Libraries ¶

In [2]:

```
# Suppressing all warnings
import warnings
warnings.filterwarnings("ignore")

# Multiprocessing
import multiprocessing

# Threading
import threading

# Time
import time

# Data handling
import pandas as pd
import numpy as np

# Plotting
import matplotlib.pyplot as plt
import seaborn as sns

# Oversampling
from imblearn.over_sampling import ADASYN

# Metrics
from sklearn import metrics

# Preprocessing
from imblearn.over_sampling import ADASYN
from sklearn.model_selection import train_test_split
from sklearn.decomposition import PCA

# Models
from sklearn.pipeline import Pipeline
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LogisticRegression
from xgboost import XGBClassifier
from sklearn.ensemble import AdaBoostClassifier
# from catboost import CatBoostClassifier

# Evaluation metrics

# Cross validation
from sklearn.model_selection import RandomizedSearchCV, GridSearchCV, train_test_split
from skopt import BayesSearchCV
from sklearn.metrics import classification_report
```

In [2]:

```
def multi_time():
    print("Starting thread...")
    start = time.time()

    while True:
        elapsed = int(time.time() - start)
        print(f"Time elapsed: {elapsed} seconds", end = "\r")
        time.sleep(1)
```

Loading CSV file onto Pandas DataFrame

In [74]:

```
df = pd.read_csv("player_stats.csv", na_values="None")
df = df[["X", "Y", "xG", "h_a", "situation", "shotType", "lastAction", "result"]]
# df = df.loc[:50000, :].copy()
```

Check for missing data and percentage

In [75]:

```
print("Percentage of data missing from each column\n")
for col in df.columns:
    if len(df[df[col].isnull() == True]):
        print(f"{col}: {len(df[df[col].isnull() == True])/len(df)*100}%",
              end = "")
        print(f" or {len(df[df[col].isnull() == True])} rows")
    else:
        print(f"{col}: {0}%")
```

```
Percentage of data missing from each column

X: 0%
Y: 0%
xG: 0%
h_a: 0%
situation: 0%
shotType: 0%
lastAction: 9.228053426520521% or 10246 rows
result: 0%
```

Dropping rows with missing values

In [76]:

```
df = df[df["lastAction"].isnull() == False].reset_index(drop =True).copy()
df = df.drop(df[df["result"]=="OwnGoal"].index)
df = df[df.situation != 'Penalty']
```

Encoding categorical columns

- h_a: One-Hot Encoder
- situation: One-Hot Encoder
- shotType: One-Hot Encoder
- lastAction: One-Hot Encoder
- result: One-Hot Encoder

In [77]:

```python
print(f"\x1b[32mUnique values in:\x1b[0m {df['h_a'].value_counts()}")
print(f"\x1b[32mUnique values in:\x1b[0m {df['situation'].value_counts()}")
print(f"\x1b[32mUnique values in:\x1b[0m {df['shotType'].value_counts()}")
print(f"\x1b[32mUnique values in:\x1b[0m {df['lastAction'].value_counts()}")
print(f"\x1b[32mUnique values in:\x1b[0m {df['result'].value_counts()}")
```

```
Unique values in: h    54108
a    44615
Name: h_a, dtype: int64
Unique values in: OpenPlay          82980
FromCorner         8514
SetPiece           3918
DirectFreekick     3311
Name: situation, dtype: int64
Unique values in: RightFoot        48933
LeftFoot         32717
Head             16725
OtherBodyPart      348
Name: shotType, dtype: int64
Unique values in: Pass                 41618
Cross              15324
Aerial              7000
Chipped             6630
TakeOn              6616
Rebound             4705
Throughball         3515
Standard            3311
BallRecovery        3081
HeadPass            2644
BallTouch           1919
LayOff               707
Dispossessed         547
Tackle               221
CornerAwarded        194
BlockedPass          171
Foul                 159
Goal                  88
Interception          65
End                   64
OffsidePass           23
GoodSkill             23
Challenge             18
Card                  18
SubstitutionOn        16
Clearance             13
OffsideProvoked        9
KeeperPickup           7
Save                   7
FormationChange        5
Start                  3
ChanceMissed           1
ShieldBallOpp          1
Name: lastAction, dtype: int64
Unique values in: MissedShots    34019
SavedShot      25463
BlockedShot    24329
Goal           12795
ShotOnPost      2117
Name: result, dtype: int64
```

In [78]:

```
remapping = {"Goal": 1,
             "MissedShots": 0,
             "SavedShot": 0,
             "BlockedShot": 0,
             "ShotOnPost": 0,
             }

lastAction = {"Cross": ["Aerial", "Cross", "Chipped"] ,
              "Pass":["Pass", "Throughball", "HeadPass", "BallTouch", "TakeOn"],
              "Dispossessed":["Dispossessed", "Tackle", "BlockedPass", "Interception",
                              "Challenge", "Clearance", "BallRecovery"],
              "Other":["Standard", "Rebound", "LayOff", "CornerAwarded",
                       "Foul", "Goal", "End", "OffsidePass",
              "GoodSkill", "Card", "SubstitutionOn", "OffsideProvoked",
                       "Save", "KeeperPickup",
              "FormationChange", "Start", "ChanceMissed" , "ShieldBallOpp"]}

df["result"] = df["result"].map(remapping)
for k, v in lastAction.items():
    for i in v:
        df["lastAction"].replace(to_replace = i, value = k, inplace = True)

df_encoded = pd.get_dummies(df,
                            drop_first = True)
df_encoded = df_encoded.loc[:50000, :]
```

In [79]:

```
X = df_encoded.drop(["result"], axis = 1).copy()
Y = df_encoded["result"].copy()
```

In [80]:

```
X_train, X_test, y_train, y_test_1 = train_test_split(X, Y,
                                                      train_size = 0.8,
                                                      stratify = Y)
```

Step 2: Grid Search

In [81]:

```python
pipe = Pipeline([("classifier", LogisticRegression())])

param_grid = [
    {
        'classifier': [LogisticRegression(random_state = 42)],
        'classifier__solver': ['saga', 'lbfgs'],
        'classifier__C': [0.1, 1],
    },
    {
        'classifier': [SVC(random_state = 42)],
        'classifier__C':[0.1, 1],
        'classifier__degree': [1, 2],
        'classifier__gamma': [0.1, 1],
    },
    {
        'classifier': [XGBClassifier(random_state = 42)],
        'classifier__n_estimators': [10, 1000],
        'classifier__max_depth': [10, 50],
    },
    {
        'classifier': [AdaBoostClassifier()],
        'classifier__base_estimator': [DecisionTreeClassifier(random_state = 42)],
        'classifier__learning_rate': [0.01, 0.1, 1],
        'classifier__base_estimator__criterion': ['gini', 'entropy'],
        'classifier__base_estimator__max_depth': [1, 5, 9],
    }
]

bs = GridSearchCV(pipe, param_grid, cv = 5, verbose = 3)
bs.fit(X_train, y_train)
```

```
[CV 5/5] END classifier=LogisticRegression(random_state=42), classifier__C=1, classifie
r__solver=saga;, score=0.876 total time=   0.1s
[CV 1/5] END classifier=LogisticRegression(random_state=42), classifier__C=1, classifie
r__solver=lbfgs;, score=0.879 total time=   0.1s
[CV 2/5] END classifier=LogisticRegression(random_state=42), classifier__C=1, classifie
r__solver=lbfgs;, score=0.879 total time=   0.1s
[CV 3/5] END classifier=LogisticRegression(random_state=42), classifier__C=1, classifie
r__solver=lbfgs;, score=0.875 total time=   0.1s
[CV 4/5] END classifier=LogisticRegression(random_state=42), classifier__C=1, classifie
r__solver=lbfgs;, score=0.877 total time=   0.1s
[CV 5/5] END classifier=LogisticRegression(random_state=42), classifier__C=1, classifie
r__solver=lbfgs;, score=0.876 total time=   0.1s
[CV 1/5] END classifier=SVC(random_state=42), classifier__C=0.1, classifier__degree=1,
classifier__gamma=0.1;, score=0.867 total time=  37.1s
[CV 2/5] END classifier=SVC(random_state=42), classifier__C=0.1, classifier__degree=1,
classifier__gamma=0.1;, score=0.867 total time=  37.5s
[CV 3/5] END classifier=SVC(random_state=42), classifier__C=0.1, classifier__degree=1,
classifier__gamma=0.1;, score=0.867 total time=  38.7s
[CV 4/5] END classifier=SVC(random_state=42), classifier__C=0.1, classifier__degree=1,
classifier__gamma=0.1;, score=0.867 total time=  37.6s
```

In [82]:

```python
bs.best_params_
```

Out[82]:

```
{'classifier': AdaBoostClassifier(base_estimator=DecisionTreeClassifier(max_depth=1,
                                                                         random_state=42),
                    learning_rate=1),
 'classifier__base_estimator': DecisionTreeClassifier(max_depth=1, random_state=42),
 'classifier__base_estimator__criterion': 'gini',
 'classifier__base_estimator__max_depth': 1,
 'classifier__learning_rate': 1}
```

In [83]:

```
y_preds_1 = bs.predict(X_test)
acc = metrics.accuracy_score(y_test_1, y_preds_1)
```

In [84]:

```
cr_1 = classification_report(y_test_1, y_preds_1)
print(classification_report(y_test_1, y_preds_1))
```

```
              precision    recall  f1-score   support

           0       0.89      0.98      0.93      8502
           1       0.60      0.20      0.30      1307

    accuracy                           0.88      9809
   macro avg       0.74      0.59      0.62      9809
weighted avg       0.85      0.88      0.85      9809
```

Recall isn't good for minority class

This can attributed to the heavy class imbalance in the dataset. We can try to balance this by first filtering data and then using ADASYN

Higher cutoff for number of shots per player

In [85]:

```python
def preprocessing(df, num_rows = 50000):

    print("\x1b[32mStarting preprocessing...\x1b[31m")

    df = df[["X", "Y", "xG", "h_a", "situation", "shotType", "lastAction", "result"]]
    df = df[df["lastAction"].isnull() == False].reset_index(drop =True).copy()
    df = df.drop(df[df["result"]=="OwnGoal"].index)
    df = df[df.situation != 'Penalty']
    remapping = {"Goal": 1,
             "MissedShots": 0,
             "SavedShot": 0,
             "BlockedShot": 0,
             "ShotOnPost": 0,
             }

    lastAction = {"Cross": ["Aerial", "Cross", "Chipped"] ,
                  "Pass":["Pass", "Throughball", "HeadPass", "BallTouch", "TakeOn"],
                  "Dispossessed":["Dispossessed", "Tackle", "BlockedPass",
                                  "Interception", "Challenge", "Clearance",
                                  "BallRecovery"],
                  "Other":["Standard", "Rebound", "LayOff", "CornerAwarded",
                           "Foul", "Goal", "End", "OffsidePass",
                  "GoodSkill", "Card", "SubstitutionOn", "OffsideProvoked",
                           "Save", "KeeperPickup", "FormationChange",
                           "Start", "ChanceMissed" , "ShieldBallOpp"]}

    print("Remapping target column")
    df["result"] = df["result"].map(remapping)

    print("Remapping lastAction column")
    for k, v in lastAction.items():
        for i in v:
            df["lastAction"].replace(to_replace = i, value = k, inplace = True)

    print("One hot encoding remaining columns")
    df_encoded = pd.get_dummies(df,
                                drop_first = True)
    if num_rows != None:
        print(f"Using only {num_rows} rows")
        df_encoded = df_encoded.loc[:num_rows, :]
    else:
        print(f"Using all rows")

    print("Preprocessing done\x1b[0m")
    return df_encoded
```

In [86]:

```python
def search(X_train, y_train, verbosity = 1, use_svc = True):

    print("\x1b[32m Starting search...\x1b[31m")

    print("Building base pipeline")
    pipe = Pipeline([("classifier", LogisticRegression())])

    print("Building parameter grid")
    if use_svc:
        print("Using SVC")
        param_grid = [
    {
        'classifier': [LogisticRegression(random_state = 42)],
        'classifier__solver': ['saga', 'lbfgs'],
        'classifier__C': [0.1, 1],
    },
    {
        'classifier': [SVC(random_state = 42)],
        'classifier__C':[0.1, 1],
        'classifier__degree': [1, 2],
        'classifier__gamma': [0.1, 1],
    },
    {
        'classifier': [XGBClassifier(random_state = 42)],
        'classifier__n_estimators': [10, 1000],
        'classifier__max_depth': [10, 50],
    },
    {
        'classifier': [AdaBoostClassifier()],
        'classifier__base_estimator': [DecisionTreeClassifier(random_state = 42)],
        'classifier__learning_rate': [0.01, 0.1, 1],
        'classifier__base_estimator__criterion': ['gini', 'entropy'],
        'classifier__base_estimator__max_depth': [1, 5, 9],
    }
]
    else:
        print("Replacing SVC with KNN")
        param_grid = [
            {
                'classifier': [LogisticRegression(random_state = 42)],
                'classifier__solver': ['saga', 'lbfgs'],
                'classifier__C': [0.1, 1],
            },
            {
                'classifier': [KNeighborsClassifier()],
                'classifier__n_neighbors':[3, 4, 5],
                'classifier__p': [1, 2],
            },
            {
                'classifier': [XGBClassifier(random_state = 42)],
                'classifier__n_estimators': [10, 1000],
                'classifier__max_depth': [10, 50],
            },
            {
                'classifier': [AdaBoostClassifier()],
                'classifier__base_estimator': [DecisionTreeClassifier(random_state = 4
                'classifier__learning_rate': [0.01, 0.1, 1],
                'classifier__base_estimator__criterion': ['gini', 'entropy'],
                'classifier__base_estimator__max_depth': [1, 5, 9],
            }
        ]
    print("Creating Grid Search")
    bs = GridSearchCV(pipe, param_grid, cv = 5, verbose = verbosity)
    print("Fitting train data onto Grid Search")
    bs.fit(X_train, y_train)

    print(f"\x1b[32mBest Parameters:\x1b[0m\n {bs.best_params_}")

    return bs
```

In [87]:

```
def test(best_model, X_test, y_test):
    y_pred = best_model.predict(X_test)
    acc = metrics.accuracy_score(y_test, y_pred)

    print(f"\x1b[32mClassification report on test accuracy:\x1b[0m\n {classification_r

    return y_pred, classification_report(y_test, y_pred)
```

In [88]:

```python
df2 = pd.read_csv("player_stats.csv",  na_values="None")

df3 = df2.copy()

print("Before filtering, df shape", df3.shape)

df3_grouped = df3.groupby(["player", "result"]).size()
df3['shot_count'] = df3.groupby('player')['player'].transform('size')
df4 = df3.groupby(["player", 'shot_count', "result"])[['shot_count']].count()
df4 = df4.rename(columns = {'shot_count':'count'})
df5 = df4.sort_values(by = df4.index.names[1], ascending = False)
df5["result"] = df5.index.get_level_values(2)
df5.index = df5.index.droplevel(2)
df5['shot_count'] = df5.index.get_level_values(1)
df5.index= df5.index.droplevel(1)
df5 = df5[df5['shot_count']>40]
df3 = df3[df3["player"].isin(df5.index)]
print("After filtering, df shape", df3.shape)

df_encoded = preprocessing(df3, num_rows = None)
X = df_encoded.drop(["result"], axis = 1).copy()
Y = df_encoded["result"].copy()

X_train, X_test, y_train, y_test_2 = train_test_split(X, Y,
                                                       train_size = 0.8,
                                                       stratify = Y)

best_model_2 = search(X_train, y_train, verbosity = 3,
                      use_svc = True)

y_preds_2, cr_2 = test(best_model_2, X_test, y_test_2)


```

```
1.6s
[CV 3/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.880 total time=  1
1.7s
[CV 4/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.878 total time=  1
1.8s
[CV 5/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.881 total time=  1
2.0s
[CV 1/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=1;, score=0.878 total time=  11.9
s
[CV 2/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=1;, score=0.879 total time=  11.6
```

Metrics didn't increase as much.

Let's try oversampling using ADASYN and replace KNN with SVC

In [29]:

```python
df2 = pd.read_csv("player_stats.csv",  na_values="None")

df3 = df2.copy()

print("Before filtering, df shape", df3.shape)

df3_grouped = df3.groupby(["player", "result"]).size()
df3['shot_count'] = df3.groupby('player')['player'].transform('size')
df4 = df3.groupby(["player", 'shot_count', "result"])[['shot_count']].count()
df4 = df4.rename(columns = {'shot_count':'count'})
df5 = df4.sort_values(by = df4.index.names[1], ascending = False)
df5["result"] = df5.index.get_level_values(2)
df5.index = df5.index.droplevel(2)
df5['shot_count'] = df5.index.get_level_values(1)
df5.index= df5.index.droplevel(1)
df5 = df5[df5['shot_count']>40]
df3 = df3[df3["player"].isin(df5.index)]
print("After filtering, df shape", df3.shape)

df_encoded = preprocessing(df3, num_rows = 50000)
df5_g = df_encoded[df_encoded["result"]==1]
df5_ng = df_encoded[df_encoded["result"]==0]

print("\x1b[32mBefore ADASYN\x1b[0m")
print(f"Ratio of goals to not goals: {len(df5_g)/len(df5_ng)}")

print("\x1b[31mOversampling using ADASYN\x1b[0m")
X = df_encoded.drop(["result"], axis = 1).copy()
Y = df_encoded["result"].copy()

X_resampled, y_resampled = ADASYN().fit_resample(X, Y)
print("\x1b[32mAfter ADASYN\x1b[0m")
print(f"Number of samples added by ADASYN {len(y_resampled) - len(Y)}, or {(len(y_resa
print(f"Ratio of goals to not goals: {len(y_resampled[y_resampled == 1])/len(y_resampl

X_train, X_test, y_train, y_test_3 = train_test_split(X_resampled, y_resampled,
                                                      train_size = 0.8,
                                                      stratify = y_resampled)

best_model_3 = search(X_train, y_train, verbosity = 3, use_svc = False)

y_preds_3, cr_3 = test(best_model_3, X_test, y_test_3)
```

```
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.787 total time=  1
3.6s
[CV 3/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.792 total time=  1
3.7s
[CV 4/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.831 total time=  1
4.3s

[CV 5/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=0.1;, score=0.768 total time=  1
4.5s
[CV 1/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=5, classifier__learning_rate=1;, score=0.817 total time=  14.5
s
[CV 2/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
```

Entire dataset since it can run faster

In [93]:

```python
df2 = pd.read_csv("player_stats.csv",  na_values="None")

df3 = df2.copy()

print("Before filtering, df shape", df3.shape)

df3_grouped = df3.groupby(["player", "result"]).size()
df3['shot_count'] = df3.groupby('player')['player'].transform('size')
df4 = df3.groupby(["player", 'shot_count', "result"])[['shot_count']].count()
df4 = df4.rename(columns = {'shot_count':'count'})
df5 = df4.sort_values(by = df4.index.names[1], ascending = False)
df5["result"] = df5.index.get_level_values(2)
df5.index = df5.index.droplevel(2)
df5['shot_count'] = df5.index.get_level_values(1)
df5.index= df5.index.droplevel(1)
df5 = df5[df5['shot_count']>40]
df3 = df3[df3["player"].isin(df5.index)]
print("After filtering, df shape", df3.shape)

df_encoded = preprocessing(df3, num_rows = None)
df5_g = df_encoded[df_encoded["result"]==1]
df5_ng = df_encoded[df_encoded["result"]==0]

print("\x1b[32mBefore ADASYN\x1b[0m")
print(f"Ratio of goals to not goals: {len(df5_g)/len(df5_ng)}")

print("\x1b[31mOversampling using ADASYN\x1b[0m")
X = df_encoded.drop(["result"], axis = 1).copy()
Y = df_encoded["result"].copy()

X_resampled, y_resampled = ADASYN().fit_resample(X, Y)
print("\x1b[32mAfter ADASYN\x1b[0m")
print(f"Number of samples added by ADASYN {len(y_resampled) - len(Y)}, or {(len(y_resam
print(f"Ratio of goals to not goals: {len(y_resampled[y_resampled == 1])/len(y_resample

X_train, X_test, y_train, y_test_4 = train_test_split(X_resampled, y_resampled,
                                                      train_size = 0.8,
                                                      stratify = y_resampled)

best_model_4 = search(X_train, y_train, verbosity = 3, use_svc = False)

y_preds_4, cr_4 = test(best_model_4, X_test, y_test_4)
```

```
assifier(random_state=42), classifier__base_estimator__criterion=gini, classifier__base
_estimator__max_depth=9, classifier__learning_rate=1;, score=0.894 total time=  39.2s
[CV 1/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=1, classifier__learning_rate=0.01;, score=0.674 total time=
7.5s
[CV 2/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=1, classifier__learning_rate=0.01;, score=0.680 total time=
7.7s
[CV 3/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=1, classifier__learning_rate=0.01;, score=0.677 total time=
7.7s
[CV 4/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
ase_estimator__max_depth=1, classifier__learning_rate=0.01;, score=0.681 total time=
8.0s
[CV 5/5] END classifier=AdaBoostClassifier(), classifier__base_estimator=DecisionTreeCl
assifier(random_state=42), classifier__base_estimator__criterion=entropy, classifier__b
```

Classification Reports

In [96]:

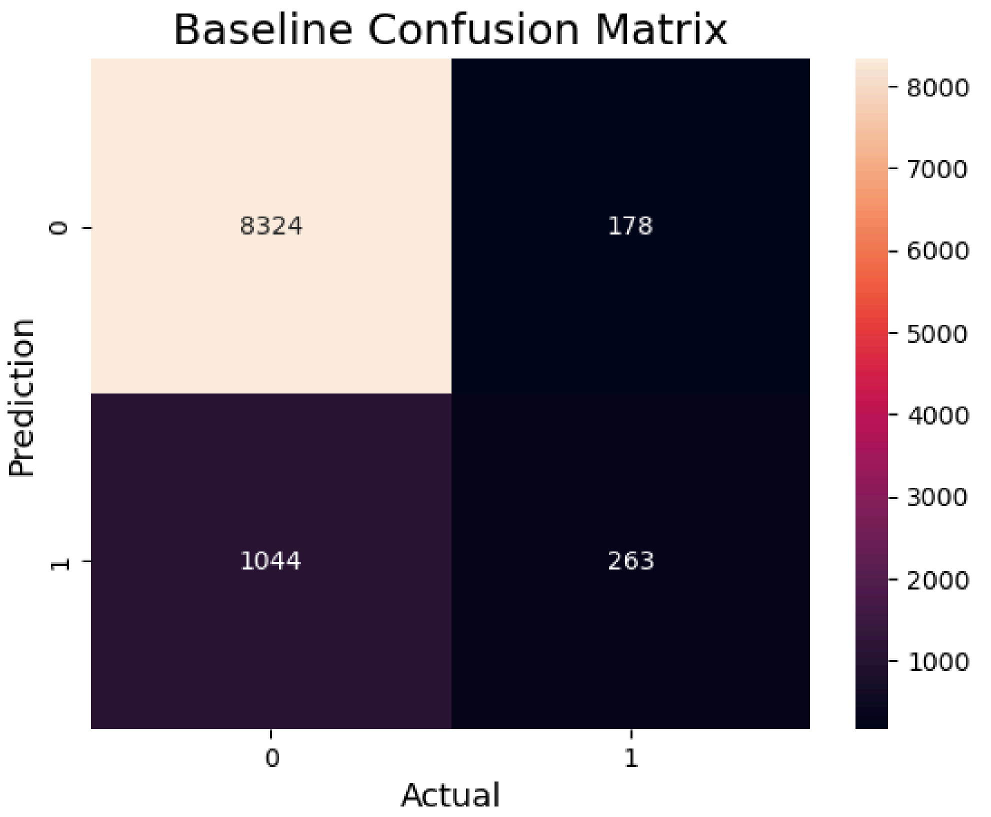
```
print("\x1b[32mBaseline evaluation metrics:\x1b[0m")
print("\x1b[31mNumber of rows = 50000")
print("List of models:\nLogistic Regression\nSVC\nXgboost\nAdaBoost\x1b[0m")
print(cr_1)

print("\x1b[36mMinority class recall and precision was low.\x1b[0m")
print("\x1b[36mChoosing top 75% percentile of players with respect to number of shots\x

print("\x1b[32mEvaluation metrics after choosing cutoff of number of shots for each pla
print("\x1b[31mNumber of rows = 50000")
print("List of models:\nLogistic Regression\nSVC\nXgboost\nAdaBoost\x1b[0m")
print(cr_2)

print("\x1b[36mMetrics did not change by much\x1b[0m")

print("\x1b[36mOversampling using ADASYN to balance classes and replacing SVC with KNN\
print("\x1b[32mEvaluation metrics after oversampling and replacing SVC with KNN:\x1b[0
print("\x1b[31mNumber of rows = 50000")
print("List of models:\nLogistic Regression\nKNN\nXgboost\nAdaBoost\x1b[0m")
print(cr_3)

print("\x1b[36mMetrics increased by a significant amount with respect to minority class
print("\x1b[36mRunning gridsearch again with entire dataset\x1b[0m")
print("\x1b[31mNumber of rows = entire dataset")
print("List of models:\nLogistic Regression\nKNN\nXgboost\nAdaBoost\x1b[0m")
print(cr_4)
```

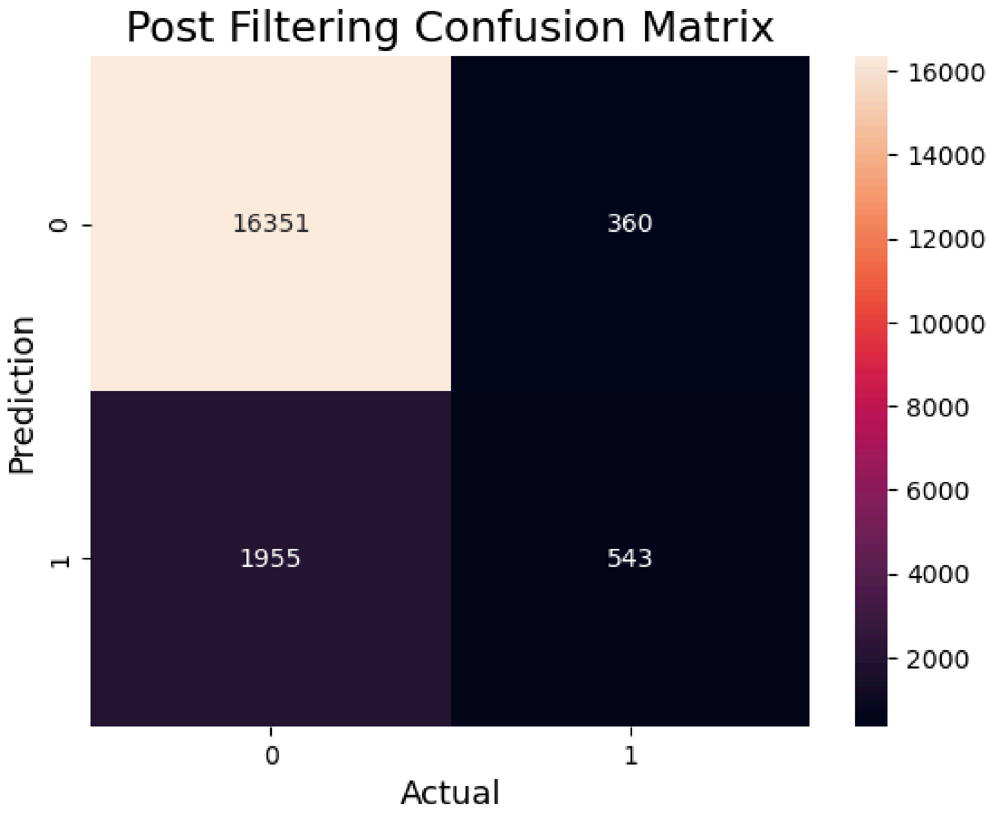
```
Baseline evaluation metrics:
Number of rows = 50000
List of models:
Logistic Regression
SVC
Xgboost
AdaBoost
              precision    recall  f1-score   support

           0       0.89      0.98      0.93      8502
           1       0.60      0.20      0.30      1307

    accuracy                           0.88      9809
   macro avg       0.74      0.59      0.62      9809
weighted avg       0.85      0.88      0.85      9809

Minority class recall and precision was low.
Choosing top 75% percentile of players with respect to number of shots
Evaluation metrics after choosing cutoff of number of shots for each player(top 75% percen
tile):
Number of rows = 50000
List of models:
Logistic Regression
SVC
Xgboost
AdaBoost
              precision    recall  f1-score   support

           0       0.89      0.98      0.93     16711
           1       0.60      0.22      0.32      2498

    accuracy                           0.88     19209
   macro avg       0.75      0.60      0.63     19209
weighted avg       0.86      0.88      0.85     19209

Metrics did not change by much
Oversampling using ADASYN to balance classes and replacing SVC with KNN
Evaluation metrics after oversampling and replacing SVC with KNN:
Number of rows = 50000
List of models:
Logistic Regression
KNN
Xgboost
AdaBoost
              precision    recall  f1-score   support

           0       0.88      0.93      0.90      8498
           1       0.92      0.87      0.90      8494

    accuracy                           0.90     16992
   macro avg       0.90      0.90      0.90     16992
weighted avg       0.90      0.90      0.90     16992

Metrics increased by a significant amount with respect to minority class and grid search r
an computationally much faster.
Running gridsearch again with entire dataset
Number of rows = entire dataset
List of models:
Logistic Regression
KNN
Xgboost
AdaBoost
              precision    recall  f1-score   support
           0       0.89      0.93      0.91     16711
           1       0.93      0.89      0.91     16977

    accuracy                           0.91     33688
   macro avg       0.91      0.91      0.91     33688
weighted avg       0.91      0.91      0.91     33688
```

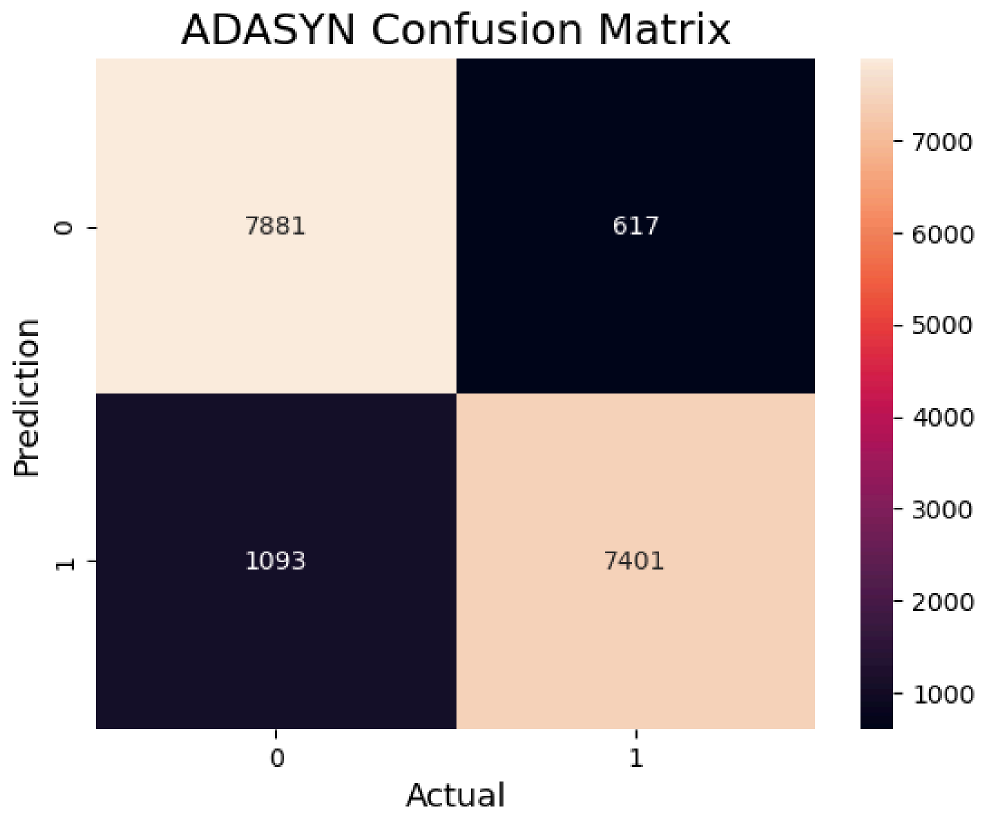
Confusion Matrices

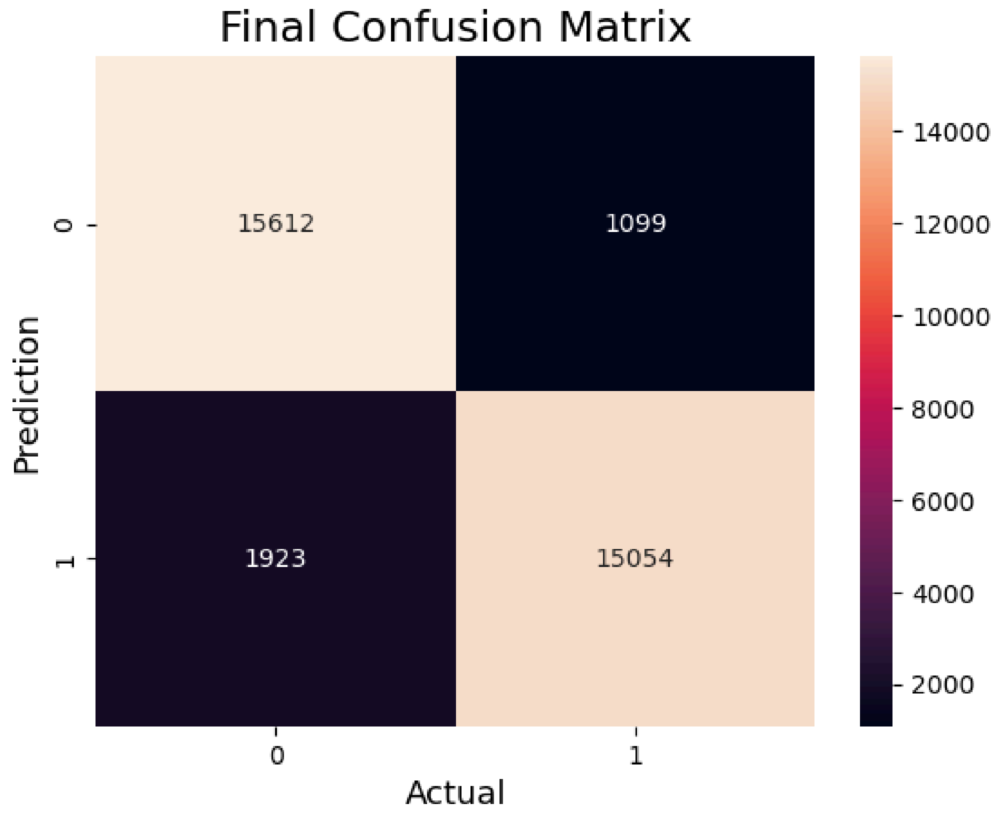
In [97]:

```
cm_1 = metrics.confusion_matrix(y_test_1, y_preds_1)
cm_2 = metrics.confusion_matrix(y_test_2, y_preds_2)
cm_3 = metrics.confusion_matrix(y_test_3, y_preds_3)
cm_4 = metrics.confusion_matrix(y_test_4, y_preds_4)

sns.heatmap(cm_1,
            annot=True,
            fmt='g',
            xticklabels=range(2),
            yticklabels=range(2))
plt.ylabel('Prediction',fontsize=13)
plt.xlabel('Actual',fontsize=13)
plt.title('Baseline Confusion Matrix',fontsize=17)
plt.show()

sns.heatmap(cm_2,
            annot=True,
            fmt='g',
            xticklabels=range(2),
            yticklabels=range(2))
plt.ylabel('Prediction',fontsize=13)
plt.xlabel('Actual',fontsize=13)
plt.title('Post Filtering Confusion Matrix',fontsize=17)
plt.show()

sns.heatmap(cm_3,
            annot=True,
            fmt='g',
            xticklabels=range(2),
            yticklabels=range(2))
plt.ylabel('Prediction',fontsize=13)
plt.xlabel('Actual',fontsize=13)
plt.title('ADASYN Confusion Matrix',fontsize=17)
plt.show()

sns.heatmap(cm_4,
            annot=True,
            fmt='g',
            xticklabels=range(2),
            yticklabels=range(2))
plt.ylabel('Prediction',fontsize=13)
plt.xlabel('Actual',fontsize=13)
plt.title('Final Confusion Matrix',fontsize=17)
plt.show()
```


Baseline Confusion Matrix
Prediction
Actual
0
1
0
1
8324
178
1044
263
8000
7000
6000
5000
4000
3000
2000
1000


Post Filtering Confusion Matrix
Prediction
Actual
0
1
0
1
16351
360
1955
543
16000
14000
12000
10000
8000
6000
4000
2000

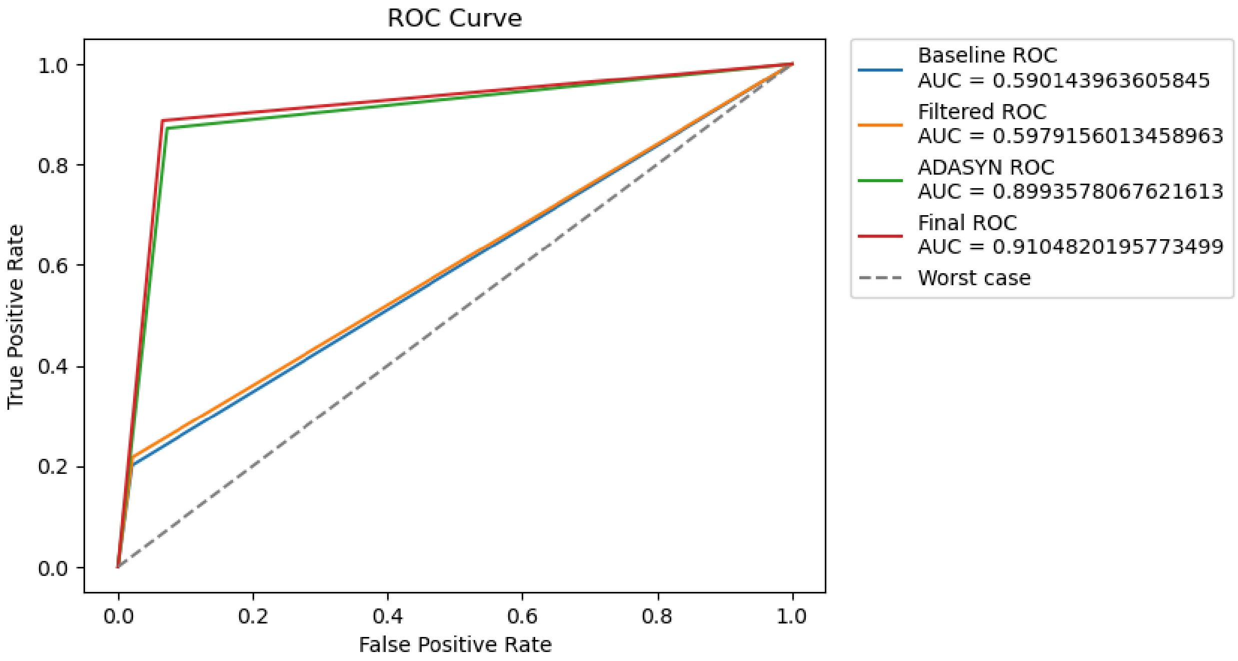




AUC_ROC Curves

In [98]:

```
fpr_1, tpr_1, _ = metrics.roc_curve(y_test_1, y_preds_1)
auc_1 = metrics.roc_auc_score(y_test_1, y_preds_1)

plt.plot(fpr_1, tpr_1, label='Baseline ROC\nAUC = '+ str(auc_1))
# plt.plot([0, 1], [0, 1], '--', color='grey', label='Worst case')
plt.plot()
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
# plt.legend();

fpr_2, tpr_2, _ = metrics.roc_curve(y_test_2, y_preds_2)
auc_2 = metrics.roc_auc_score(y_test_2, y_preds_2)

plt.plot(fpr_2, tpr_2, label='Filtered ROC\nAUC = '+ str(auc_2))
# plt.plot([0, 1], [0, 1], '--', color='grey', label='Worst case')
plt.plot()
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
# plt.legend();

fpr_3, tpr_3, _ = metrics.roc_curve(y_test_3, y_preds_3)
auc_3 = metrics.roc_auc_score(y_test_3, y_preds_3)

plt.plot(fpr_3, tpr_3, label='ADASYN ROC\nAUC = '+ str(auc_3))
# plt.plot([0, 1], [0, 1], '--', color='grey', label='Worst case')
plt.plot()
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
# plt.legend();

fpr_4, tpr_4, _ = metrics.roc_curve(y_test_4, y_preds_4)
auc_4 = metrics.roc_auc_score(y_test_4, y_preds_4)

plt.plot(fpr_4, tpr_4, label='Final ROC\nAUC = '+ str(auc_4))
plt.plot([0, 1], [0, 1], '--', color='grey', label='Worst case')
plt.plot()
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(bbox_to_anchor = (1.02, 1.02));
```


ROC Curve
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
Baseline ROC
AUC = 0.590143963605845
Filtered ROC
AUC = 0.5979156013458963
ADASYN ROC
AUC = 0.8993578067621613
Final ROC
AUC = 0.9104820195773499
Worst case

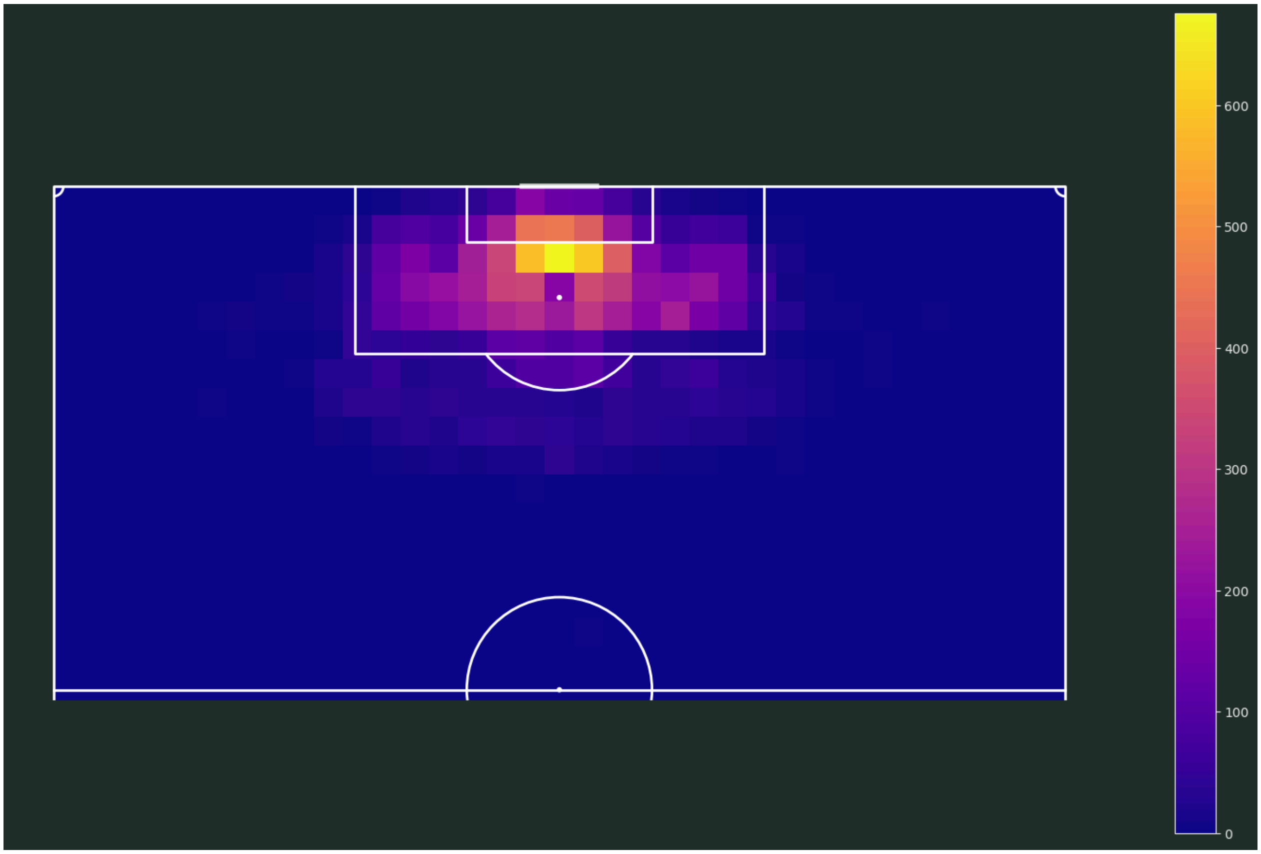
Heatmap

Predicted Label Heatmap

In [94]:

```python
# from highlight_text import fig_text
import matplotlib.patheffects as path_effects

from matplotlib.colors import LinearSegmentedColormap
from scipy.ndimage import gaussian_filter

from mplsoccer import Pitch, VerticalPitch, FontManager, Sbopen
from sklearn.model_selection import train_test_split

mean_with_zero = lambda x: np.sum(x) if not np.sum(np.sum(x)) else 0
pred_heatmap = pd.concat([pd.DataFrame(X_test), pd.Series(y_preds_4,index=X_test.index

pred_heatmap = pred_heatmap.rename(columns = {0 : 'Result'})

plt.figure(dpi=4800)
path_eff = [path_effects.Stroke(linewidth=0.5, foreground='black'),
            path_effects.Normal()]
pitch = VerticalPitch(pad_bottom = 1, half = True, goal_type = 'line', goal_alpha = 0.
                      pitch_type = 'custom', pitch_length = 99.5, pitch_width = 100,
                     line_zorder=2, line_color='white', corner_arcs=True, pitch_color=

fig, ax = pitch.draw(figsize=(15,15))
fig.set_facecolor('#22312b')

bin_statistic = pitch.bin_statistic(pred_heatmap.X * 100, pred_heatmap.Y* 100,
                                    values = pred_heatmap.Result, statistic='sum', bin

bin_statistic['statistic'] = gaussian_filter(bin_statistic['statistic'], -10)

pcm = pitch.heatmap(bin_statistic, ax=ax, cmap='plasma')
cbar = fig.colorbar(pcm, ax=ax, shrink=0.6)

cbar.outline.set_edgecolor('#efefef')
cbar.ax.yaxis.set_tick_params(color='#efefef')

ticks = plt.setp(plt.getp(cbar.ax.axes, 'yticklabels'), color='#efefef')
# labels = pitch.label_heatmap(bin_statistic, color='black', fontsize=10,
#                              ax=ax, ha='center', va='center',
#                              str_format='{:.2f}%', path_effects=path_eff)
```

```
<Figure size 30720x23040 with 0 Axes>
```

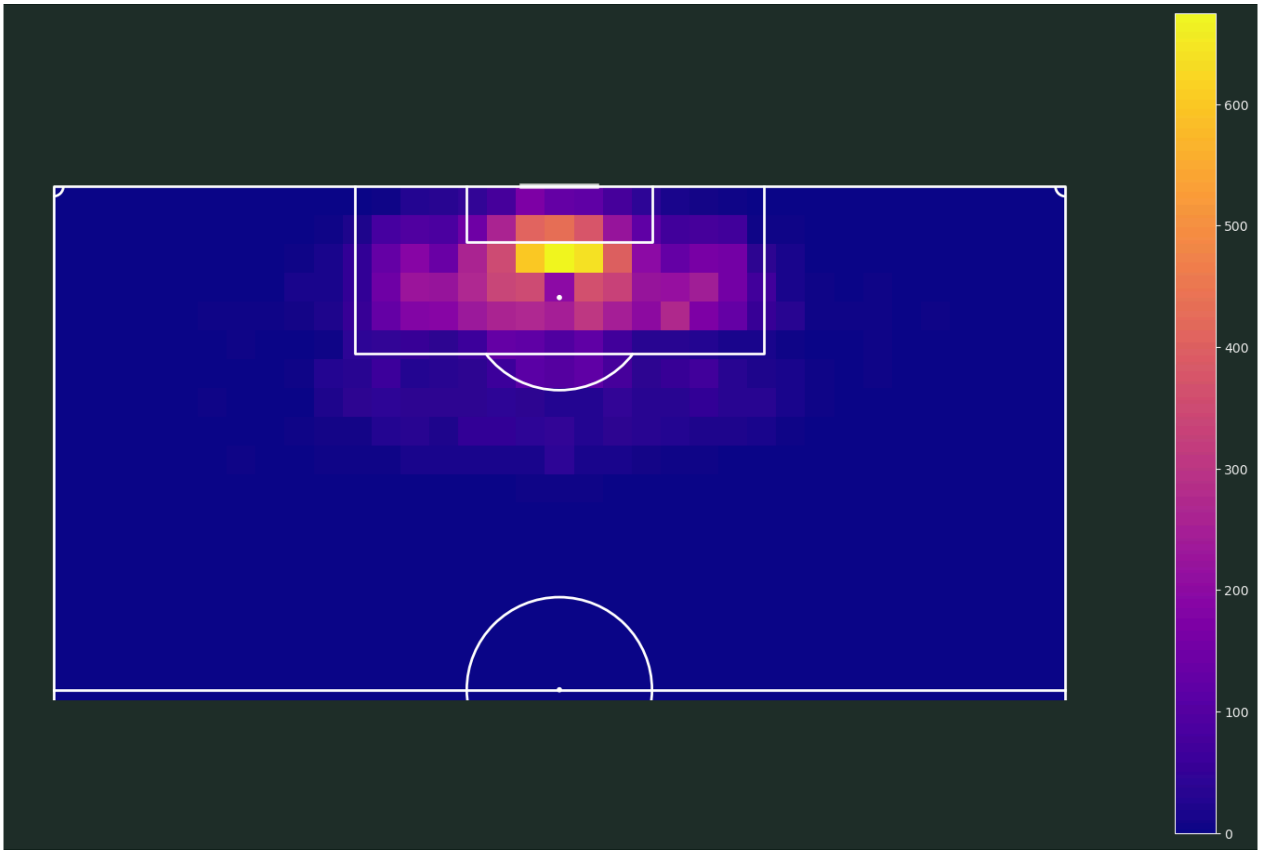

600
500
400
300
200
100
0

True Label Heatmap

In [95]:

```
# from highlight_text import fig_text
import matplotlib.patheffects as path_effects

from matplotlib.colors import LinearSegmentedColormap
from scipy.ndimage import gaussian_filter

from mplsoccer import Pitch, VerticalPitch, FontManager, Sbopen
from sklearn.model_selection import train_test_split

mean_with_zero = lambda x: np.sum(x) if not np.sum(np.sum(x)) else 0
pred_heatmap = pd.concat([pd.DataFrame(X_test), pd.Series(y_test_4,index=X_test.index)

# pred_heatmap = pred_heatmap.rename(columns = {0 : 'Result'})

plt.figure(dpi=4800)
path_eff = [path_effects.Stroke(linewidth=0.5, foreground='black'),
            path_effects.Normal()]
pitch = VerticalPitch(pad_bottom = 1, half = True, goal_type = 'line', goal_alpha = 0.
                      pitch_type = 'custom', pitch_length = 99.5, pitch_width = 100,
                     line_zorder=2, line_color='white', corner_arcs=True, pitch_color=

fig, ax = pitch.draw(figsize=(15,15))
fig.set_facecolor('#22312b')

bin_statistic = pitch.bin_statistic(pred_heatmap.X * 100, pred_heatmap.Y* 100,
                                    values = pred_heatmap.result, statistic='sum', bin

bin_statistic['statistic'] = gaussian_filter(bin_statistic['statistic'], -10)

pcm = pitch.heatmap(bin_statistic, ax=ax, cmap='plasma')
cbar = fig.colorbar(pcm, ax=ax, shrink=0.6)

cbar.outline.set_edgecolor('#efefef')
cbar.ax.yaxis.set_tick_params(color='#efefef')

ticks = plt.setp(plt.getp(cbar.ax.axes, 'yticklabels'), color='#efefef')
# labels = pitch.label_heatmap(bin_statistic, color='black', fontsize=10,
#                              ax=ax, ha='center', va='center',
#                              str_format='{:.2f}%', path_effects=path_eff)
```

```
<Figure size 30720x23040 with 0 Axes>
```



In [ ]: