=20)
    plt.xticks(fontsize=16)
    plt.yticks(fontsize=16)

plt.subplot(221)
create_scatterplot('pH','fixed acidity')

plt.subplot(222)
create_scatterplot('free sulfur dioxide','total sulfur dioxide')

plt.subplot(223)
create_scatterplot('alcohol','density')

plt.subplot(224)
create_scatterplot('chlorides','free sulfur dioxide')

plt.show()
```



观察 - pH vs 固定酸度：pH 和固定酸度之间有强负相关性 - 游离二氧化硫 vs 总二氧化硫：有一定的正相关性 - 酒精 vs 密度：负相关性 - 氯化物 vs 二氧化硫：没有可以分辨的相关性

[12]:
```
# Pair plots
sns.pairplot(
    data=df,
    hue="quality",
    palette=[
        custom_colors[0],
        custom_colors[1],
        custom_colors[2],
        custom_colors[3],
        custom_colors[4],
```

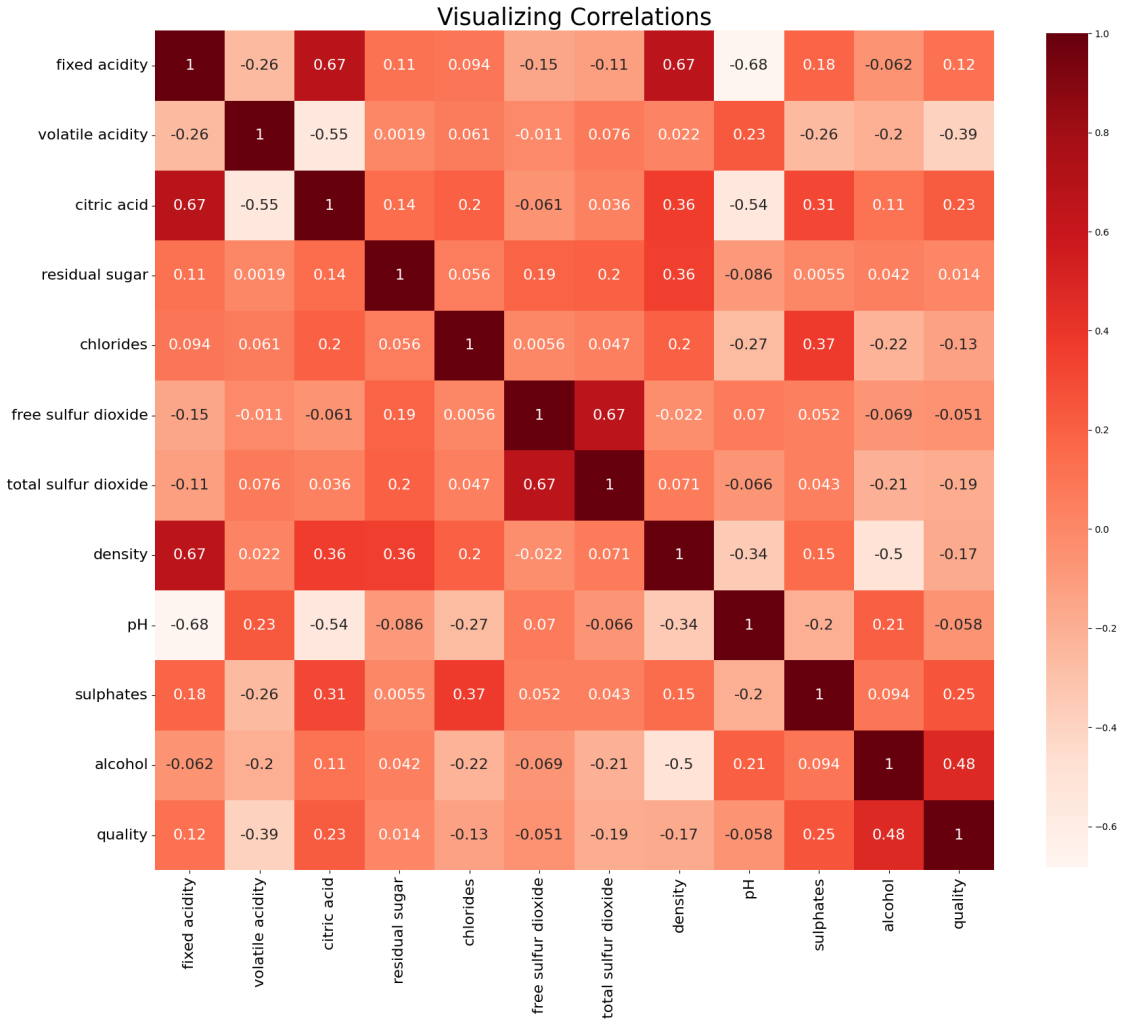
```
        custom_colors[5],
    ],
)
plt.show()
```



4 检查相关性

[13]:
```
# correlation matrix
plt.figure(figsize=(20, 20))
sns.heatmap(
    df.corr(),
    cmap="Reds",
    square=True,
```

```
    annot=True,
    annot_kws={"size": 16},
    cbar_kws={"shrink": 0.80},
)
plt.title('Visualizing Correlations',size=25)
plt.xticks(fontsize=16)
plt.yticks(fontsize=16)
plt.show()
```

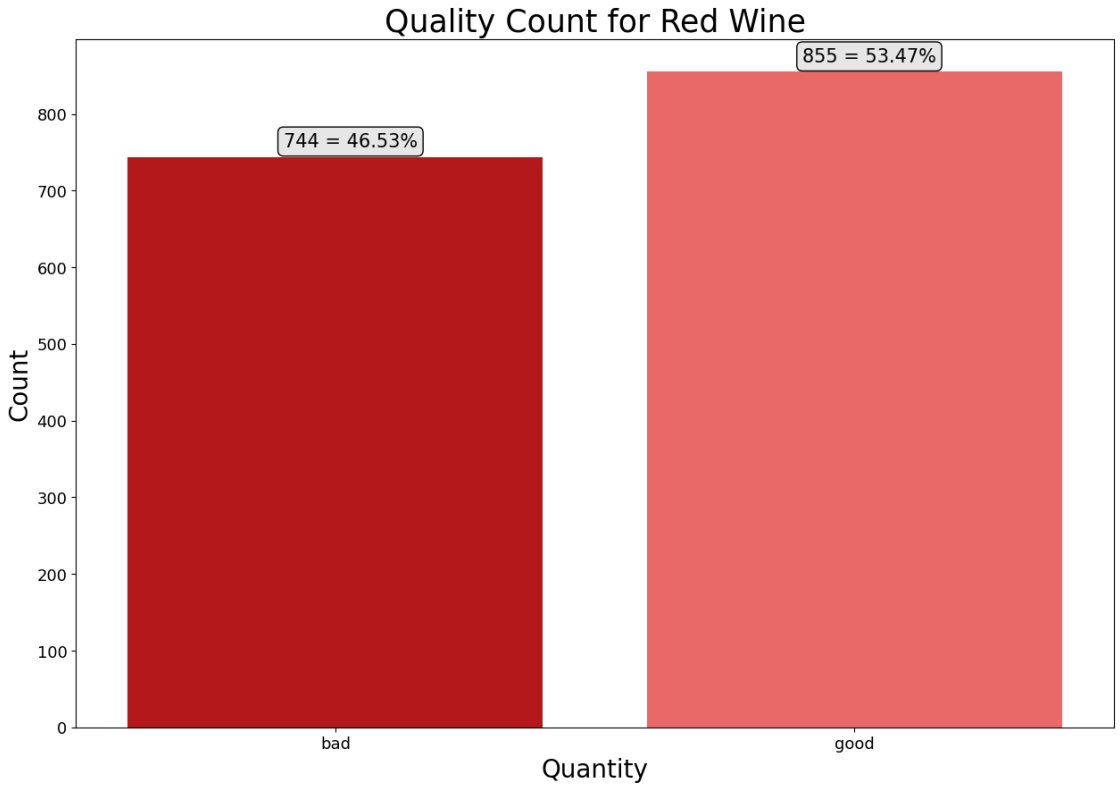


5 修复类不平衡

为了纠正数据集中的类不平衡, 需要使用 binning. 将数据集区分为坏和好两种品质的酒, 使得坏品质的酒喝好品质的酒的数量大致相同

[14]:
```
print(df.head())
df["quality"] = pd.cut(df["quality"], bins=[1, 5, 10], labels=["bad", "good"])

plt.figure(figsize=(15, 10))
ax = sns.countplot(
    x="quality", data=df, palette=[custom_colors[1], custom_colors[-3]]
)
bbox_args = dict(boxstyle="round", fc="0.9")
for p in ax.patches:
    ax.annotate(
        "{:.0f} = {:.2f}%".format(
            p.get_height(), (p.get_height() / len(df["quality"])) * 100
        ),
        (p.get_x() + 0.3, p.get_height() + 13),
        color="black",
        bbox=bbox_args,
        fontsize=15,
    )

plt.title("Quality Count for Red Wine", fontsize=25)
plt.xlabel("Quantity", fontsize=20)
plt.ylabel("Count", fontsize=20)
plt.xticks(fontsize=13)
plt.yticks(fontsize=13)
plt.show()
```

```
   fixed acidity  volatile acidity  citric acid  residual sugar  chlorides  \
0            7.4              0.70         0.00             1.9      0.076
1            7.8              0.88         0.00             2.6      0.098
2            7.8              0.76         0.04             2.3      0.092
3           11.2              0.28         0.56             1.9      0.075
4            7.4              0.70         0.00             1.9      0.076

   free sulfur dioxide  total sulfur dioxide  density    pH  sulphates  \
0                 11.0                  34.0   0.9978  3.51       0.56
1                 25.0                  67.0   0.9968  3.20       0.68
2                 15.0                  54.0   0.9970  3.26       0.65
3                 17.0                  60.0   0.9980  3.16       0.58
4                 11.0                  34.0   0.9978  3.51       0.56

   alcohol  quality
0      9.4        5
1      9.8        5
2      9.8        5
3      9.8        6
4      9.4        5
```



6 对标签进行编码

[15]:
```
label_encoder=LabelEncoder()
df['quality']=label_encoder.fit_transform(df['quality'])
df['quality'].value_counts()
```

[15]:
```
1    855
0    744
Name: quality, dtype: int64
```

7 对数据缩放

StandardScaler 可以通过减去平均值, 并缩放导单位方差内对一个特征进行缩放.

$$z = \frac{x-\mu}{\theta}\mu = \text{Mean}\theta = \text{Standard Deviation}$$

[16]:
```
print(df.head())
scaler=StandardScaler()
features=[features for features in df.columns if df[features].dtype!=int]
df[features]=scaler.fit_transform(df[features])
```

```
df
```

```
   fixed acidity  volatile acidity  citric acid  residual sugar  chlorides  \
0            7.4              0.70         0.00             1.9      0.076
1            7.8              0.88         0.00             2.6      0.098
2            7.8              0.76         0.04             2.3      0.092
3           11.2              0.28         0.56             1.9      0.075
4            7.4              0.70         0.00             1.9      0.076

   free sulfur dioxide  total sulfur dioxide  density    pH  sulphates  \
0                 11.0                  34.0   0.9978  3.51       0.56
1                 25.0                  67.0   0.9968  3.20       0.68
2                 15.0                  54.0   0.9970  3.26       0.65
3                 17.0                  60.0   0.9980  3.16       0.58
4                 11.0                  34.0   0.9978  3.51       0.56

   alcohol  quality
0      9.4        0
1      9.8        0
2      9.8        0
3      9.8        1
4      9.4        0
```

[16]:

```
      fixed acidity  volatile acidity  citric acid  residual sugar  chlorides  \
0         -0.528360          0.961877    -1.391472       -0.453218  -0.243707
1         -0.298547          1.967442    -1.391472        0.043416   0.223875
2         -0.298547          1.297065    -1.186070       -0.169427   0.096353
3          1.654856         -1.384443     1.484154       -0.453218  -0.264960
4         -0.528360          0.961877    -1.391472       -0.453218  -0.243707
…               …                 …            …               …          …
1594      -1.217796          0.403229    -0.980669       -0.382271   0.053845
1595      -1.390155          0.123905    -0.877968       -0.240375  -0.541259
1596      -1.160343         -0.099554    -0.723916       -0.169427  -0.243707
1597      -1.390155          0.654620    -0.775267       -0.382271  -0.264960
1598      -1.332702         -1.216849     1.021999        0.752894  -0.434990

      free sulfur dioxide  total sulfur dioxide   density        pH  \
0               -0.466193             -0.379133  0.558274  1.288643
1                0.872638              0.624363  0.028261 -0.719933
2               -0.083669              0.229047  0.134264 -0.331177
3                0.107592              0.411500  0.664277 -0.979104
4               -0.466193             -0.379133  0.558274  1.288643
…                     …                     …         …         …
1594             1.542054             -0.075043 -0.978765  0.899886
1595             2.211469              0.137820 -0.862162  1.353436
1596             1.255161             -0.196679 -0.533554  0.705508
1597             1.542054             -0.075043 -0.676657  1.677400
```

```
1598             0.203223             -0.135861 -0.666057  0.511130

      sulphates   alcohol  quality
0     -0.579207 -0.960246        0
1      0.128950 -0.584777        0
2     -0.048089 -0.584777        0
3     -0.461180 -0.584777        1
4     -0.579207 -0.960246        0
…           …        …        …
1594  -0.461180  0.072294        0
1595   0.601055  0.729364        1
1596   0.542042  0.541630        1
1597   0.305990 -0.209308        0
1598   0.010924  0.541630        1

[1599 rows x 12 columns]
```

[17]:
```
# Split Features and Target
X=df.drop('quality',axis=1)
y=df['quality']
print(X,'\n\n\n',y)
```

```
      fixed acidity  volatile acidity  citric acid  residual sugar  chlorides  \
0         -0.528360          0.961877    -1.391472       -0.453218  -0.243707
1         -0.298547          1.967442    -1.391472        0.043416   0.223875
2         -0.298547          1.297065    -1.186070       -0.169427   0.096353
3          1.654856         -1.384443     1.484154       -0.453218  -0.264960
4         -0.528360          0.961877    -1.391472       -0.453218  -0.243707
…               …                 …            …               …          …
1594      -1.217796          0.403229    -0.980669       -0.382271   0.053845
1595      -1.390155          0.123905    -0.877968       -0.240375  -0.541259
1596      -1.160343         -0.099554    -0.723916       -0.169427  -0.243707
1597      -1.390155          0.654620    -0.775267       -0.382271  -0.264960
1598      -1.332702         -1.216849     1.021999        0.752894  -0.434990

      free sulfur dioxide  total sulfur dioxide   density        pH  \
0               -0.466193             -0.379133  0.558274  1.288643
1                0.872638              0.624363  0.028261 -0.719933
2               -0.083669              0.229047  0.134264 -0.331177
3                0.107592              0.411500  0.664277 -0.979104
4               -0.466193             -0.379133  0.558274  1.288643
…                     …                     …         …         …
1594             1.542054             -0.075043 -0.978765  0.899886
1595             2.211469              0.137820 -0.862162  1.353436
1596             1.255161             -0.196679 -0.533554  0.705508
1597             1.542054             -0.075043 -0.676657  1.677400
1598             0.203223             -0.135861 -0.666057  0.511130
```

```
      sulphates   alcohol
0     -0.579207 -0.960246
1      0.128950 -0.584777
2     -0.048089 -0.584777
3     -0.461180 -0.584777
4     -0.579207 -0.960246
…           …         …
1594  -0.461180  0.072294
1595   0.601055  0.729364
1596   0.542042  0.541630
1597   0.305990 -0.209308
1598   0.010924  0.541630

[1599 rows x 11 columns]
```

```
 0       0
1        0
2        0
3        1
4        0
        ..
1594     0
1595     1
1596     1
1597     0
1598     1
Name: quality, Length: 1599, dtype: int64
```

8 训练集和测试集划分

[18]:
```
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.
↪2,random_state=0,stratify=y)
```

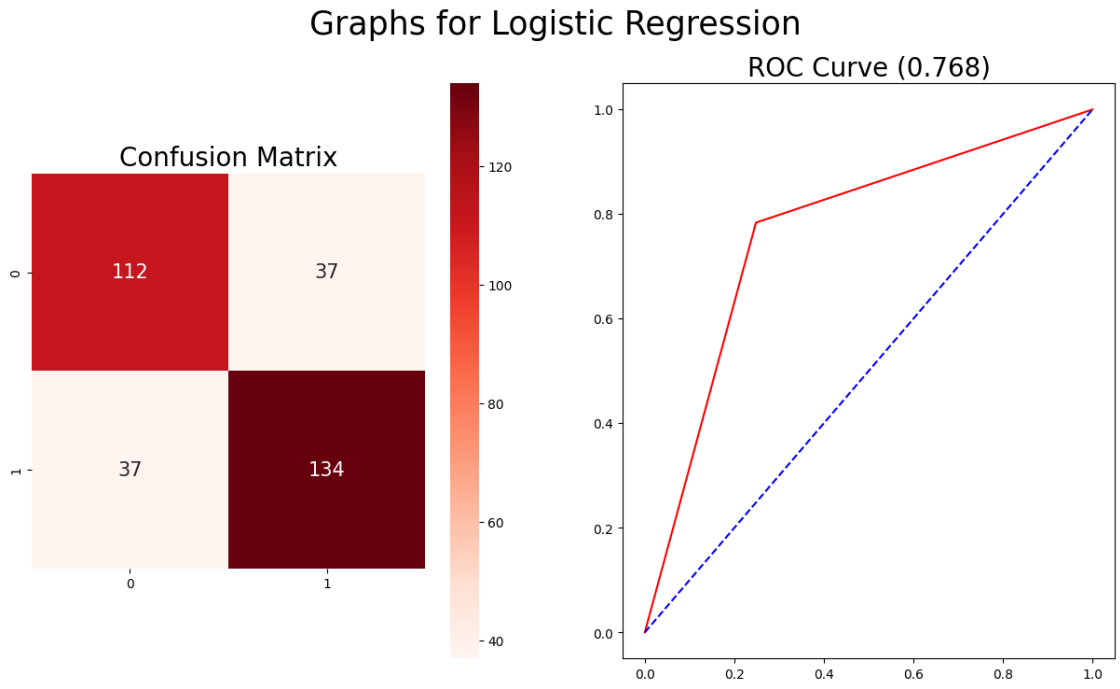
9 训练机器学习模型

[19]:
```
algo_name = []
accuracy = []


def display_results_and_graphs(algorithm_name, model):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    acc_model = model.score(X_test, y_test)

    algo_name.append(algorithm_name)
```

```
    accuracy.append(acc_model)

    print(f"---For {algorithm_name}---")
    print(
        "Training Accuracy: {}%\nTesting Accuracy: {}%\nF1 Score: {}".format(
            model.score(X_train, y_train) * 100,
            model.score(X_test, y_test) * 100,
            f1_score(y_test, y_pred),
        )
    )
    print("\n")

    fig, axes = plt.subplots(1, 2, figsize=(15, 8))

    fig.suptitle("Graphs for " + algorithm_name, fontsize=25)

    sns.heatmap(
        confusion_matrix(y_test, y_pred),
        annot=True,
        cmap="Reds",
        annot_kws={"size": 15},
        square=True,
        fmt=".0f",
        ax=axes[0],
    )
    axes[0].set_title("Confusion Matrix", fontsize=20)

    fpr, tpr, threshould = metrics.roc_curve(y_test, y_pred)
    roc_auc = metrics.auc(fpr, tpr)
    sns.lineplot(x=fpr, y=tpr, ax=axes[1], color="red")
    axes[1].set_title("ROC Curve (" + str(round(roc_auc, 3)) + ")", fontsize=20)
    axes[1].plot(
        [0, 1],
        [
            0,
            1,
        ],
        "b--",
    )
    plt.show()


display_results_and_graphs("Logistic Regression", LogisticRegression())
display_results_and_graphs(
    "K Nearest Neighbors", KNeighborsClassifier(n_neighbors=13)
)
display_results_and_graphs("Support Vector Classifier", SVC())
```

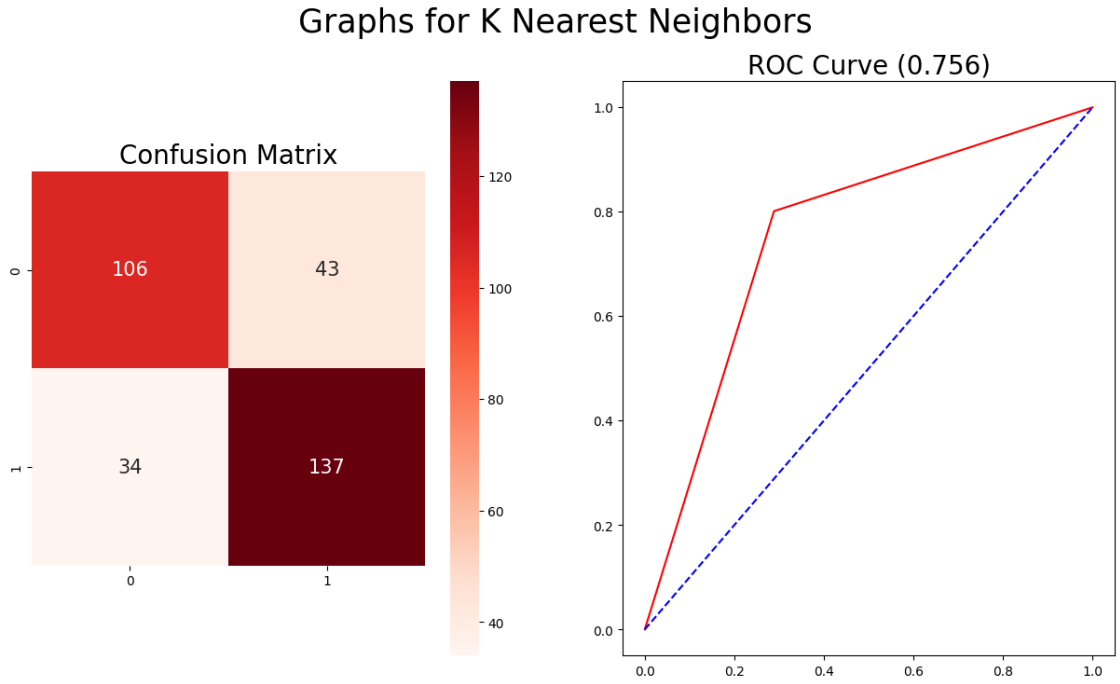
```
display_results_and_graphs(
    "Decision Tree Classifier", DecisionTreeClassifier(random_state=10)
)
display_results_and_graphs("Random Forest Classifier", RandomForestClassifier())
display_results_and_graphs(
    "Gradient Boosting Classifier", GradientBoostingClassifier(random_state=10)
)
display_results_and_graphs(
    "Ada Boost Classifier", AdaBoostClassifier(random_state=0)
)
display_results_and_graphs(
    "Cat Boost Classifier", CatBoostClassifier(verbose=0)
)
display_results_and_graphs("XGBoost Classifier", XGBClassifier())
display_results_and_graphs(
    "Light Gradient Boosting Machine", lgbm.LGBMClassifier()
)
```

```
---For Logistic Regression---
Training Accuracy: 73.88584831899921%
Testing Accuracy: 76.875%
F1 Score: 0.783625730994152
```



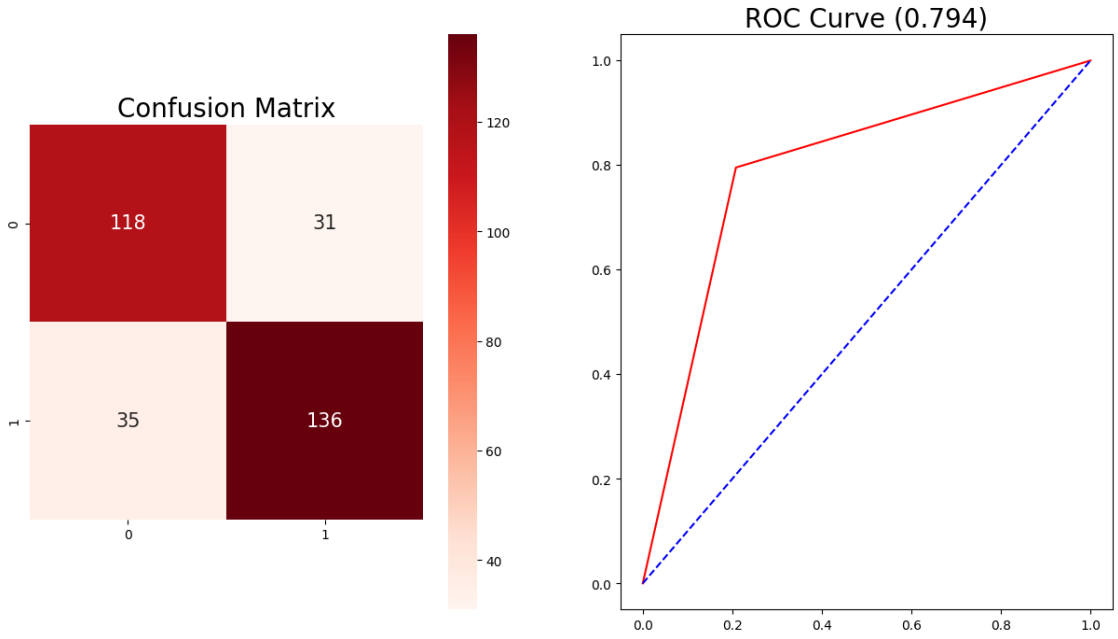

```
---For K Nearest Neighbors---
```

```
Training Accuracy: 77.79515246286161%
Testing Accuracy: 75.9375%
F1 Score: 0.7806267806267805
```



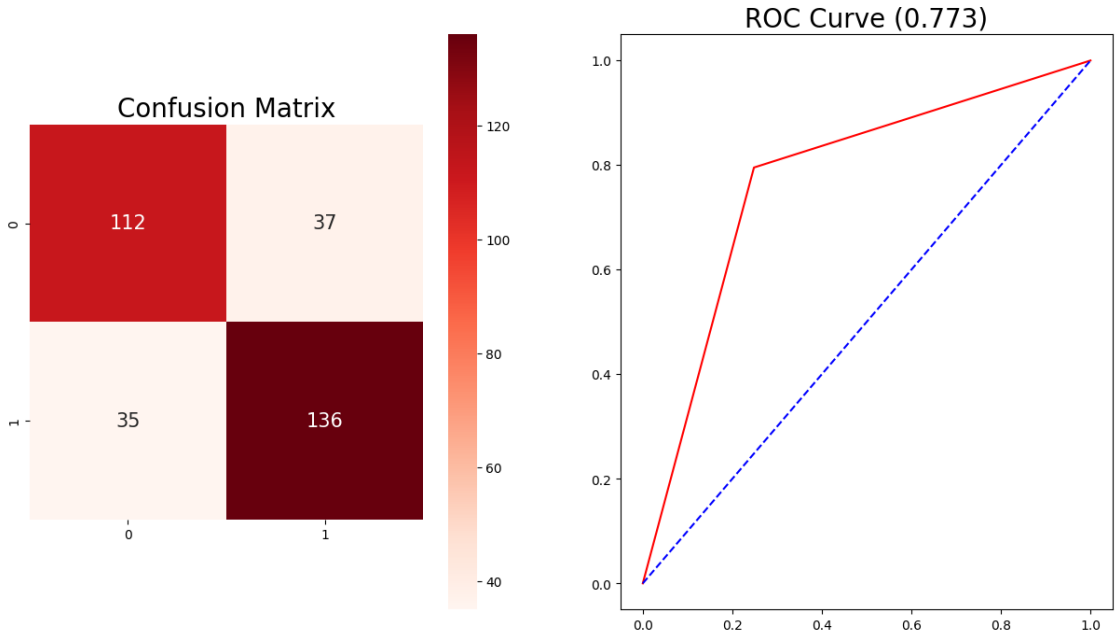

```
---For Support Vector Classifier---
Training Accuracy: 78.65519937451134%
Testing Accuracy: 79.375%
F1 Score: 0.8047337278106509
```

Graphs for Support Vector Classifier

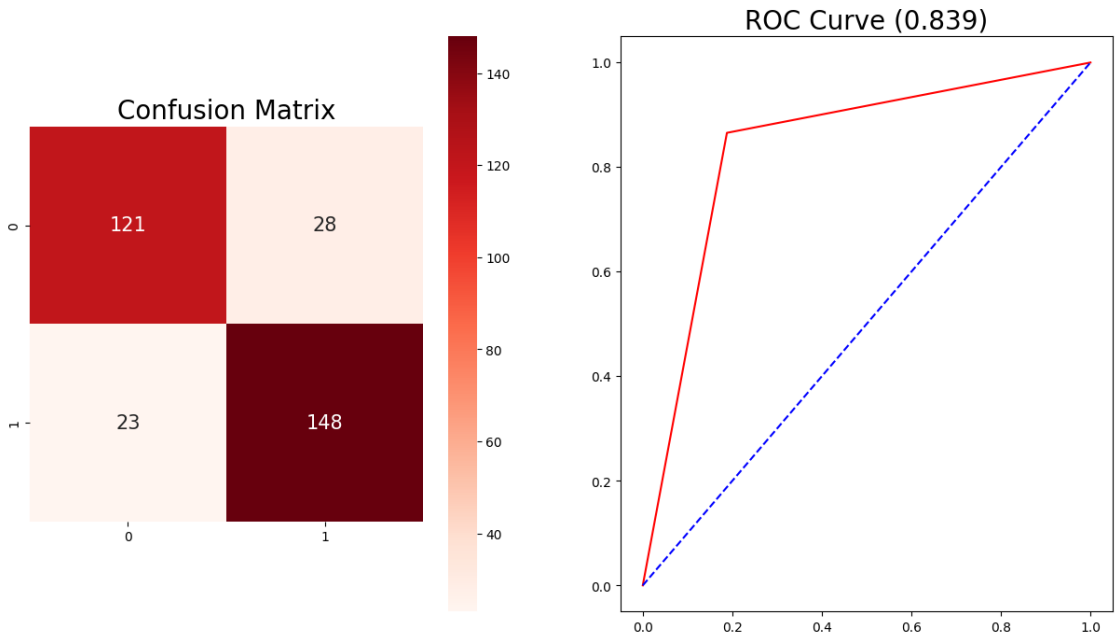



```
---For Decision Tree Classifier---
Training Accuracy: 100.0%
Testing Accuracy: 77.5%
F1 Score: 0.7906976744186047
```

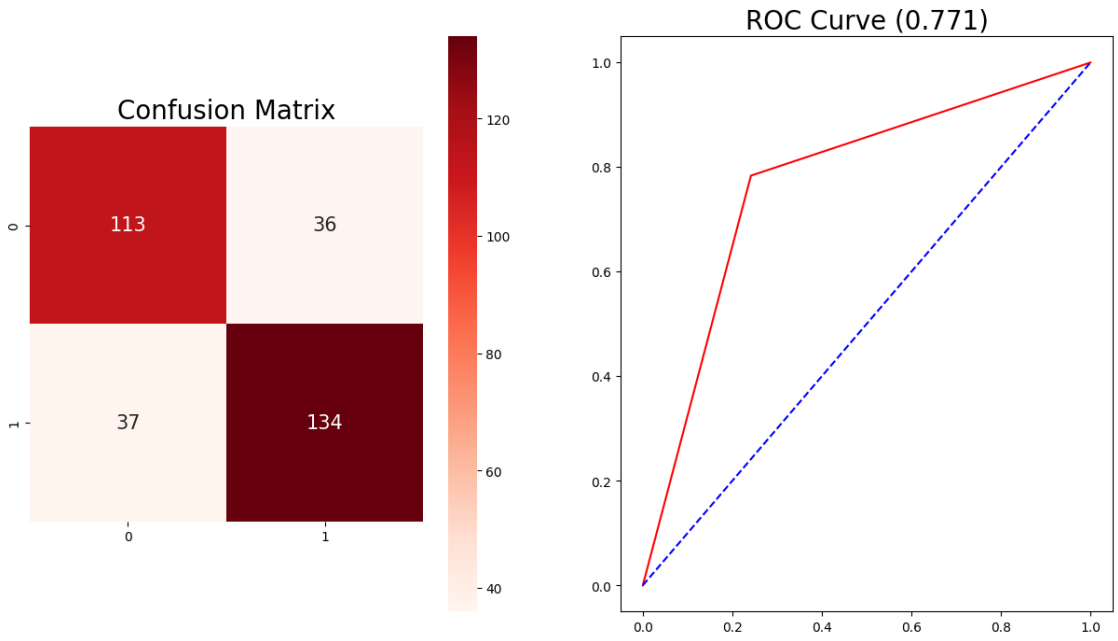
Graphs for Decision Tree Classifier




```
---For Random Forest Classifier---
Training Accuracy: 100.0%
Testing Accuracy: 84.0625%
F1 Score: 0.8530259365994236
```

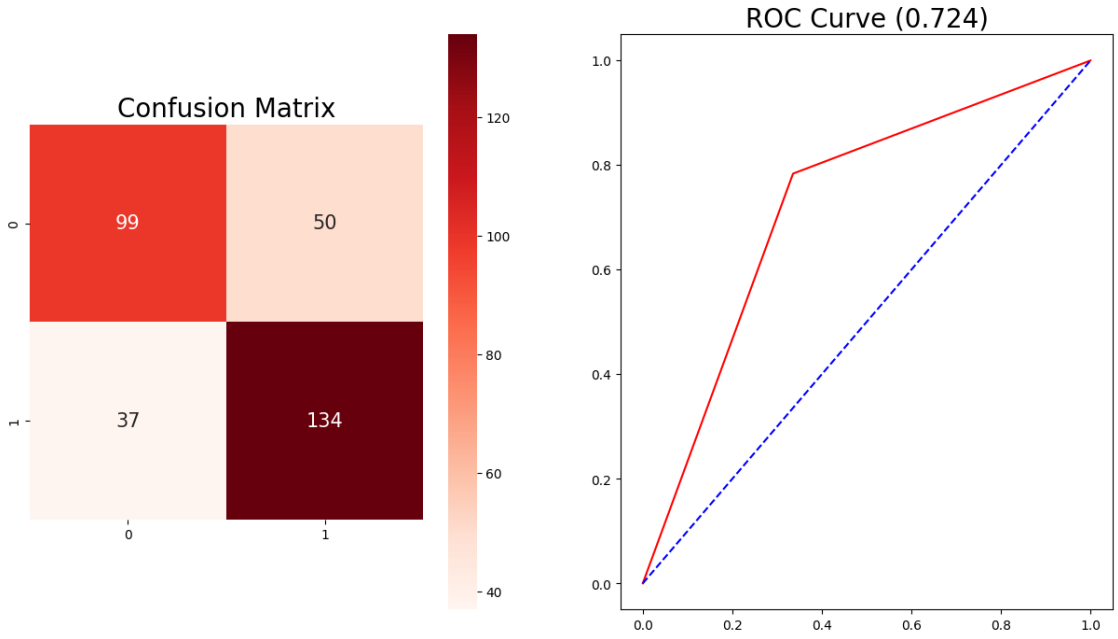



```
---For Gradient Boosting Classifier---
Training Accuracy: 87.33385457388584%
Testing Accuracy: 77.1875%
F1 Score: 0.7859237536656891
```

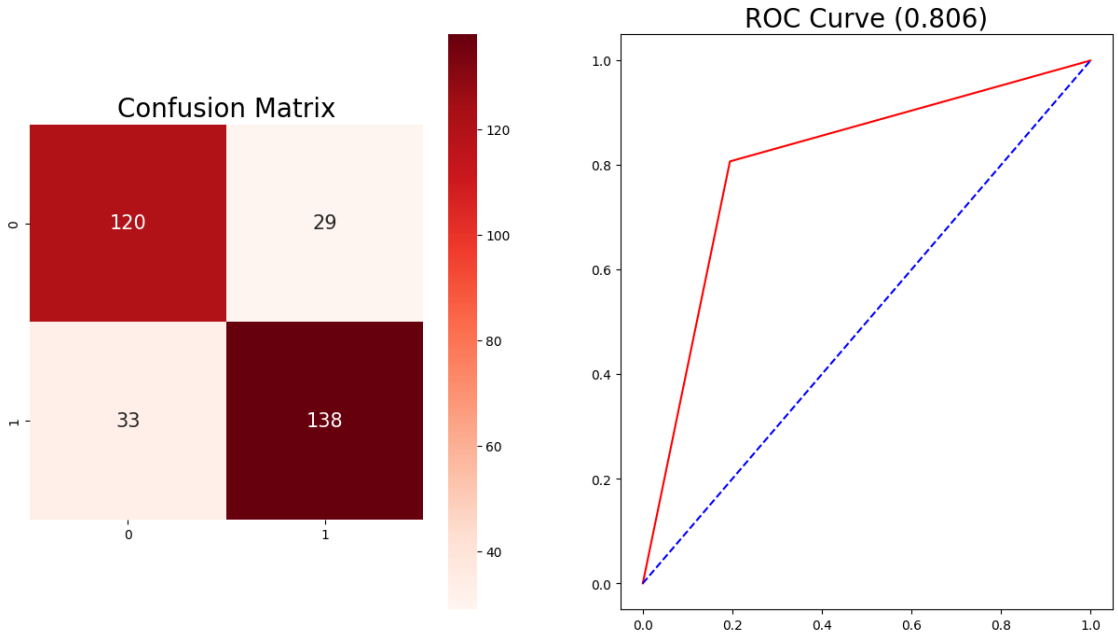



```
---For Ada Boost Classifier---
Training Accuracy: 78.18608287724786%
Testing Accuracy: 72.8125%
F1 Score: 0.7549295774647887
```

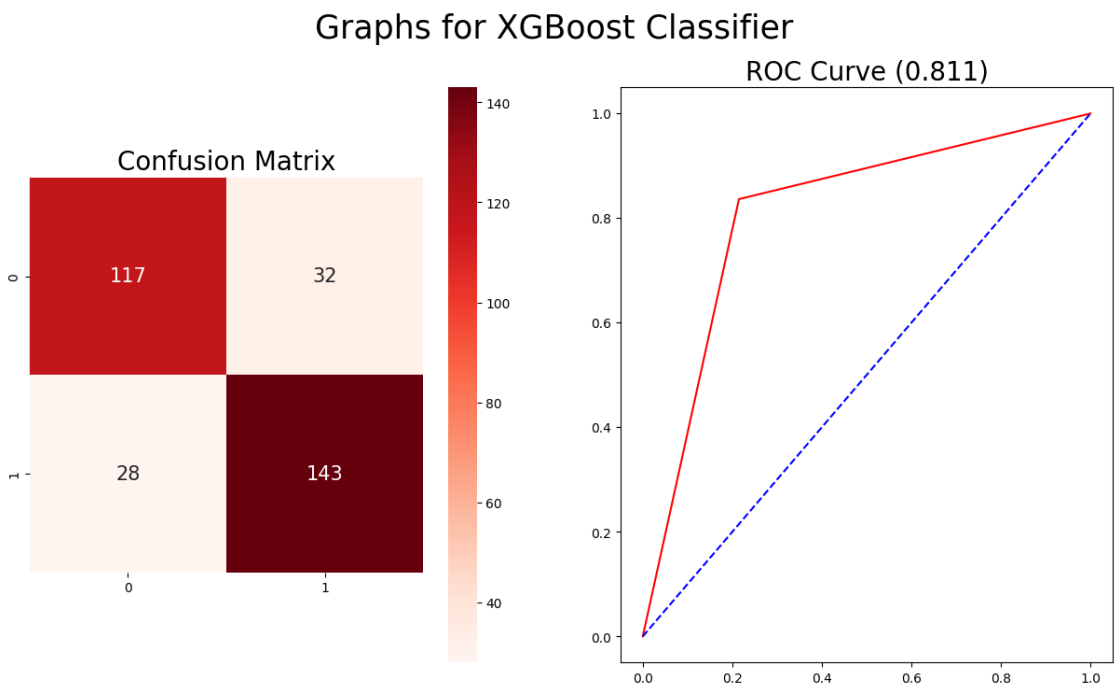
Graphs for Ada Boost Classifier



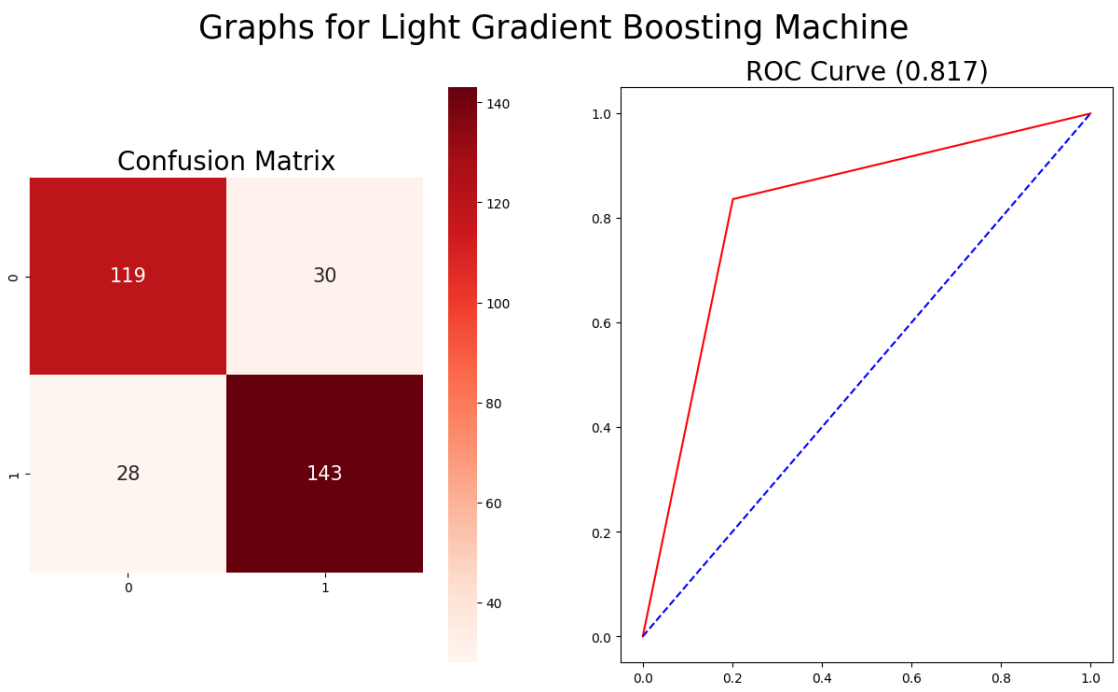
---For Cat Boost Classifier---
Training Accuracy: 93.58874120406567%
Testing Accuracy: 80.625%
F1 Score: 0.8165680473372781



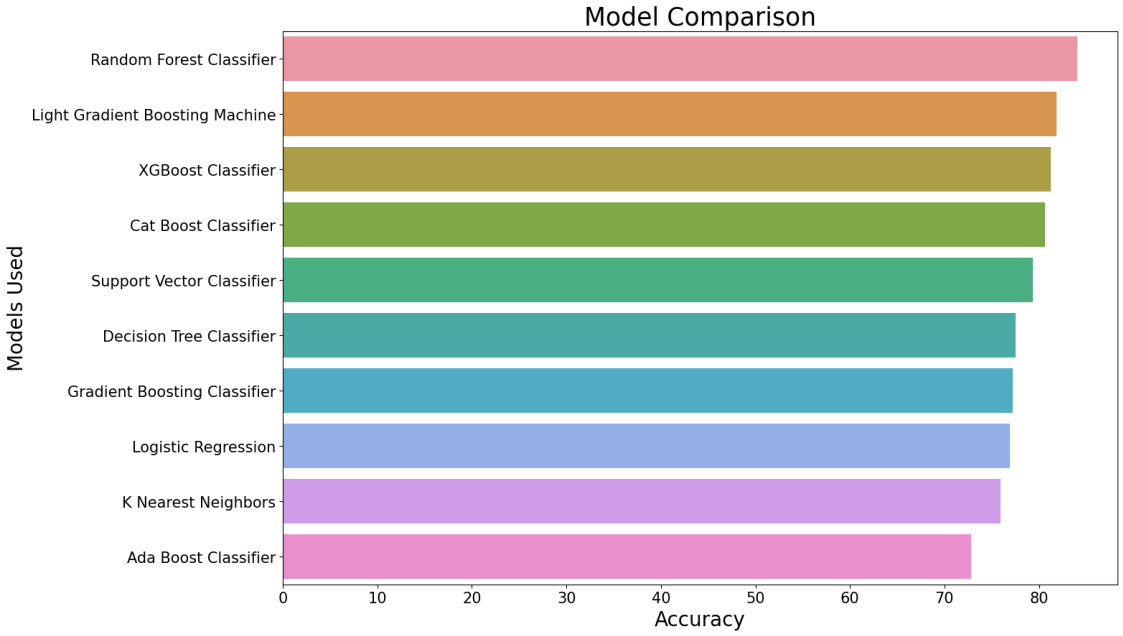

```
---For XGBoost Classifier---
Training Accuracy: 100.0%
Testing Accuracy: 81.25%
F1 Score: 0.8265895953757226
```




```
[LightGBM] [Warning] Found whitespace in feature_names, replace with underlines
[LightGBM] [Info] Number of positive: 684, number of negative: 595
[LightGBM] [Warning] Auto-choosing col-wise multi-threading, the overhead of
testing was 0.000110 seconds.
You can set `force_col_wise=true` to remove the overhead.
[LightGBM] [Info] Total Bins 1019
[LightGBM] [Info] Number of data points in the train set: 1279, number of used
features: 11
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.534793 -> initscore=0.139397
[LightGBM] [Info] Start training from score 0.139397
---For Light Gradient Boosting Machine---
Training Accuracy: 100.0%
Testing Accuracy: 81.875%
F1 Score: 0.8313953488372092
```



[20]:
```python
# model comparation
model_comparison = {}

for k, v in zip(algo_name, accuracy):
    model_comparison.update({k: v * 100})

model_comparison = dict(
    sorted(model_comparison.items(), key=lambda x: x[1], reverse=True)
)
models = list(model_comparison.keys())
accuracy = list(model_comparison.values())

plt.figure(figsize=(15, 10))
sns.barplot(x=accuracy, y=models)
plt.title("Model Comparison", fontsize=25)
plt.xlabel("Accuracy", fontsize=20)
plt.ylabel("Models used".title(), fontsize=20)
plt.xticks(size=15)
plt.yticks(size=15)
plt.show()
```



观察随机森林给出了最好的结果, 具有 82.8125% 的准确率. LGBM 和 XGBoost 提供了第二和第三的最好结果. 为了提升准确率, 将借助 **Optuna** 进行超参数优化.

10 使用 Optuna 进行超参数优化

Optuna 是一个自动超参数优化框架, 为机器学习特别设计.

[21]:
```python
def objective(trial):
    param_grid = {
        "tree_method": "gpu_hist",
        "lambda": trial.suggest_loguniform("lambda", 1e-3, 10.0),
        "alpha": trial.suggest_loguniform("alpha", 1e-3, 10.0),
        "colsample_bytree": trial.suggest_categorical(
            "colsample_bytree", [0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0]
        ),
        "subsample": trial.suggest_categorical(
            "subsample",
            [0.4, 0.5, 0.6, 0.7, 0.8, 1.0],
        ),
        "learning_rate": trial.suggest_categorical(
            "learning_rate", [0.008, 0.01, 0.012, 0.014, 0.016, 0.018, 0.02]
        ),
        "n_estimators": trial.suggest_int("n_estimators", 100, 1000, 50),
        "max_depth": trial.suggest_categorical(
            "max_depth", [5, 7, 9, 11, 13, 15, 17]
        ),
```

```
        "random_state": 0,
        "min_child_weight": trial.suggest_int("min_child_weight", 1, 300),
    }

    model = XGBClassifier(**param_grid)
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    acc_model = model.score(X_test, y_test)

    return acc_model


study = optuna.create_study(direction="maximize")
study.optimize(objective, n_trials=300)
```

```
[I 2023-08-01 18:31:54,638] A new study created in memory with name: no-
name-25b8ca68-7933-4255-89d8-2ba0b20197dc
[I 2023-08-01 18:31:55,306] Trial 0 finished with value: 0.534375 and
parameters: {'lambda': 0.007004038685186259, 'alpha': 0.001491260857527076,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.01,
'n_estimators': 1000, 'max_depth': 15, 'min_child_weight': 164}. Best is trial 0
with value: 0.534375.
[I 2023-08-01 18:31:55,870] Trial 1 finished with value: 0.534375 and
parameters: {'lambda': 0.008308675547941435, 'alpha': 0.29466313595873356,
'colsample_bytree': 0.3, 'subsample': 1.0, 'learning_rate': 0.018,
'n_estimators': 900, 'max_depth': 5, 'min_child_weight': 288}. Best is trial 0
with value: 0.534375.
[I 2023-08-01 18:31:56,370] Trial 2 finished with value: 0.73125 and parameters:
{'lambda': 0.003302355349323962, 'alpha': 0.05134114340944663,
'colsample_bytree': 0.8, 'subsample': 0.5, 'learning_rate': 0.016,
'n_estimators': 550, 'max_depth': 13, 'min_child_weight': 45}. Best is trial 2
with value: 0.73125.
[I 2023-08-01 18:31:56,993] Trial 3 finished with value: 0.69375 and parameters:
{'lambda': 0.005073043148306853, 'alpha': 0.46563298166100686,
'colsample_bytree': 0.8, 'subsample': 1.0, 'learning_rate': 0.014,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 117}. Best is trial 2
with value: 0.73125.
[I 2023-08-01 18:31:57,313] Trial 4 finished with value: 0.465625 and
parameters: {'lambda': 0.15627129006677057, 'alpha': 0.1771674483469551,
'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.012,
'n_estimators': 350, 'max_depth': 5, 'min_child_weight': 247}. Best is trial 2
with value: 0.73125.
[I 2023-08-01 18:31:57,721] Trial 5 finished with value: 0.534375 and
parameters: {'lambda': 0.19377792488992224, 'alpha': 0.29690725848985466,
'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.012,
'n_estimators': 500, 'max_depth': 9, 'min_child_weight': 129}. Best is trial 2
with value: 0.73125.
[I 2023-08-01 18:31:58,294] Trial 6 finished with value: 0.61875 and parameters:
```

{'lambda': 0.5759579083879521, 'alpha': 0.1418597171277494, 'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.018, 'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 130}. Best is trial 2 with value: 0.73125.
[I 2023-08-01 18:31:58,879] Trial 7 finished with value: 0.465625 and parameters: {'lambda': 1.911658051652501, 'alpha': 0.021826824345678956, 'colsample_bytree': 0.7, 'subsample': 0.5, 'learning_rate': 0.018, 'n_estimators': 1000, 'max_depth': 15, 'min_child_weight': 234}. Best is trial 2 with value: 0.73125.
[I 2023-08-01 18:31:59,255] Trial 8 finished with value: 0.534375 and parameters: {'lambda': 0.008124736186622843, 'alpha': 0.7914423703530653, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.02, 'n_estimators': 450, 'max_depth': 17, 'min_child_weight': 230}. Best is trial 2 with value: 0.73125.
[I 2023-08-01 18:31:59,912] Trial 9 finished with value: 0.765625 and parameters: {'lambda': 0.0756284136139953, 'alpha': 0.0011875980514888015, 'colsample_bytree': 0.4, 'subsample': 1.0, 'learning_rate': 0.01, 'n_estimators': 550, 'max_depth': 13, 'min_child_weight': 31}. Best is trial 9 with value: 0.765625.
[I 2023-08-01 18:32:00,174] Trial 10 finished with value: 0.746875 and parameters: {'lambda': 7.610941364049985, 'alpha': 9.15132968068564, 'colsample_bytree': 0.4, 'subsample': 0.4, 'learning_rate': 0.01, 'n_estimators': 200, 'max_depth': 13, 'min_child_weight': 4}. Best is trial 9 with value: 0.765625.
[I 2023-08-01 18:32:00,472] Trial 11 finished with value: 0.74375 and parameters: {'lambda': 9.484421307861217, 'alpha': 4.746993465383783, 'colsample_bytree': 0.4, 'subsample': 0.4, 'learning_rate': 0.01, 'n_estimators': 100, 'max_depth': 13, 'min_child_weight': 4}. Best is trial 9 with value: 0.765625.
[I 2023-08-01 18:32:00,839] Trial 12 finished with value: 0.725 and parameters: {'lambda': 0.0437469367856355, 'alpha': 5.911619606803201, 'colsample_bytree': 0.4, 'subsample': 0.6, 'learning_rate': 0.008, 'n_estimators': 200, 'max_depth': 7, 'min_child_weight': 61}. Best is trial 9 with value: 0.765625.
[I 2023-08-01 18:32:01,868] Trial 13 finished with value: 0.778125 and parameters: {'lambda': 1.424049157736476, 'alpha': 0.001285515482284065, 'colsample_bytree': 0.4, 'subsample': 0.4, 'learning_rate': 0.01, 'n_estimators': 700, 'max_depth': 11, 'min_child_weight': 5}. Best is trial 13 with value: 0.778125.
[I 2023-08-01 18:32:02,365] Trial 14 finished with value: 0.534375 and parameters: {'lambda': 0.05128280873241269, 'alpha': 0.0010379817702606904, 'colsample_bytree': 0.9, 'subsample': 0.4, 'learning_rate': 0.01, 'n_estimators': 700, 'max_depth': 11, 'min_child_weight': 73}. Best is trial 13 with value: 0.778125.
[I 2023-08-01 18:32:02,984] Trial 15 finished with value: 0.775 and parameters: {'lambda': 0.704765318593652, 'alpha': 0.003646777853332872, 'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.01, 'n_estimators': 700, 'max_depth': 11, 'min_child_weight': 28}. Best is trial 13 with value: 0.778125.
[I 2023-08-01 18:32:03,412] Trial 16 finished with value: 0.73125 and parameters: {'lambda': 1.2339497582097598, 'alpha': 0.00525296927684122,

```
'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.008,
'n_estimators': 650, 'max_depth': 11, 'min_child_weight': 87}. Best is trial 13
with value: 0.778125.
[I 2023-08-01 18:32:03,897] Trial 17 finished with value: 0.534375 and
parameters: {'lambda': 0.5252906043974788, 'alpha': 0.005989859500745756,
'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.02,
'n_estimators': 700, 'max_depth': 11, 'min_child_weight': 182}. Best is trial 13
with value: 0.778125.
[I 2023-08-01 18:32:04,604] Trial 18 finished with value: 0.76875 and
parameters: {'lambda': 3.124309706207792, 'alpha': 0.004642679824891579,
'colsample_bytree': 0.5, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 750, 'max_depth': 11, 'min_child_weight': 25}. Best is trial 13
with value: 0.778125.
[I 2023-08-01 18:32:05,102] Trial 19 finished with value: 0.534375 and
parameters: {'lambda': 0.5443889694031155, 'alpha': 0.01582824471107527,
'colsample_bytree': 1.0, 'subsample': 0.4, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 11, 'min_child_weight': 88}. Best is trial 13
with value: 0.778125.
[I 2023-08-01 18:32:05,591] Trial 20 finished with value: 0.6875 and parameters:
{'lambda': 0.0012068015675762514, 'alpha': 0.0022536852152028343,
'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.01,
'n_estimators': 600, 'max_depth': 17, 'min_child_weight': 100}. Best is trial 13
with value: 0.778125.
[I 2023-08-01 18:32:06,252] Trial 21 finished with value: 0.753125 and
parameters: {'lambda': 3.501766094551345, 'alpha': 0.003568560218877961,
'colsample_bytree': 0.5, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 750, 'max_depth': 11, 'min_child_weight': 31}. Best is trial 13
with value: 0.778125.
[I 2023-08-01 18:32:07,731] Trial 22 finished with value: 0.815625 and
parameters: {'lambda': 3.2126970451874817, 'alpha': 0.008921118496333954,
'colsample_bytree': 0.5, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 800, 'max_depth': 11, 'min_child_weight': 2}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:08,314] Trial 23 finished with value: 0.71875 and
parameters: {'lambda': 1.5643345044500618, 'alpha': 0.011452743364694032,
'colsample_bytree': 0.5, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 11, 'min_child_weight': 53}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:09,402] Trial 24 finished with value: 0.80625 and
parameters: {'lambda': 4.189984863500664, 'alpha': 0.0024641967396025898,
'colsample_bytree': 0.9, 'subsample': 0.8, 'learning_rate': 0.01,
'n_estimators': 650, 'max_depth': 11, 'min_child_weight': 4}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:10,158] Trial 25 finished with value: 0.79375 and
parameters: {'lambda': 5.326544202796009, 'alpha': 0.002156013694967132,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 400, 'max_depth': 7, 'min_child_weight': 2}. Best is trial 22
with value: 0.815625.
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[I 2023-08-01 18:32:10,905] Trial 26 finished with value: 0.790625 and
parameters: {'lambda': 4.645867539796677, 'alpha': 0.009691056595823828,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 400, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:11,259] Trial 27 finished with value: 0.728125 and
parameters: {'lambda': 6.155852580182607, 'alpha': 0.0025730212629353167,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 300, 'max_depth': 7, 'min_child_weight': 50}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:11,756] Trial 28 finished with value: 0.534375 and
parameters: {'lambda': 3.137355184320755, 'alpha': 0.028620785152151995,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 600, 'max_depth': 7, 'min_child_weight': 189}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:12,166] Trial 29 finished with value: 0.534375 and
parameters: {'lambda': 9.285550656069029, 'alpha': 0.002100844208278497,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 450, 'max_depth': 15, 'min_child_weight': 162}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:13,058] Trial 30 finished with value: 0.76875 and
parameters: {'lambda': 4.734752596117164, 'alpha': 0.007664646515339332,
'colsample_bytree': 0.6, 'subsample': 0.5, 'learning_rate': 0.008,
'n_estimators': 950, 'max_depth': 7, 'min_child_weight': 22}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:13,715] Trial 31 finished with value: 0.7875 and parameters:
{'lambda': 4.2467329374728955, 'alpha': 0.010406907305681865,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 350, 'max_depth': 7, 'min_child_weight': 5}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:14,170] Trial 32 finished with value: 0.740625 and
parameters: {'lambda': 2.565850736774043, 'alpha': 0.008263590185685534,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 450, 'max_depth': 7, 'min_child_weight': 69}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:14,589] Trial 33 finished with value: 0.74375 and
parameters: {'lambda': 5.53969745345034, 'alpha': 0.00206210708952295,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.016,
'n_estimators': 350, 'max_depth': 5, 'min_child_weight': 43}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:15,014] Trial 34 finished with value: 0.7625 and parameters:
{'lambda': 9.40502078053599, 'alpha': 0.03689376375006456, 'colsample_bytree':
1.0, 'subsample': 0.6, 'learning_rate': 0.014, 'n_estimators': 250, 'max_depth':
7, 'min_child_weight': 21}. Best is trial 22 with value: 0.815625.
[I 2023-08-01 18:32:15,378] Trial 35 finished with value: 0.465625 and
parameters: {'lambda': 2.24372348990074, 'alpha': 0.019791402472483923,
'colsample_bytree': 0.9, 'subsample': 0.7, 'learning_rate': 0.012,
'n_estimators': 400, 'max_depth': 7, 'min_child_weight': 300}. Best is trial 22
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with value: 0.815625.
[I 2023-08-01 18:32:16,025] Trial 36 finished with value: 0.78125 and
parameters: {'lambda': 4.651065203411241, 'alpha': 0.05468720854100396,
'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.014,
'n_estimators': 500, 'max_depth': 5, 'min_child_weight': 1}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:16,572] Trial 37 finished with value: 0.7375 and parameters:
{'lambda': 5.961708977092425, 'alpha': 0.0032185913358039496,
'colsample_bytree': 0.9, 'subsample': 0.5, 'learning_rate': 0.02,
'n_estimators': 600, 'max_depth': 17, 'min_child_weight': 41}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:16,940] Trial 38 finished with value: 0.534375 and
parameters: {'lambda': 1.010982071596743, 'alpha': 0.012544592196299987,
'colsample_bytree': 0.8, 'subsample': 1.0, 'learning_rate': 0.018,
'n_estimators': 500, 'max_depth': 15, 'min_child_weight': 270}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:17,803] Trial 39 finished with value: 0.775 and parameters:
{'lambda': 2.7273754123344482, 'alpha': 0.00669220328584392, 'colsample_bytree':
0.9, 'subsample': 0.6, 'learning_rate': 0.012, 'n_estimators': 800, 'max_depth':
9, 'min_child_weight': 17}. Best is trial 22 with value: 0.815625.
[I 2023-08-01 18:32:18,209] Trial 40 finished with value: 0.675 and parameters:
{'lambda': 1.9087584611501291, 'alpha': 0.0018586506042768379,
'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 400, 'max_depth': 7, 'min_child_weight': 105}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:18,719] Trial 41 finished with value: 0.78125 and
parameters: {'lambda': 3.828332254647497, 'alpha': 0.010126848240049773,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 350, 'max_depth': 7, 'min_child_weight': 18}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:19,125] Trial 42 finished with value: 0.740625 and
parameters: {'lambda': 5.0285327216689835, 'alpha': 0.0050367770073665285,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.014,
'n_estimators': 300, 'max_depth': 7, 'min_child_weight': 37}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:19,726] Trial 43 finished with value: 0.775 and parameters:
{'lambda': 9.877183865823117, 'alpha': 0.01750340374063586, 'colsample_bytree':
0.9, 'subsample': 0.6, 'learning_rate': 0.014, 'n_estimators': 400, 'max_depth':
7, 'min_child_weight': 12}. Best is trial 22 with value: 0.815625.
[I 2023-08-01 18:32:20,604] Trial 44 finished with value: 0.79375 and
parameters: {'lambda': 1.9804075857994143, 'alpha': 0.0015468122120308148,
'colsample_bytree': 0.8, 'subsample': 0.6, 'learning_rate': 0.018,
'n_estimators': 500, 'max_depth': 9, 'min_child_weight': 5}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:21,177] Trial 45 finished with value: 0.7375 and parameters:
{'lambda': 1.9500741947069433, 'alpha': 0.0014025606164460441,
'colsample_bytree': 0.8, 'subsample': 1.0, 'learning_rate': 0.018,
'n_estimators': 550, 'max_depth': 9, 'min_child_weight': 55}. Best is trial 22
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with value: 0.815625.
[I 2023-08-01 18:32:21,596] Trial 46 finished with value: 0.534375 and
parameters: {'lambda': 1.0443886197350074, 'alpha': 0.001006583421775816,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.018,
'n_estimators': 550, 'max_depth': 9, 'min_child_weight': 130}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:22,200] Trial 47 finished with value: 0.75625 and
parameters: {'lambda': 2.2656132705666305, 'alpha': 0.0028890790019607763,
'colsample_bytree': 0.8, 'subsample': 0.6, 'learning_rate': 0.018,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 36}. Best is trial 22
with value: 0.815625.
[I 2023-08-01 18:32:23,455] Trial 48 finished with value: 0.821875 and
parameters: {'lambda': 0.3284679028874424, 'alpha': 0.0015468326311184912,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 500, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 48
with value: 0.821875.
[I 2023-08-01 18:32:23,930] Trial 49 finished with value: 0.728125 and
parameters: {'lambda': 0.20047158859938283, 'alpha': 0.0019787874717947162,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 500, 'max_depth': 13, 'min_child_weight': 69}. Best is trial 48
with value: 0.821875.
[I 2023-08-01 18:32:24,745] Trial 50 finished with value: 0.775 and parameters:
{'lambda': 0.339079744972654, 'alpha': 0.0015119037142865969,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 13, 'min_child_weight': 15}. Best is trial 48
with value: 0.821875.
[I 2023-08-01 18:32:25,913] Trial 51 finished with value: 0.834375 and
parameters: {'lambda': 1.3256013686138948, 'alpha': 0.003517995485059574,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 450, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:26,664] Trial 52 finished with value: 0.784375 and
parameters: {'lambda': 0.8567253986981243, 'alpha': 0.0044021802912080086,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 450, 'max_depth': 13, 'min_child_weight': 11}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:27,262] Trial 53 finished with value: 0.778125 and
parameters: {'lambda': 1.408905215039836, 'alpha': 0.0030945968486083557,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 500, 'max_depth': 13, 'min_child_weight': 26}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:27,881] Trial 54 finished with value: 0.7625 and parameters:
{'lambda': 1.4078090584778662, 'alpha': 0.0014110657033289706,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 550, 'max_depth': 13, 'min_child_weight': 33}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:28,301] Trial 55 finished with value: 0.534375 and
parameters: {'lambda': 0.7466344222800126, 'alpha': 0.00397070444744456,
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'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.01,
'n_estimators': 600, 'max_depth': 13, 'min_child_weight': 204}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:29,348] Trial 56 finished with value: 0.784375 and
parameters: {'lambda': 3.1046696180118696, 'alpha': 0.0016267629075492785,
'colsample_bytree': 0.7, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 11, 'min_child_weight': 12}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:30,933] Trial 57 finished with value: 0.825 and parameters:
{'lambda': 1.0900955459157429, 'alpha': 0.0010884426572567336,
'colsample_bytree': 0.3, 'subsample': 0.5, 'learning_rate': 0.02,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:31,613] Trial 58 finished with value: 0.73125 and
parameters: {'lambda': 1.0055656024159283, 'alpha': 0.0027280049736596915,
'colsample_bytree': 0.3, 'subsample': 0.5, 'learning_rate': 0.02,
'n_estimators': 1000, 'max_depth': 11, 'min_child_weight': 46}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:32,331] Trial 59 finished with value: 0.75 and parameters:
{'lambda': 0.554274576074888, 'alpha': 0.0010803334667066028,
'colsample_bytree': 0.3, 'subsample': 0.5, 'learning_rate': 0.02,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 26}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:32,969] Trial 60 finished with value: 0.75 and parameters:
{'lambda': 0.35914460427074074, 'alpha': 0.006190729172439443,
'colsample_bytree': 0.3, 'subsample': 0.5, 'learning_rate': 0.02,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 55}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:34,505] Trial 61 finished with value: 0.815625 and
parameters: {'lambda': 1.6754617119725068, 'alpha': 0.0016833973371023056,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 2}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:35,531] Trial 62 finished with value: 0.78125 and
parameters: {'lambda': 1.539079491244445, 'alpha': 0.002176413970182299,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 12}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:37,259] Trial 63 finished with value: 0.803125 and
parameters: {'lambda': 7.468417630313449, 'alpha': 0.0037327995865318224,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:38,054] Trial 64 finished with value: 0.746875 and
parameters: {'lambda': 7.503174748178387, 'alpha': 0.0049279009511849405,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 28}. Best is trial 51
with value: 0.834375.

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[I 2023-08-01 18:32:39,626] Trial 65 finished with value: 0.803125 and
parameters: {'lambda': 3.2510653875801854, 'alpha': 0.0036575286707245624,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 2}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:40,461] Trial 66 finished with value: 0.778125 and
parameters: {'lambda': 6.83133439138281, 'alpha': 0.001066727733912755,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 18}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:41,166] Trial 67 finished with value: 0.734375 and
parameters: {'lambda': 2.7382202371798634, 'alpha': 0.0029596667309907568,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 850, 'max_depth': 11, 'min_child_weight': 35}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:41,750] Trial 68 finished with value: 0.534375 and
parameters: {'lambda': 3.555144676660946, 'alpha': 0.0025191563694379904,
'colsample_bytree': 1.0, 'subsample': 0.4, 'learning_rate': 0.008,
'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 79}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:42,342] Trial 69 finished with value: 0.740625 and
parameters: {'lambda': 0.7638904661807864, 'alpha': 0.0014253535876867461,
'colsample_bytree': 0.4, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 900, 'max_depth': 5, 'min_child_weight': 61}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:43,621] Trial 70 finished with value: 0.7875 and parameters:
{'lambda': 1.2328987928385446, 'alpha': 0.006578427280050292,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 950, 'max_depth': 15, 'min_child_weight': 8}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:45,056] Trial 71 finished with value: 0.796875 and
parameters: {'lambda': 3.5586102607687415, 'alpha': 0.0037403250765655704,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 4}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:45,747] Trial 72 finished with value: 0.765625 and
parameters: {'lambda': 2.0293532751953034, 'alpha': 0.003984297376672909,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.01,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 23}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:47,749] Trial 73 finished with value: 0.825 and parameters:
{'lambda': 6.5043814991188205, 'alpha': 0.001931362170427621,
'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.01,
'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:32:48,698] Trial 74 finished with value: 0.775 and parameters:
{'lambda': 6.644853482504744, 'alpha': 0.0018387456773352319,
'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.02,
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'n_estimators': 800, 'max_depth': 11, 'min_child_weight': 18}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:50,070] Trial 75 finished with value: 0.784375 and parameters: {'lambda': 4.733691400057782, 'alpha': 0.00247320563462909, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.012, 'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 9}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:50,926] Trial 76 finished with value: 0.765625 and parameters: {'lambda': 7.5020520969838635, 'alpha': 0.0012476431194073153, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.01, 'n_estimators': 850, 'max_depth': 11, 'min_child_weight': 31}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:52,689] Trial 77 finished with value: 0.834375 and parameters: {'lambda': 2.6382393550483245, 'alpha': 0.0018046063083888893, 'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:53,420] Trial 78 finished with value: 0.746875 and parameters: {'lambda': 1.716906168429163, 'alpha': 0.0017367638844511756, 'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 44}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:53,969] Trial 79 finished with value: 0.534375 and parameters: {'lambda': 3.856285373578656, 'alpha': 0.002355553595429677, 'colsample_bytree': 1.0, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 1000, 'max_depth': 17, 'min_child_weight': 145}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:54,776] Trial 80 finished with value: 0.775 and parameters: {'lambda': 2.331704345762283, 'alpha': 0.001313749206200177, 'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 21}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:56,395] Trial 81 finished with value: 0.81875 and parameters: {'lambda': 5.421589303221688, 'alpha': 0.0048601540969573425, 'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016, 'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 2}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:57,813] Trial 82 finished with value: 0.771875 and parameters: {'lambda': 5.739696224942672, 'alpha': 0.0018265341812914834, 'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016, 'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 11}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:32:59,653] Trial 83 finished with value: 0.828125 and parameters: {'lambda': 2.6855566029700646, 'alpha': 0.0048840799414728835, 'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016, 'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:33:00,949] Trial 84 finished with value: 0.778125 and parameters: {'lambda': 1.7032615333863914, 'alpha': 0.00806094969190182,

'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 15}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:01,953] Trial 85 finished with value: 0.76875 and
parameters: {'lambda': 2.5491275745715396, 'alpha': 0.004818456452557415,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 26}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:03,372] Trial 86 finished with value: 0.784375 and
parameters: {'lambda': 1.211907211357327, 'alpha': 0.00551367236366188,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 8}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:04,254] Trial 87 finished with value: 0.7625 and parameters:
{'lambda': 2.799283955021536, 'alpha': 0.002953133077553253, 'colsample_bytree':
0.7, 'subsample': 1.0, 'learning_rate': 0.016, 'n_estimators': 950, 'max_depth':
9, 'min_child_weight': 37}. Best is trial 51 with value: 0.834375.
[I 2023-08-01 18:33:05,347] Trial 88 finished with value: 0.76875 and
parameters: {'lambda': 4.251544061354876, 'alpha': 0.0011972666651421868,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 15, 'min_child_weight': 17}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:05,687] Trial 89 finished with value: 0.78125 and
parameters: {'lambda': 2.3199019519407953, 'alpha': 0.001998108788945012,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.008,
'n_estimators': 100, 'max_depth': 9, 'min_child_weight': 2}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:06,171] Trial 90 finished with value: 0.465625 and
parameters: {'lambda': 1.750930701141685, 'alpha': 0.0031593478192219727,
'colsample_bytree': 0.3, 'subsample': 0.4, 'learning_rate': 0.016,
'n_estimators': 1000, 'max_depth': 5, 'min_child_weight': 252}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:07,516] Trial 91 finished with value: 0.790625 and
parameters: {'lambda': 4.13753812650697, 'alpha': 0.0017318249357144999,
'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.02,
'n_estimators': 900, 'max_depth': 11, 'min_child_weight': 8}. Best is trial 51
with value: 0.834375.
[I 2023-08-01 18:33:09,319] Trial 92 finished with value: 0.840625 and
parameters: {'lambda': 5.30954240034579, 'alpha': 0.002677051211230696,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 92
with value: 0.840625.
[I 2023-08-01 18:33:11,149] Trial 93 finished with value: 0.84375 and
parameters: {'lambda': 5.149313851915358, 'alpha': 0.004644015955229921,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:12,008] Trial 94 finished with value: 0.775 and parameters:

{'lambda': 6.069219644978829, 'alpha': 0.005667283620610717, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 20}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:12,933] Trial 95 finished with value: 0.778125 and parameters: {'lambda': 5.307400555307189, 'alpha': 0.007754591847417766, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 13}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:13,965] Trial 96 finished with value: 0.80625 and parameters: {'lambda': 8.330963724324006, 'alpha': 0.004564191057536763, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 450, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:14,760] Trial 97 finished with value: 0.775 and parameters: {'lambda': 3.1251525391703656, 'alpha': 0.012794990553441014, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 13, 'min_child_weight': 26}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:15,888] Trial 98 finished with value: 0.784375 and parameters: {'lambda': 5.271824426362449, 'alpha': 0.002380272897288952, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 9}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:16,711] Trial 99 finished with value: 0.75625 and parameters: {'lambda': 8.756009182723018, 'alpha': 0.0034449688536269288, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 32}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:17,576] Trial 100 finished with value: 0.753125 and parameters: {'lambda': 3.827470301666452, 'alpha': 0.0010087193229699693, 'colsample_bytree': 0.8, 'subsample': 1.0, 'learning_rate': 0.012, 'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 39}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:19,295] Trial 101 finished with value: 0.84375 and parameters: {'lambda': 3.0141064738378223, 'alpha': 0.0016614861975835604, 'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:20,395] Trial 102 finished with value: 0.775 and parameters: {'lambda': 2.860033502296052, 'alpha': 0.002729559912753648, 'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 15}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:21,613] Trial 103 finished with value: 0.778125 and parameters: {'lambda': 2.1519181966652376, 'alpha': 0.001345394233281047, 'colsample_bytree': 0.3, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 9}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:22,686] Trial 104 finished with value: 0.78125 and

parameters: {'lambda': 4.6179624155916095, 'alpha': 0.0020932460573541015,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 1000, 'max_depth': 9, 'min_child_weight': 21}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:24,145] Trial 105 finished with value: 0.7875 and
parameters: {'lambda': 5.826478706702502, 'alpha': 0.00449472396084796,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:25,991] Trial 106 finished with value: 0.8375 and
parameters: {'lambda': 3.289938527619379, 'alpha': 0.0064984939968834345,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 17, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:27,142] Trial 107 finished with value: 0.78125 and
parameters: {'lambda': 9.755223301081967, 'alpha': 0.006761494860788178,
'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 950, 'max_depth': 17, 'min_child_weight': 14}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:28,088] Trial 108 finished with value: 0.775 and parameters:
{'lambda': 3.4511843367880437, 'alpha': 0.0014684189499564433,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 1000, 'max_depth': 17, 'min_child_weight': 23}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:28,572] Trial 109 finished with value: 0.775 and parameters:
{'lambda': 2.4575553937270644, 'alpha': 0.0032066929574778164,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 150, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:29,277] Trial 110 finished with value: 0.753125 and
parameters: {'lambda': 6.619466964939553, 'alpha': 0.0022543210938526454,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.02,
'n_estimators': 750, 'max_depth': 17, 'min_child_weight': 30}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:31,439] Trial 111 finished with value: 0.821875 and
parameters: {'lambda': 3.127577310922995, 'alpha': 0.004407750068634352,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 17, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:32,926] Trial 112 finished with value: 0.78125 and
parameters: {'lambda': 4.472905042294315, 'alpha': 0.004047490796802893,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 17, 'min_child_weight': 8}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:33,536] Trial 113 finished with value: 0.6875 and
parameters: {'lambda': 3.0129273466013085, 'alpha': 0.005589548357408673,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 17, 'min_child_weight': 118}. Best is trial 93

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with value: 0.84375.
[I 2023-08-01 18:33:34,586] Trial 114 finished with value: 0.778125 and
parameters: {'lambda': 1.9638006543386735, 'alpha': 0.0011888188065450496,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 17, 'min_child_weight': 16}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:36,551] Trial 115 finished with value: 0.83125 and
parameters: {'lambda': 1.3877187584487156, 'alpha': 0.00269507923383934,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 17, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:37,745] Trial 116 finished with value: 0.78125 and
parameters: {'lambda': 0.9295590325553663, 'alpha': 0.0027171668179067927,
'colsample_bytree': 0.3, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 17, 'min_child_weight': 8}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:38,538] Trial 117 finished with value: 0.753125 and
parameters: {'lambda': 1.3350187905880049, 'alpha': 0.001608320729811807,
'colsample_bytree': 0.4, 'subsample': 0.4, 'learning_rate': 0.008,
'n_estimators': 800, 'max_depth': 17, 'min_child_weight': 20}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:39,452] Trial 118 finished with value: 0.778125 and
parameters: {'lambda': 1.3808237128718752, 'alpha': 0.0021510794251443847,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 17, 'min_child_weight': 13}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:40,879] Trial 119 finished with value: 0.796875 and
parameters: {'lambda': 1.1211078977916984, 'alpha': 0.0037066213623640977,
'colsample_bytree': 0.6, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 17, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:41,311] Trial 120 finished with value: 0.534375 and
parameters: {'lambda': 1.5317301415483382, 'alpha': 0.009318839400497509,
'colsample_bytree': 0.8, 'subsample': 0.7, 'learning_rate': 0.02,
'n_estimators': 500, 'max_depth': 13, 'min_child_weight': 200}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:42,084] Trial 121 finished with value: 0.809375 and
parameters: {'lambda': 3.7996659950506233, 'alpha': 0.004476902844827968,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 450, 'max_depth': 9, 'min_child_weight': 3}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:43,338] Trial 122 finished with value: 0.778125 and
parameters: {'lambda': 2.468716062256812, 'alpha': 0.002831762472460235,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 15, 'min_child_weight': 13}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:44,436] Trial 123 finished with value: 0.828125 and
parameters: {'lambda': 3.3432751301910315, 'alpha': 0.007137600277583676,
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'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 2}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:45,302] Trial 124 finished with value: 0.7875 and
parameters: {'lambda': 1.8742204560876827, 'alpha': 0.006745498214977098,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.016,
'n_estimators': 600, 'max_depth': 5, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:45,903] Trial 125 finished with value: 0.775 and parameters:
{'lambda': 3.1819084132670192, 'alpha': 0.0018651687316379232,
'colsample_bytree': 0.5, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 23}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:46,756] Trial 126 finished with value: 0.790625 and
parameters: {'lambda': 0.8274603452948309, 'alpha': 0.0014768953038769414,
'colsample_bytree': 0.5, 'subsample': 1.0, 'learning_rate': 0.018,
'n_estimators': 550, 'max_depth': 13, 'min_child_weight': 8}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:47,702] Trial 127 finished with value: 0.784375 and
parameters: {'lambda': 2.224731411184787, 'alpha': 0.003480364542240802,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.012,
'n_estimators': 850, 'max_depth': 17, 'min_child_weight': 18}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:49,195] Trial 128 finished with value: 0.828125 and
parameters: {'lambda': 1.2170817407887924, 'alpha': 0.0024515452894466323,
'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:49,889] Trial 129 finished with value: 0.76875 and
parameters: {'lambda': 0.6219031935379715, 'alpha': 0.0012525324866011136,
'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 29}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:50,902] Trial 130 finished with value: 0.771875 and
parameters: {'lambda': 1.1107556168052932, 'alpha': 0.0026798788486017797,
'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:52,096] Trial 131 finished with value: 0.803125 and
parameters: {'lambda': 1.3441383584066946, 'alpha': 0.0023522134744701434,
'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:33:53,619] Trial 132 finished with value: 0.828125 and
parameters: {'lambda': 0.988653168180005, 'alpha': 0.0032250300896054253,
'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.

[I 2023-08-01 18:33:54,559] Trial 133 finished with value: 0.778125 and parameters: {'lambda': 0.903437328730161, 'alpha': 0.0017770230094792503, 'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 15}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:55,749] Trial 134 finished with value: 0.784375 and parameters: {'lambda': 0.4642877909256941, 'alpha': 0.003324568070508978, 'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:56,591] Trial 135 finished with value: 0.775 and parameters: {'lambda': 1.008919613391666, 'alpha': 0.005507190185724194, 'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.02, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 18}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:58,017] Trial 136 finished with value: 0.828125 and parameters: {'lambda': 1.651267267633554, 'alpha': 0.0010191074905447856, 'colsample_bytree': 0.8, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:59,384] Trial 137 finished with value: 0.834375 and parameters: {'lambda': 1.5575745534899204, 'alpha': 0.001001922192398799, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:33:59,872] Trial 138 finished with value: 0.534375 and parameters: {'lambda': 1.7166049732419717, 'alpha': 0.0010191236659240932, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 226}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:00,851] Trial 139 finished with value: 0.784375 and parameters: {'lambda': 1.4420351501271134, 'alpha': 0.0010251956276258072, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 11}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:01,680] Trial 140 finished with value: 0.778125 and parameters: {'lambda': 0.6807657445956994, 'alpha': 0.0012986014922414099, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 25}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:03,206] Trial 141 finished with value: 0.83125 and parameters: {'lambda': 1.9854018498632449, 'alpha': 0.0019696412313027433, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:04,702] Trial 142 finished with value: 0.825 and parameters: {'lambda': 1.181353227601006, 'alpha': 0.002058638570292426, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.

[I 2023-08-01 18:34:05,867] Trial 143 finished with value: 0.784375 and parameters: {'lambda': 2.1106080068853075, 'alpha': 0.0015625075691651292, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 8}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:06,734] Trial 144 finished with value: 0.76875 and parameters: {'lambda': 1.7064865394873279, 'alpha': 0.0012702274541855135, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 13}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:07,877] Trial 145 finished with value: 0.778125 and parameters: {'lambda': 2.535785810184716, 'alpha': 0.002524313507732191, 'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:09,438] Trial 146 finished with value: 0.8375 and parameters: {'lambda': 1.5435722074753726, 'alpha': 0.0030939290197729724, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:10,356] Trial 147 finished with value: 0.778125 and parameters: {'lambda': 1.9268389735470581, 'alpha': 0.0031191027534203243, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 19}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:10,889] Trial 148 finished with value: 0.534375 and parameters: {'lambda': 2.773350237823747, 'alpha': 0.004082750578165988, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 157}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:11,814] Trial 149 finished with value: 0.775 and parameters: {'lambda': 1.6024630705679304, 'alpha': 0.006023000565682785, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 600, 'max_depth': 9, 'min_child_weight': 12}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:13,273] Trial 150 finished with value: 0.834375 and parameters: {'lambda': 1.2396989595971049, 'alpha': 0.00915968146281295, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:14,711] Trial 151 finished with value: 0.8375 and parameters: {'lambda': 1.2732579966480075, 'alpha': 0.012646606451873616, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:15,907] Trial 152 finished with value: 0.79375 and parameters: {'lambda': 0.8004052806512529, 'alpha': 0.009380746514534617, 'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,

'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:17,260] Trial 153 finished with value: 0.803125 and
parameters: {'lambda': 1.1663081681180598, 'alpha': 0.007961533879768725,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:18,238] Trial 154 finished with value: 0.784375 and
parameters: {'lambda': 1.3722155908247526, 'alpha': 0.007330703528017439,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 16}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:19,106] Trial 155 finished with value: 0.78125 and
parameters: {'lambda': 0.9399687052741904, 'alpha': 0.010805920836909587,
'colsample_bytree': 0.6, 'subsample': 0.4, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 15, 'min_child_weight': 10}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:20,314] Trial 156 finished with value: 0.834375 and
parameters: {'lambda': 2.292265462378281, 'alpha': 0.013941521519959078,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:21,157] Trial 157 finished with value: 0.778125 and
parameters: {'lambda': 3.7609001921743817, 'alpha': 0.01364451822807948,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.008,
'n_estimators': 650, 'max_depth': 5, 'min_child_weight': 18}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:21,930] Trial 158 finished with value: 0.775 and parameters:
{'lambda': 2.4182737749480667, 'alpha': 0.020212357965046134,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 23}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:23,291] Trial 159 finished with value: 0.834375 and
parameters: {'lambda': 2.0393583310206935, 'alpha': 0.008856797480337941,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:23,716] Trial 160 finished with value: 0.534375 and
parameters: {'lambda': 2.158679192681409, 'alpha': 0.013871484928409823,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 13, 'min_child_weight': 171}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:25,113] Trial 161 finished with value: 0.834375 and
parameters: {'lambda': 2.9314446305129125, 'alpha': 0.007728465555673399,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:26,119] Trial 162 finished with value: 0.78125 and

parameters: {'lambda': 3.224090153921975, 'alpha': 0.011256939500541727,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 8}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:26,983] Trial 163 finished with value: 0.778125 and
parameters: {'lambda': 2.764896548744625, 'alpha': 0.00921263247278647,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 600, 'max_depth': 9, 'min_child_weight': 13}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:28,065] Trial 164 finished with value: 0.784375 and
parameters: {'lambda': 4.38158300923573, 'alpha': 0.016489333843045635,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:29,485] Trial 165 finished with value: 0.834375 and
parameters: {'lambda': 2.0758960156298523, 'alpha': 0.006928417165134921,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:30,363] Trial 166 finished with value: 0.775 and parameters:
{'lambda': 2.320264194371635, 'alpha': 0.008353816061675498, 'colsample_bytree':
0.6, 'subsample': 0.8, 'learning_rate': 0.018, 'n_estimators': 700, 'max_depth':
9, 'min_child_weight': 11}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:31,679] Trial 167 finished with value: 0.825 and parameters:
{'lambda': 1.911332273898519, 'alpha': 0.006131930411521553, 'colsample_bytree':
0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 600, 'max_depth':
9, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:32,620] Trial 168 finished with value: 0.784375 and
parameters: {'lambda': 2.085581618401785, 'alpha': 0.010294104729743202,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 15}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:33,919] Trial 169 finished with value: 0.778125 and
parameters: {'lambda': 1.5269081483765454, 'alpha': 0.005114669652931924,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.012,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:34,546] Trial 170 finished with value: 0.78125 and
parameters: {'lambda': 2.791406729910678, 'alpha': 0.02548238446666787,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 23}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:35,662] Trial 171 finished with value: 0.8 and parameters:
{'lambda': 3.6596367890360355, 'alpha': 0.00761363867845262, 'colsample_bytree':
0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 650, 'max_depth':
9, 'min_child_weight': 5}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:37,105] Trial 172 finished with value: 0.840625 and
parameters: {'lambda': 4.192796637025857, 'alpha': 0.006917401272218283,

'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:38,495] Trial 173 finished with value: 0.840625 and
parameters: {'lambda': 4.433694193726152, 'alpha': 0.011659552897050002,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:39,471] Trial 174 finished with value: 0.7875 and
parameters: {'lambda': 5.104654552473045, 'alpha': 0.011134470104903265,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:40,638] Trial 175 finished with value: 0.80625 and
parameters: {'lambda': 4.046385032418813, 'alpha': 0.014053114591791852,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:42,382] Trial 176 finished with value: 0.84375 and
parameters: {'lambda': 4.839422144999134, 'alpha': 0.01553974299643787,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:43,281] Trial 177 finished with value: 0.778125 and
parameters: {'lambda': 5.041391844666915, 'alpha': 0.015325028278925035,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 650, 'max_depth': 13, 'min_child_weight': 14}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:44,174] Trial 178 finished with value: 0.778125 and
parameters: {'lambda': 7.225615428250005, 'alpha': 0.008862920788956242,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 18}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:45,192] Trial 179 finished with value: 0.79375 and
parameters: {'lambda': 4.379160333453782, 'alpha': 0.012504868833172833,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:45,846] Trial 180 finished with value: 0.725 and parameters:
{'lambda': 5.341273442738807, 'alpha': 0.017842462319810556, 'colsample_bytree':
0.6, 'subsample': 0.8, 'learning_rate': 0.016, 'n_estimators': 700, 'max_depth':
13, 'min_child_weight': 95}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:34:46,952] Trial 181 finished with value: 0.790625 and
parameters: {'lambda': 3.4231696352903263, 'alpha': 0.010969364217617822,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 7, 'min_child_weight': 5}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:48,607] Trial 182 finished with value: 0.834375 and

parameters: {'lambda': 1.632456386131946, 'alpha': 0.006945535674461979,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:49,780] Trial 183 finished with value: 0.784375 and
parameters: {'lambda': 6.145670920829333, 'alpha': 0.00662742545808633,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:51,084] Trial 184 finished with value: 0.803125 and
parameters: {'lambda': 1.4834501266241777, 'alpha': 0.0057156012349333304,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 5}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:53,005] Trial 185 finished with value: 0.840625 and
parameters: {'lambda': 2.6215640691497217, 'alpha': 0.008413393246550568,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 17, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:54,562] Trial 186 finished with value: 0.834375 and
parameters: {'lambda': 3.0193718097447695, 'alpha': 0.009992939711119137,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:55,620] Trial 187 finished with value: 0.784375 and
parameters: {'lambda': 2.362563502391574, 'alpha': 0.011713673412713569,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 15, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:56,732] Trial 188 finished with value: 0.80625 and
parameters: {'lambda': 4.499437464741145, 'alpha': 0.007327010391786125,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 5, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:57,700] Trial 189 finished with value: 0.784375 and
parameters: {'lambda': 3.616101571312417, 'alpha': 0.008050052594854019,
'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 18}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:58,334] Trial 190 finished with value: 0.775 and parameters:
{'lambda': 0.1335325863757063, 'alpha': 0.016009001701550677,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 300, 'max_depth': 13, 'min_child_weight': 9}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:34:59,850] Trial 191 finished with value: 0.834375 and
parameters: {'lambda': 2.8487646982054002, 'alpha': 0.009390625445183286,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93

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with value: 0.84375.
[I 2023-08-01 18:35:01,537] Trial 192 finished with value: 0.8375 and
parameters: {'lambda': 2.873269782829749, 'alpha': 0.012151789674144702,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:02,832] Trial 193 finished with value: 0.778125 and
parameters: {'lambda': 1.7420380668913593, 'alpha': 0.012260341205665883,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 8}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:03,838] Trial 194 finished with value: 0.78125 and
parameters: {'lambda': 2.464189438654218, 'alpha': 0.006572465128551413,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:05,230] Trial 195 finished with value: 0.778125 and
parameters: {'lambda': 4.164154830793155, 'alpha': 0.01805953024772528,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.008,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:06,870] Trial 196 finished with value: 0.828125 and
parameters: {'lambda': 1.9576958621842881, 'alpha': 0.0084110301802626,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:07,676] Trial 197 finished with value: 0.784375 and
parameters: {'lambda': 3.1002748924732, 'alpha': 0.02308923253341766,
'colsample_bytree': 0.4, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 17, 'min_child_weight': 16}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:08,708] Trial 198 finished with value: 0.79375 and
parameters: {'lambda': 0.01734490041590833, 'alpha': 0.005565179283065046,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.018,
'n_estimators': 650, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:10,161] Trial 199 finished with value: 0.80625 and
parameters: {'lambda': 7.82705526431091, 'alpha': 0.01402038017781716,
'colsample_bytree': 0.6, 'subsample': 0.4, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:10,591] Trial 200 finished with value: 0.465625 and
parameters: {'lambda': 6.045383504750903, 'alpha': 0.009652059029736568,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 550, 'max_depth': 13, 'min_child_weight': 273}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:11,910] Trial 201 finished with value: 0.790625 and
parameters: {'lambda': 3.0564331340838997, 'alpha': 0.010299912500712712,
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'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:12,950] Trial 202 finished with value: 0.78125 and
parameters: {'lambda': 2.554030720847988, 'alpha': 0.008350080245732205,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:14,603] Trial 203 finished with value: 0.8375 and
parameters: {'lambda': 3.982073540520971, 'alpha': 0.012423829871954067,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:16,197] Trial 204 finished with value: 0.8375 and
parameters: {'lambda': 3.8632244152345536, 'alpha': 0.013966280800619027,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:17,497] Trial 205 finished with value: 0.790625 and
parameters: {'lambda': 3.8520758536540987, 'alpha': 0.015336602976273282,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:18,366] Trial 206 finished with value: 0.784375 and
parameters: {'lambda': 5.122893671630767, 'alpha': 0.01921807680214375,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.012,
'n_estimators': 600, 'max_depth': 9, 'min_child_weight': 13}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:20,122] Trial 207 finished with value: 0.8375 and
parameters: {'lambda': 4.350557073868012, 'alpha': 0.012653843162945653,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:21,109] Trial 208 finished with value: 0.76875 and
parameters: {'lambda': 4.609173189397683, 'alpha': 0.012422717797692669,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 21}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:22,323] Trial 209 finished with value: 0.784375 and
parameters: {'lambda': 3.809746366605398, 'alpha': 0.02304153004005002,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:23,360] Trial 210 finished with value: 0.778125 and
parameters: {'lambda': 4.919459423066083, 'alpha': 0.01350482911260164,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 15}. Best is trial 93
with value: 0.84375.

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[I 2023-08-01 18:35:25,172] Trial 211 finished with value: 0.8375 and
parameters: {'lambda': 3.40461549699571, 'alpha': 0.01615840254213251,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:26,932] Trial 212 finished with value: 0.84375 and
parameters: {'lambda': 6.551253227998094, 'alpha': 0.016945483385050916,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:28,328] Trial 213 finished with value: 0.790625 and
parameters: {'lambda': 6.880144438380247, 'alpha': 0.01593959777902291,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:29,493] Trial 214 finished with value: 0.778125 and
parameters: {'lambda': 6.230589875941227, 'alpha': 0.02060561255271493,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 9}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:30,892] Trial 215 finished with value: 0.79375 and
parameters: {'lambda': 4.243998367150289, 'alpha': 0.016996195920671746,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:32,644] Trial 216 finished with value: 0.83125 and
parameters: {'lambda': 8.095370728824163, 'alpha': 0.012560354628241198,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:33,819] Trial 217 finished with value: 0.78125 and
parameters: {'lambda': 3.416788411140076, 'alpha': 0.02572039203582608,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 10}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:35,264] Trial 218 finished with value: 0.8375 and
parameters: {'lambda': 4.9002145529954095, 'alpha': 0.014571754130646753,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:36,297] Trial 219 finished with value: 0.775 and parameters:
{'lambda': 5.695806026935499, 'alpha': 0.033457801191674554, 'colsample_bytree':
0.7, 'subsample': 0.7, 'learning_rate': 0.014, 'n_estimators': 850, 'max_depth':
7, 'min_child_weight': 14}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:35:37,613] Trial 220 finished with value: 0.78125 and
parameters: {'lambda': 4.836921409857147, 'alpha': 0.01545256696336561,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 7, 'min_child_weight': 7}. Best is trial 93
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with value: 0.84375.
[I 2023-08-01 18:35:39,091] Trial 221 finished with value: 0.828125 and
parameters: {'lambda': 3.7964451491909954, 'alpha': 0.011140644694649607,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:40,382] Trial 222 finished with value: 0.828125 and
parameters: {'lambda': 5.514746840326631, 'alpha': 0.020567177625861112,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:40,833] Trial 223 finished with value: 0.534375 and
parameters: {'lambda': 0.2602597178168327, 'alpha': 0.013962353426732141,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 143}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:42,223] Trial 224 finished with value: 0.790625 and
parameters: {'lambda': 6.877932266810487, 'alpha': 0.017609599739480744,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 11, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:43,423] Trial 225 finished with value: 0.7875 and
parameters: {'lambda': 4.254188975899722, 'alpha': 0.04693797183404495,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:45,326] Trial 226 finished with value: 0.8375 and
parameters: {'lambda': 3.372319023676401, 'alpha': 0.011123443758330265,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:46,638] Trial 227 finished with value: 0.778125 and
parameters: {'lambda': 3.4533068185645472, 'alpha': 0.011866126843757537,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:47,622] Trial 228 finished with value: 0.78125 and
parameters: {'lambda': 4.541914305196204, 'alpha': 0.012980307032845577,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 17}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:49,679] Trial 229 finished with value: 0.840625 and
parameters: {'lambda': 3.5814711447200023, 'alpha': 0.018072805149626222,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:50,864] Trial 230 finished with value: 0.784375 and
parameters: {'lambda': 3.546165969672507, 'alpha': 0.018355773361480275,

'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:52,971] Trial 231 finished with value: 0.828125 and
parameters: {'lambda': 5.414808769903963, 'alpha': 0.015275968270307489,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:54,338] Trial 232 finished with value: 0.7875 and
parameters: {'lambda': 2.7350988730848904, 'alpha': 0.01105223912893788,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:56,219] Trial 233 finished with value: 0.834375 and
parameters: {'lambda': 4.098786673179204, 'alpha': 0.07822671342836664,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:57,625] Trial 234 finished with value: 0.790625 and
parameters: {'lambda': 3.2805306164857595, 'alpha': 0.02076763231247735,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:35:59,466] Trial 235 finished with value: 0.809375 and
parameters: {'lambda': 9.199980610596269, 'alpha': 0.015093094659688833,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:00,772] Trial 236 finished with value: 0.784375 and
parameters: {'lambda': 0.06877617260582268, 'alpha': 0.028212829437620785,
'colsample_bytree': 0.9, 'subsample': 0.7, 'learning_rate': 0.008,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 10}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:02,135] Trial 237 finished with value: 0.79375 and
parameters: {'lambda': 4.912440040789338, 'alpha': 0.010214052949552382,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 15, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:03,445] Trial 238 finished with value: 0.8375 and
parameters: {'lambda': 2.671471794049647, 'alpha': 0.012860802832354726,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:04,679] Trial 239 finished with value: 0.778125 and
parameters: {'lambda': 3.9869807191908864, 'alpha': 0.3454446265014116,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 950, 'max_depth': 7, 'min_child_weight': 13}. Best is trial 93
with value: 0.84375.

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[I 2023-08-01 18:36:05,299] Trial 240 finished with value: 0.7875 and
parameters: {'lambda': 6.007382288362379, 'alpha': 0.14571925139399697,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 350, 'max_depth': 7, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:06,594] Trial 241 finished with value: 0.8 and parameters:
{'lambda': 2.673730597640869, 'alpha': 0.012452266891665889, 'colsample_bytree':
0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 900, 'max_depth':
7, 'min_child_weight': 6}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:36:08,015] Trial 242 finished with value: 0.834375 and
parameters: {'lambda': 3.4732002135195597, 'alpha': 0.0135062076395855,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:09,085] Trial 243 finished with value: 0.815625 and
parameters: {'lambda': 2.9325194757843183, 'alpha': 0.01886230665484365,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 5, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:10,283] Trial 244 finished with value: 0.78125 and
parameters: {'lambda': 2.263034331101702, 'alpha': 0.010450733121708982,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:11,557] Trial 245 finished with value: 0.784375 and
parameters: {'lambda': 4.501940313391942, 'alpha': 0.016781436495338253,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:13,053] Trial 246 finished with value: 0.7875 and
parameters: {'lambda': 3.3523369139412607, 'alpha': 0.014634052175198102,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.018,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:14,357] Trial 247 finished with value: 0.828125 and
parameters: {'lambda': 2.7679706677416087, 'alpha': 0.009486779944510361,
'colsample_bytree': 0.6, 'subsample': 0.6, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:15,318] Trial 248 finished with value: 0.778125 and
parameters: {'lambda': 3.92071377373392, 'alpha': 0.00390942902941666,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 13}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:16,626] Trial 249 finished with value: 0.834375 and
parameters: {'lambda': 0.39007828726177257, 'alpha': 0.02308760964316569,
'colsample_bytree': 0.6, 'subsample': 0.4, 'learning_rate': 0.014,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
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with value: 0.84375.
[I 2023-08-01 18:36:17,732] Trial 250 finished with value: 0.775 and parameters:
{'lambda': 2.369772773221609, 'alpha': 0.011692712318970358, 'colsample_bytree':
0.6, 'subsample': 0.7, 'learning_rate': 0.016, 'n_estimators': 950, 'max_depth':
13, 'min_child_weight': 16}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:36:18,759] Trial 251 finished with value: 0.78125 and
parameters: {'lambda': 0.6765761492621808, 'alpha': 1.1311200011686653,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.012,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 10}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:20,350] Trial 252 finished with value: 0.83125 and
parameters: {'lambda': 0.4908660736242479, 'alpha': 0.013639455935721162,
'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:21,646] Trial 253 finished with value: 0.784375 and
parameters: {'lambda': 6.511733054677517, 'alpha': 0.008677700556347851,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:22,176] Trial 254 finished with value: 0.76875 and
parameters: {'lambda': 1.1638671301526011, 'alpha': 0.004422623173207455,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 400, 'max_depth': 9, 'min_child_weight': 19}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:23,266] Trial 255 finished with value: 0.784375 and
parameters: {'lambda': 5.119839293221084, 'alpha': 0.01633572386608947,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:24,740] Trial 256 finished with value: 0.840625 and
parameters: {'lambda': 3.05972019502187, 'alpha': 0.011033167024446422,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:25,892] Trial 257 finished with value: 0.7875 and
parameters: {'lambda': 3.358970616102382, 'alpha': 0.009898386976170901,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:27,295] Trial 258 finished with value: 0.83125 and
parameters: {'lambda': 4.1417701261736655, 'alpha': 0.011122095005994577,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 7, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:27,751] Trial 259 finished with value: 0.534375 and
parameters: {'lambda': 2.926816179728339, 'alpha': 0.0015842783069082516,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
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'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 119}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:28,812] Trial 260 finished with value: 0.784375 and
parameters: {'lambda': 7.121588642443303, 'alpha': 0.005090160528161244,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.02,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:30,055] Trial 261 finished with value: 0.79375 and
parameters: {'lambda': 0.8412314611925901, 'alpha': 0.0028797490572277642,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:31,126] Trial 262 finished with value: 0.78125 and
parameters: {'lambda': 4.862684322725397, 'alpha': 0.0034134066599517112,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 11, 'min_child_weight': 17}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:32,538] Trial 263 finished with value: 0.790625 and
parameters: {'lambda': 1.2795649145861838, 'alpha': 0.008252471989395 85,
'colsample_bytree': 0.9, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:34,194] Trial 264 finished with value: 0.83125 and
parameters: {'lambda': 5.7880914652299245, 'alpha': 0.012750990106424989,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 700, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:35,207] Trial 265 finished with value: 0.771875 and
parameters: {'lambda': 0.0011563261861022535, 'alpha': 0.006167221198950807,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 9, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:36,689] Trial 266 finished with value: 0.796875 and
parameters: {'lambda': 3.7427714505833953, 'alpha': 0.01977753751287091,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:38,407] Trial 267 finished with value: 0.83125 and
parameters: {'lambda': 0.0016229646708838122, 'alpha': 0.0290272499761118,
'colsample_bytree': 0.6, 'subsample': 0.6, 'learning_rate': 0.008,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:39,537] Trial 268 finished with value: 0.771875 and
parameters: {'lambda': 0.11016191944520648, 'alpha': 0.0021643997555594804,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 15}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:40,202] Trial 269 finished with value: 0.73125 and

parameters: {'lambda': 3.050314625418992, 'alpha': 0.009890860648653606,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 15, 'min_child_weight': 83}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:41,033] Trial 270 finished with value: 0.7875 and
parameters: {'lambda': 0.17882894918150746, 'alpha': 0.01635962700924725,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 900, 'max_depth': 9, 'min_child_weight': 21}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:42,164] Trial 271 finished with value: 0.78125 and
parameters: {'lambda': 1.0339148500172293, 'alpha': 0.012358367956536666,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 7, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:43,076] Trial 272 finished with value: 0.78125 and
parameters: {'lambda': 4.458563755281386, 'alpha': 0.001838677913421918,
'colsample_bytree': 0.6, 'subsample': 0.4, 'learning_rate': 0.014,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:44,144] Trial 273 finished with value: 0.809375 and
parameters: {'lambda': 0.24799146807088387, 'alpha': 0.004145815298948927,
'colsample_bytree': 0.3, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 5, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:45,383] Trial 274 finished with value: 0.78125 and
parameters: {'lambda': 1.802073313407549, 'alpha': 0.007573304248529872,
'colsample_bytree': 0.6, 'subsample': 0.8, 'learning_rate': 0.016,
'n_estimators': 750, 'max_depth': 13, 'min_child_weight': 8}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:46,390] Trial 275 finished with value: 0.778125 and
parameters: {'lambda': 8.38285028422116, 'alpha': 0.011241736574673974,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 850, 'max_depth': 9, 'min_child_weight': 15}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:48,228] Trial 276 finished with value: 0.84375 and
parameters: {'lambda': 2.6367157818745297, 'alpha': 0.001293507514047573,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:49,679] Trial 277 finished with value: 0.78125 and
parameters: {'lambda': 2.5272957162648724, 'alpha': 0.0013849420088258774,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 1000, 'max_depth': 17, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:50,263] Trial 278 finished with value: 0.534375 and
parameters: {'lambda': 3.3400548185678707, 'alpha': 0.0011955978531879106,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 9, 'min_child_weight': 214}. Best is trial 93

```
with value: 0.84375.
[I 2023-08-01 18:36:52,403] Trial 279 finished with value: 0.8375 and
parameters: {'lambda': 2.5476982750217636, 'alpha': 0.023364003572183264,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:53,648] Trial 280 finished with value: 0.784375 and
parameters: {'lambda': 2.695246618904368, 'alpha': 0.025174815385351813,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 1000, 'max_depth': 13, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:55,920] Trial 281 finished with value: 0.8375 and
parameters: {'lambda': 3.933757280876075, 'alpha': 0.0209921828132624,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 1000, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:57,407] Trial 282 finished with value: 0.7875 and
parameters: {'lambda': 3.6779773758716656, 'alpha': 0.02084813028975548,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:36:58,421] Trial 283 finished with value: 0.778125 and
parameters: {'lambda': 4.726520528714829, 'alpha': 0.018055297611500307,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 21}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:00,619] Trial 284 finished with value: 0.834375 and
parameters: {'lambda': 5.663677255284177, 'alpha': 0.01561730689568772,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 1000, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:01,805] Trial 285 finished with value: 0.784375 and
parameters: {'lambda': 4.031807343897151, 'alpha': 0.020197286854106756,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:03,338] Trial 286 finished with value: 0.784375 and
parameters: {'lambda': 3.105219662767846, 'alpha': 0.033300708417181135,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:04,437] Trial 287 finished with value: 0.778125 and
parameters: {'lambda': 2.223341493631332, 'alpha': 0.023517895124821015,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 14}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:05,063] Trial 288 finished with value: 0.465625 and
parameters: {'lambda': 0.03729800396783941, 'alpha': 0.014652391200870637,
```

'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 13, 'min_child_weight': 243}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:07,126] Trial 289 finished with value: 0.825 and parameters:
{'lambda': 4.009519935615115, 'alpha': 0.01842506182508061, 'colsample_bytree':
1.0, 'subsample': 0.7, 'learning_rate': 0.014, 'n_estimators': 900, 'max_depth':
13, 'min_child_weight': 1}. Best is trial 93 with value: 0.84375.
[I 2023-08-01 18:37:08,463] Trial 290 finished with value: 0.78125 and
parameters: {'lambda': 4.984127232574688, 'alpha': 0.013855256082796155,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:09,433] Trial 291 finished with value: 0.778125 and
parameters: {'lambda': 3.4886453294354274, 'alpha': 0.005102368152046385,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 800, 'max_depth': 7, 'min_child_weight': 17}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:10,704] Trial 292 finished with value: 0.784375 and
parameters: {'lambda': 7.071814459505025, 'alpha': 0.039056142302419126,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.018,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 7}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:11,921] Trial 293 finished with value: 0.78125 and
parameters: {'lambda': 2.61626481742725, 'alpha': 0.02389613619923142,
'colsample_bytree': 0.9, 'subsample': 0.7, 'learning_rate': 0.012,
'n_estimators': 950, 'max_depth': 17, 'min_child_weight': 11}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:13,864] Trial 294 finished with value: 0.834375 and
parameters: {'lambda': 5.44760720457331, 'alpha': 0.01173997678526268,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:15,157] Trial 295 finished with value: 0.790625 and
parameters: {'lambda': 3.0345201369803454, 'alpha': 0.015789745427364246,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:16,102] Trial 296 finished with value: 0.778125 and
parameters: {'lambda': 4.320801816992467, 'alpha': 0.0034334795577078197,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 950, 'max_depth': 11, 'min_child_weight': 25}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:17,013] Trial 297 finished with value: 0.778125 and
parameters: {'lambda': 6.000149944593228, 'alpha': 0.06396424759651625,
'colsample_bytree': 0.6, 'subsample': 0.5, 'learning_rate': 0.02,
'n_estimators': 850, 'max_depth': 13, 'min_child_weight': 12}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:18,724] Trial 298 finished with value: 0.803125 and

```
parameters: {'lambda': 9.823045503836632, 'alpha': 0.006277754478184082,
'colsample_bytree': 0.4, 'subsample': 0.7, 'learning_rate': 0.01,
'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 1}. Best is trial 93
with value: 0.84375.
[I 2023-08-01 18:37:20,120] Trial 299 finished with value: 0.790625 and
parameters: {'lambda': 2.1459105466725354, 'alpha': 0.010267441761335127,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.014,
'n_estimators': 900, 'max_depth': 17, 'min_child_weight': 6}. Best is trial 93
with value: 0.84375.
```

[22]:
```
print("Number of finished trails:", len(study.trials))
print("Best Parameters:", study.best_trial.params)
print(
    "Improvement in XGBClassifier Accuracy: {}%".format(
        (
            (study.best_trial.value * 100)
            - (model_comparison["XGBoost Classifier"] / 100)
        )
    )
)
```

```
Number of finished trails: 300
Best Parameters: {'lambda': 5.149313851915358, 'alpha': 0.004644015955229921,
'colsample_bytree': 0.6, 'subsample': 0.7, 'learning_rate': 0.016,
'n_estimators': 800, 'max_depth': 13, 'min_child_weight': 1}
Improvement in XGBClassifier Accuracy: 83.5625%
```

11 将超参数优化的结果可视化

[23]:
```
optuna.visualization.plot_optimization_history(study)
```

[24]:
```
optuna.visualization.plot_parallel_coordinate(study)
```

[25]:
```
optuna.visualization.plot_slice(study)
```

[26]:
```
optuna.visualization.
 ↪plot_contour(study,params=['alpha','learning_rate','max_depth','n_estimators'])
```

[27]:
```
optuna.visualization.plot_param_importances(study)
```

[28]:
```
optuna.visualization.plot_edf(study)
```

[29]:
```
X_train=X_train.drop(columns=['free sulfur dioxide'],axis=1)
temp=np.array(X_train)
X_train_nn=temp.reshape(-1,2,5,1)
print('New shape of training data:',X_train_nn.shape)

X_test=X_test.drop(columns=['free sulfur dioxide'],axis=1)
```

```
temp=np.array(X_test)
X_test_nn=temp.reshape(-1,2,5,1)
print('New shape of testing data:',X_test_nn.shape)
```

```
New shape of training data: (1279, 2, 5, 1)
New shape of testing data: (320, 2, 5, 1)
```

12 使用神经网络预测

[30]:
```
model = Sequential(
    [
        Input(shape=(2, 5, 1)),
        Conv2D(32, 3, padding="same", activation="relu"),
        Conv2D(32, 3, padding="same", activation="relu"),
        Conv2D(32, 3, padding="same", activation="relu"),
        MaxPooling2D(),
        Conv2D(64, 3, padding="same", activation="relu"),
        Conv2D(64, 3, padding="same", activation="relu"),
        Conv2D(64, 3, padding="same", activation="relu"),
        Conv2D(64, 3, padding="same", activation="relu"),
        Flatten(),
        Dropout(0.2),
        Dense(256, input_shape=(2, 5, 1), activation="relu"),
        Dense(128, activation="relu"),
        Dense(32, activation="relu"),
        Dense(1, activation="sigmoid"),
    ]
)

model.compile(
    loss="binary_crossentropy",
    optimizer=Adam(),
    metrics=["acc"],
)
reduce_lr = ReduceLROnPlateau(
    monitor="acc", patience=3, verbose=1, factor=0.5, min_lr=0.00001
)
```

```
2023-08-01 18:37:32.783903: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.809905: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.810097: I
```

```
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.810880: I tensorflow/core/platform/cpu_feature_guard.cc:193]
This TensorFlow binary is optimized with oneAPI Deep Neural Network Library
(oneDNN) to use the following CPU instructions in performance-critical
operations:  SSE4.1 SSE4.2 AVX AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate
compiler flags.
2023-08-01 18:37:32.811358: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.811503: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.811623: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.814413: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.814549: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.814677: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:981]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero
2023-08-01 18:37:32.814766: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1613] Created device
/job:localhost/replica:0/task:0/device:GPU:0 with 4261 MB memory:  -> device: 0,
name: NVIDIA GeForce RTX 3060 Laptop GPU, pci bus id: 0000:01:00.0, compute
capability: 8.6
```

[31]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 2, 5, 32)          320

 conv2d_1 (Conv2D)           (None, 2, 5, 32)          9248
```

```
conv2d_2 (Conv2D)           (None, 2, 5, 32)          9248

max_pooling2d (MaxPooling2D  (None, 1, 2, 32)         0
)

conv2d_3 (Conv2D)           (None, 1, 2, 64)          18496

conv2d_4 (Conv2D)           (None, 1, 2, 64)          36928

conv2d_5 (Conv2D)           (None, 1, 2, 64)          36928

conv2d_6 (Conv2D)           (None, 1, 2, 64)          36928

flatten (Flatten)           (None, 128)               0

dropout (Dropout)           (None, 128)               0

dense (Dense)               (None, 256)               33024

dense_1 (Dense)             (None, 128)               32896

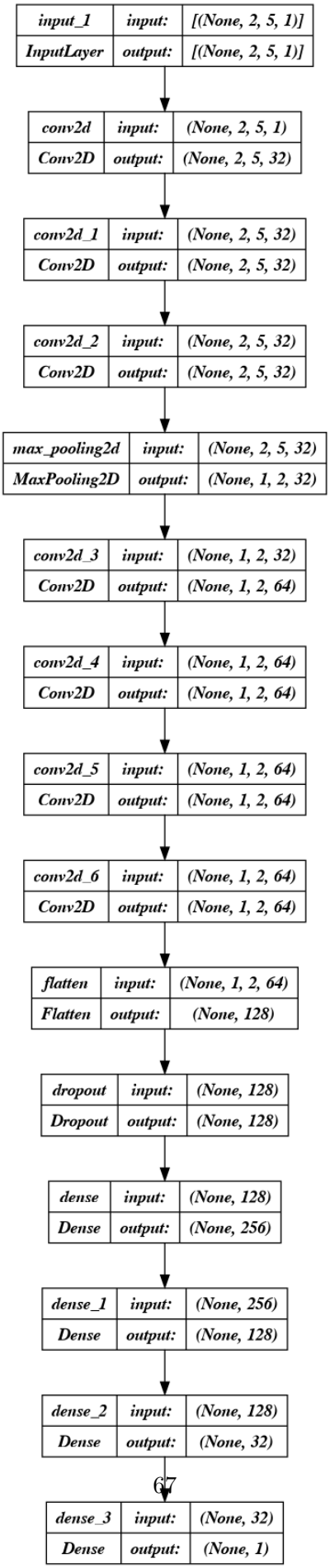
dense_2 (Dense)             (None, 32)                4128

dense_3 (Dense)             (None, 1)                 33

=================================================================
Total params: 218,177
Trainable params: 218,177
Non-trainable params: 0
_________________________________________________________________
```

[32]:
```
plot_model(model,show_shapes=True)
```

[32]:


input_1 | input: | [(None, 2, 5, 1)]
InputLayer | output: | [(None, 2, 5, 1)]
conv2d | input: | (None, 2, 5, 1)
Conv2D | output: | (None, 2, 5, 32)
conv2d_1 | input: | (None, 2, 5, 32)
Conv2D | output: | (None, 2, 5, 32)
conv2d_2 | input: | (None, 2, 5, 32)
Conv2D | output: | (None, 2, 5, 32)
max_pooling2d | input: | (None, 2, 5, 32)
MaxPooling2D | output: | (None, 1, 2, 32)
conv2d_3 | input: | (None, 1, 2, 32)
Conv2D | output: | (None, 1, 2, 64)
conv2d_4 | input: | (None, 1, 2, 64)
Conv2D | output: | (None, 1, 2, 64)
conv2d_5 | input: | (None, 1, 2, 64)
Conv2D | output: | (None, 1, 2, 64)
conv2d_6 | input: | (None, 1, 2, 64)
Conv2D | output: | (None, 1, 2, 64)
flatten | input: | (None, 1, 2, 64)
Flatten | output: | (None, 128)
dropout | input: | (None, 128)
Dropout | output: | (None, 128)
dense | input: | (None, 128)
Dense | output: | (None, 256)
dense_1 | input: | (None, 256)
Dense | output: | (None, 128)
dense_2 | input: | (None, 128)
Dense | output: | (None, 32)
dense_3 | input: | (None, 32)
Dense | output: | (None, 1)

[33]:
```
history=model.fit(X_train_nn,y_train,epochs=100,callbacks=[reduce_lr])
```

```
Epoch 1/100
2023-08-01 18:37:34.398968: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:428] Loaded cuDNN
version 8800
2023-08-01 18:37:34.932915: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_blas.cc:630] TensorFloat-32
will be used for the matrix multiplication. This will only be logged once.
2023-08-01 18:37:34.988888: I tensorflow/compiler/xla/service/service.cc:173]
XLA service 0x7f8b43887720 initialized for platform CUDA (this does not
guarantee that XLA will be used). Devices:
2023-08-01 18:37:34.988917: I tensorflow/compiler/xla/service/service.cc:181]
StreamExecutor device (0): NVIDIA GeForce RTX 3060 Laptop GPU, Compute
Capability 8.6
2023-08-01 18:37:35.012622: I
tensorflow/compiler/mlir/tensorflow/utils/dump_mlir_util.cc:268] disabling MLIR
crash reproducer, set env var `MLIR_CRASH_REPRODUCER_DIRECTORY` to enable.
2023-08-01 18:37:35.220265: I
tensorflow/compiler/jit/xla_compilation_cache.cc:477] Compiled cluster using
XLA!  This line is logged at most once for the lifetime of the process.
40/40 [==============================] - 4s 11ms/step - loss: 0.6577 - acc:
0.5590 - lr: 0.0010
Epoch 2/100
40/40 [==============================] - 0s 4ms/step - loss: 0.5783 - acc:
0.7037 - lr: 0.0010
Epoch 3/100
40/40 [==============================] - 0s 4ms/step - loss: 0.5262 - acc:
0.7279 - lr: 0.0010
Epoch 4/100
40/40 [==============================] - 0s 4ms/step - loss: 0.5052 - acc:
0.7287 - lr: 0.0010
Epoch 5/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4951 - acc:
0.7529 - lr: 0.0010
Epoch 6/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4862 - acc:
0.7576 - lr: 0.0010
Epoch 7/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4746 - acc:
0.7709 - lr: 0.0010
Epoch 8/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4631 - acc:
0.7709 - lr: 0.0010
```

```
Epoch 9/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4580 - acc:
0.7733 - lr: 0.0010
Epoch 10/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4452 - acc:
0.7834 - lr: 0.0010
Epoch 11/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4464 - acc:
0.7991 - lr: 0.0010
Epoch 12/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4398 - acc:
0.7795 - lr: 0.0010
Epoch 13/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4298 - acc:
0.7991 - lr: 0.0010
Epoch 14/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4057 - acc:
0.8170 - lr: 0.0010
Epoch 15/100
40/40 [==============================] - 0s 4ms/step - loss: 0.4018 - acc:
0.8131 - lr: 0.0010
Epoch 16/100
40/40 [==============================] - 0s 5ms/step - loss: 0.3924 - acc:
0.8147 - lr: 0.0010
Epoch 17/100
40/40 [==============================] - 0s 4ms/step - loss: 0.3729 - acc:
0.8350 - lr: 0.0010
Epoch 18/100
40/40 [==============================] - 0s 4ms/step - loss: 0.3711 - acc:
0.8319 - lr: 0.0010
Epoch 19/100
40/40 [==============================] - 0s 4ms/step - loss: 0.3607 - acc:
0.8421 - lr: 0.0010
Epoch 20/100
40/40 [==============================] - 0s 4ms/step - loss: 0.3464 - acc:
0.8593 - lr: 0.0010
Epoch 21/100
40/40 [==============================] - 0s 4ms/step - loss: 0.3661 - acc:
0.8241 - lr: 0.0010
Epoch 22/100
40/40 [==============================] - 0s 4ms/step - loss: 0.3177 - acc:
0.8585 - lr: 0.0010
Epoch 23/100
29/40 [====================>…] - ETA: 0s - loss: 0.2844 - acc: 0.8718
Epoch 23: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
40/40 [==============================] - 0s 4ms/step - loss: 0.3120 - acc:
0.8585 - lr: 0.0010
Epoch 24/100
```

```
40/40 [==============================] - 0s 4ms/step - loss: 0.2626 - acc:
0.8890 - lr: 5.0000e-04
Epoch 25/100
40/40 [==============================] - 0s 4ms/step - loss: 0.2319 - acc:
0.9030 - lr: 5.0000e-04
Epoch 26/100
40/40 [==============================] - 0s 4ms/step - loss: 0.2106 - acc:
0.9101 - lr: 5.0000e-04
Epoch 27/100
40/40 [==============================] - 0s 5ms/step - loss: 0.1732 - acc:
0.9335 - lr: 5.0000e-04
Epoch 28/100
40/40 [==============================] - 0s 4ms/step - loss: 0.1675 - acc:
0.9320 - lr: 5.0000e-04
Epoch 29/100
40/40 [==============================] - 0s 4ms/step - loss: 0.2022 - acc:
0.9187 - lr: 5.0000e-04
Epoch 30/100
37/40 [==========================>...] - ETA: 0s - loss: 0.1799 - acc: 0.9282
Epoch 30: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
40/40 [==============================] - 0s 4ms/step - loss: 0.1895 - acc:
0.9242 - lr: 5.0000e-04
Epoch 31/100
40/40 [==============================] - 0s 4ms/step - loss: 0.1294 - acc:
0.9476 - lr: 2.5000e-04
Epoch 32/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0945 - acc:
0.9601 - lr: 2.5000e-04
Epoch 33/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0791 - acc:
0.9695 - lr: 2.5000e-04
Epoch 34/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0759 - acc:
0.9734 - lr: 2.5000e-04
Epoch 35/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0913 - acc:
0.9656 - lr: 2.5000e-04
Epoch 36/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0812 - acc:
0.9711 - lr: 2.5000e-04
Epoch 37/100
29/40 [====================>...] - ETA: 0s - loss: 0.0849 - acc: 0.9655
Epoch 37: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
40/40 [==============================] - 0s 4ms/step - loss: 0.0816 - acc:
0.9679 - lr: 2.5000e-04
Epoch 38/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0493 - acc:
0.9844 - lr: 1.2500e-04
```

```
Epoch 39/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0356 - acc:
0.9891 - lr: 1.2500e-04
Epoch 40/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0302 - acc:
0.9906 - lr: 1.2500e-04
Epoch 41/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0272 - acc:
0.9914 - lr: 1.2500e-04
Epoch 42/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0248 - acc:
0.9914 - lr: 1.2500e-04
Epoch 43/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0197 - acc:
0.9945 - lr: 1.2500e-04
Epoch 44/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0215 - acc:
0.9922 - lr: 1.2500e-04
Epoch 45/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0209 - acc:
0.9930 - lr: 1.2500e-04
Epoch 46/100
29/40 [====================>...] - ETA: 0s - loss: 0.0140 - acc: 0.9935
Epoch 46: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
40/40 [==============================] - 0s 4ms/step - loss: 0.0212 - acc:
0.9914 - lr: 1.2500e-04
Epoch 47/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0142 - acc:
0.9969 - lr: 6.2500e-05
Epoch 48/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0136 - acc:
0.9953 - lr: 6.2500e-05
Epoch 49/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0155 - acc:
0.9953 - lr: 6.2500e-05
Epoch 50/100
27/40 [====================>...] - ETA: 0s - loss: 0.0120 - acc: 0.9965
Epoch 50: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
40/40 [==============================] - 0s 4ms/step - loss: 0.0120 - acc:
0.9961 - lr: 6.2500e-05
Epoch 51/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0130 - acc:
0.9961 - lr: 3.1250e-05
Epoch 52/100
40/40 [==============================] - 0s 5ms/step - loss: 0.0110 - acc:
0.9969 - lr: 3.1250e-05
Epoch 53/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0108 - acc:
```

```
0.9977 - lr: 3.1250e-05
Epoch 54/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0106 - acc:
0.9969 - lr: 3.1250e-05
Epoch 55/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0105 - acc:
0.9969 - lr: 3.1250e-05
Epoch 56/100
29/40 [====================>…] - ETA: 0s - loss: 0.0112 - acc: 0.9957
Epoch 56: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
40/40 [==============================] - 0s 4ms/step - loss: 0.0098 - acc:
0.9961 - lr: 3.1250e-05
Epoch 57/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0097 - acc:
0.9969 - lr: 1.5625e-05
Epoch 58/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0092 - acc:
0.9961 - lr: 1.5625e-05
Epoch 59/100
28/40 [====================>…] - ETA: 0s - loss: 0.0102 - acc: 0.9967
Epoch 59: ReduceLROnPlateau reducing learning rate to 1e-05.
40/40 [==============================] - 0s 4ms/step - loss: 0.0098 - acc:
0.9961 - lr: 1.5625e-05
Epoch 60/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0086 - acc:
0.9961 - lr: 1.0000e-05
Epoch 61/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0082 - acc:
0.9977 - lr: 1.0000e-05
Epoch 62/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0082 - acc:
0.9969 - lr: 1.0000e-05
Epoch 63/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0076 - acc:
0.9984 - lr: 1.0000e-05
Epoch 64/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0085 - acc:
0.9977 - lr: 1.0000e-05
Epoch 65/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0074 - acc:
0.9984 - lr: 1.0000e-05
Epoch 66/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0069 - acc:
0.9984 - lr: 1.0000e-05
Epoch 67/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0068 - acc:
0.9992 - lr: 1.0000e-05
Epoch 68/100
```

```
40/40 [==============================] - 0s 4ms/step - loss: 0.0073 - acc:
0.9984 - lr: 1.0000e-05
Epoch 69/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0067 - acc:
0.9984 - lr: 1.0000e-05
Epoch 70/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0066 - acc:
0.9984 - lr: 1.0000e-05
Epoch 71/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0064 - acc:
0.9984 - lr: 1.0000e-05
Epoch 72/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0066 - acc:
0.9977 - lr: 1.0000e-05
Epoch 73/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0063 - acc:
0.9992 - lr: 1.0000e-05
Epoch 74/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0063 - acc:
0.9992 - lr: 1.0000e-05
Epoch 75/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0062 - acc:
0.9984 - lr: 1.0000e-05
Epoch 76/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0063 - acc:
0.9992 - lr: 1.0000e-05
Epoch 77/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0064 - acc:
0.9977 - lr: 1.0000e-05
Epoch 78/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0055 - acc:
0.9984 - lr: 1.0000e-05
Epoch 79/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0057 - acc:
0.9984 - lr: 1.0000e-05
Epoch 80/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0057 - acc:
0.9984 - lr: 1.0000e-05
Epoch 81/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0061 - acc:
0.9984 - lr: 1.0000e-05
Epoch 82/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0060 - acc:
0.9984 - lr: 1.0000e-05
Epoch 83/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0058 - acc:
0.9984 - lr: 1.0000e-05
Epoch 84/100
```

```
40/40 [==============================] - 0s 4ms/step - loss: 0.0056 - acc:
0.9984 - lr: 1.0000e-05
Epoch 85/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0054 - acc:
0.9984 - lr: 1.0000e-05
Epoch 86/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0053 - acc:
0.9977 - lr: 1.0000e-05
Epoch 87/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0050 - acc:
0.9992 - lr: 1.0000e-05
Epoch 88/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0055 - acc:
0.9977 - lr: 1.0000e-05
Epoch 89/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0052 - acc:
0.9984 - lr: 1.0000e-05
Epoch 90/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0054 - acc:
0.9977 - lr: 1.0000e-05
Epoch 91/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0042 - acc:
0.9984 - lr: 1.0000e-05
Epoch 92/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0043 - acc:
0.9992 - lr: 1.0000e-05
Epoch 93/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0042 - acc:
0.9984 - lr: 1.0000e-05
Epoch 94/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0037 - acc:
0.9977 - lr: 1.0000e-05
Epoch 95/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0030 - acc:
0.9984 - lr: 1.0000e-05
Epoch 96/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0030 - acc:
0.9992 - lr: 1.0000e-05
Epoch 97/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0027 - acc:
0.9984 - lr: 1.0000e-05
Epoch 98/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0027 - acc:
0.9984 - lr: 1.0000e-05
Epoch 99/100
40/40 [==============================] - 0s 4ms/step - loss: 0.0028 - acc:
0.9984 - lr: 1.0000e-05
Epoch 100/100
```

```
40/40 [==============================] - 0s 4ms/step - loss: 0.0027 - acc:
0.9984 - lr: 1.0000e-05
```

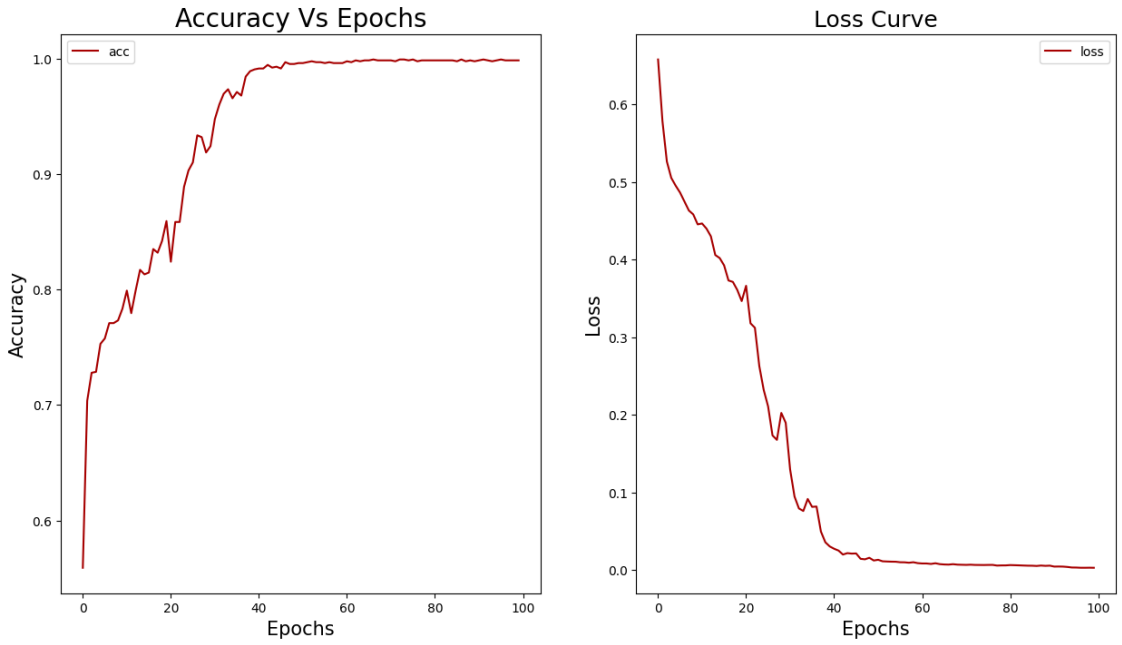
[34]:
```
def model_performance_graphs(classifier):
    fig,axes=plt.subplots(1,2,figsize=(15,8))

    axes[0].plot(classifier.epoch,classifier.history['acc'],label='acc')
    axes[0].set_title('accuracy vs epochs'.title(),fontsize=20)
    axes[0].set_xlabel('Epochs',fontsize=15)
    axes[0].set_ylabel('Accuracy',fontsize=15
                       )
    axes[0].legend()

    axes[1].plot(classifier.epoch,classifier.history['loss'],label='loss')
    axes[1].set_title('loss curve'.title(),fontsize=18)
    axes[1].set_xlabel('Epochs',fontsize=15)
    axes[1].set_ylabel('Loss',fontsize=15)
    axes[1].legend()

    plt.show()

model_performance_graphs(history)
```



[35]:
```
nn_train_acc=model.evaluate(X_train_nn,y_train)[-1]
nn_test_acc=model.evaluate(X_test_nn,y_test)[-1]
print(nn_train_acc,nn_test_acc)
```

```
40/40 [==============================] - 0s 1ms/step - loss: 0.0023 - acc:
0.9992
10/10 [==============================] - 0s 2ms/step - loss: 4.2840 - acc:
0.7812
0.9992181658744812 0.78125
```

[40]:
```python
# RUC AOC of the Neural Network
y_pred = (model.predict(X_test_nn) > 0.5).astype(int)

print("---For the Neural Network---")
print(
    "Training Accuracy: {}%\nTesting Accuracy: {}%\nF1-Score: {}".format(
        nn_train_acc * 100, nn_test_acc * 100, f1_score(y_test, y_pred)
    )
)

fig, axes = plt.subplots(1, 2, figsize=(15, 8))

fig.suptitle("Graphs for the Neural Network", fontsize=25)

sns.heatmap(
    confusion_matrix(y_test, y_pred),
    annot=True,
    cmap="Reds",
    annot_kws={"size": 15},
    square=True,
    fmt=".0f",
    ax=axes[0],
)
axes[0].set_title("Confusion Matrix", fontsize=20)

fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
roc_auc = metrics.auc(fpr, tpr)
sns.lineplot(x=fpr, y=tpr, ax=axes[1], color="red")
axes[1].set_title("ROC Curve (" + str(round(roc_auc, 3)) + ")", fontsize=20)
axes[1].plot(
    [0, 1],
    [0, 1],
    "b--",
)
plt.show()
```

```
10/10 [==============================] - 0s 1ms/step
---For the Neural Network---
Training Accuracy: 99.92181658744812%
Testing Accuracy: 78.125%
F1-Score: 0.7965116279069767
```

Graphs for the Neural Network