World Cup 2022 Predictions with Machine Learning

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Setup

Importing necessary packages.

In [1]:
```
import numpy as np # 1.21.5
import pandas as pd # 1.3.5
import matplotlib.pyplot as plt # 3.5.1
import seaborn as sns # 0.11.2
# sklearn # 1.0.2
# scipy # 1.7.3
import warnings

from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import cross_val_score
from scipy import stats

from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.svm import SVC
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split, GridSearchCV

from sklearn.metrics import confusion_matrix, roc_curve, roc_auc_score

from operator import itemgetter
```

Import results of international soccer matches from 6/14/2018 (start of FIFA 2018 World Cup) to 9/27/2022 (final game before FIFA 2022 World Cup).

In [2]:
```
games = pd.read_csv('results.csv')
games
```

Out[2]:

	date	home_team	away_team	home_score	away_score	tournament
0	6/14/2018	Russia	Saudi Arabia	5	0	FIFA World Cup
1	6/15/2018	Egypt	Uruguay	0	1	FIFA World Cup
2	6/15/2018	Morocco	Iran	0	1	FIFA World Cup
3	6/15/2018	Portugal	Spain	3	3	FIFA World Cup
4	6/16/2018	France	Australia	2	1	FIFA World Cup
...	...	...	...	...	...	...
3617	9/27/2022	Albania	Iceland	1	1	UEFA Nations League
3618	9/27/2022	Norway	Serbia	0	2	UEFA Nations League
3619	9/27/2022	Sweden	Slovenia	1	1	UEFA Nations League
3620	9/27/2022	Kosovo	Cyprus	5	1	UEFA Nations League
3621	9/27/2022	Greece	Northern Ireland	3	1	UEFA Nations League

3622 rows × 6 columns

Import FIFA International World Rankings from 6/7/2018 to 10/6/2022.

In [3]:
```
ranks = pd.read_csv('fifa_ranking.csv')
ranks
```

Out[3]:

	rank	country_full	country_abrv	total_points	previous_points	rank_change	confederation	r
0	145	Afghanistan	AFG	188.00	199.00	5	AFC	
1	146	Afghanistan	AFG	1161.00	1161.00	0	AFC	
2	145	Afghanistan	AFG	1068.00	1068.00	0	AFC	8
3	146	Afghanistan	AFG	1068.00	1068.00	1	AFC	9
4	145	Afghanistan	AFG	1068.00	1068.00	-1	AFC	10
...	...	...	...	...	...	...	...	
7354	122	Zimbabwe	ZIM	1138.56	1138.44	1	CAF	2
7355	122	Zimbabwe	ZIM	1138.56	1138.56	0	CAF	3
7356	123	Zimbabwe	ZIM	1138.56	1138.56	1	CAF	6
7357	123	Zimbabwe	ZIM	1138.56	1138.56	0	CAF	8
7358	125	Zimbabwe	ZIM	1138.56	1138.56	2	CAF	1

7359 rows × 8 columns

Data Cleaning

The date columns are changed to be in the datetime format.

In [4]:
```
games['date'] = pd.to_datetime(games['date'])
ranks['rank_date'] = pd.to_datetime(ranks['rank_date'])
```

Teams with different names in each dataset will be changed.

In [5]:
```
warnings.simplefilter(action='ignore', category=FutureWarning)
ranks['country_full'] = ranks['country_full']\
                        .str.replace('IR Iran', 'Iran')\
                        .str.replace('Korea Republic', 'South Korea')\
                        .str.replace('USA', 'United States')\
                        .str.replace('Curacao', 'Curaçao')\
                        .str.replace('FYR Macedonia', 'North Macedonia')\
                        .str.replace('Cabo Verde', 'Cape Verde')\
                        .str.replace('Cape Verde Islands', 'Cape Verde')\
                        .str.replace('St. Vincent / Grenadines', 'Saint Vincent and th
                        .str.replace('St. Vincent and the Grenadines', 'Saint Vincent
                        .str.replace('Swaziland', 'Eswatini')\
                        .str.replace('Sao Tome e Principe', 'São Tomé and Príncipe')\
                        .str.replace('Türkiye', 'Turkey')\
                        .str.replace('Congo DR', 'DR Congo')\
                        .str.replace('Korea DPR', 'North Korea')\
                        .str.replace('Kyrgyz Republic', 'Kyrgyzstan')\
                        .str.replace('US Virgin Islands', 'United States Virgin Islanc
                        .str.replace('Côte d\'Ivoire', 'Ivory Coast')\
                        .str.replace('St. Lucia', 'Saint Lucia')\
                        .str.replace('Chinese Taipei', 'Taiwan')\
                        .str.replace('St. Kitts and Nevis', 'Saint Kitts and Nevis')\
                        .str.replace('Brunei Darussalam', 'Brunei')
```

The rankings will be restrucutred to associate a country's ranking with each day.

In [6]:
```
ranks = ranks.set_index(['rank_date'])\
             .groupby(['country_full'], group_keys=False)\
             .resample('D')\
             .first()\
             .fillna(method='ffill')\
             .reset_index()
```

In [7]:
```
ranks
```

Out[7]:

	rank_date	rank	country_full	country_abrv	total_points	previous_points	rank_change	con
0	2018-06-07	145.0	Afghanistan	AFG	188.00	199.00	5.0	
1	2018-06-08	145.0	Afghanistan	AFG	188.00	199.00	5.0	
2	2018-06-09	145.0	Afghanistan	AFG	188.00	199.00	5.0	
3	2018-06-10	145.0	Afghanistan	AFG	188.00	199.00	5.0	
4	2018-06-11	145.0	Afghanistan	AFG	188.00	199.00	5.0	
...	...	...	...	...	...	...	...	
322927	2022-10-02	123.0	Zimbabwe	ZIM	1138.56	1138.56	0.0	
322928	2022-10-03	123.0	Zimbabwe	ZIM	1138.56	1138.56	0.0	
322929	2022-10-04	123.0	Zimbabwe	ZIM	1138.56	1138.56	0.0	
322930	2022-10-05	123.0	Zimbabwe	ZIM	1138.56	1138.56	0.0	
322931	2022-10-06	125.0	Zimbabwe	ZIM	1138.56	1138.56	2.0	

322932 rows × 8 columns

The game results dataframe will append the FIFA ranking data to the right-most columns for the home team on each specific date while making sure to not add redundant columns.

In [8]:
```
df_wc_ranked = games.merge(ranks[['country_full',
                                  'total_points',
                                  'previous_points',
                                  'rank',
                                  'rank_change',
                                  'rank_date']],
                           left_on=['date',
                                    'home_team'],
                           right_on=['rank_date',
                                     'country_full'])\
                    .drop(['rank_date', 'country_full'],
                          axis=1)
```

In [9]:
```
df_wc_ranked
```

Out[9]:

	date	home_team	away_team	home_score	away_score	tournament	total_points	previous_p
0	2018-06-14	Russia	Saudi Arabia	5	0	FIFA World Cup	457.00	4
1	2018-06-15	Egypt	Uruguay	0	1	FIFA World Cup	649.00	6
2	2018-06-15	Morocco	Iran	0	1	FIFA World Cup	686.00	6
3	2018-06-15	Portugal	Spain	3	3	FIFA World Cup	1274.00	13
4	2018-06-16	France	Australia	2	1	FIFA World Cup	1198.00	11
...	...	...	...	...	...	...	...	
3617	2022-09-27	Albania	Iceland	1	1	UEFA Nations League	1361.81	13
3618	2022-09-27	Norway	Serbia	0	2	UEFA Nations League	1488.57	14
3619	2022-09-27	Sweden	Slovenia	1	1	UEFA Nations League	1563.44	15
3620	2022-09-27	Kosovo	Cyprus	5	1	UEFA Nations League	1183.90	11
3621	2022-09-27	Greece	Northern Ireland	3	1	UEFA Nations League	1441.45	14

3622 rows × 10 columns

The game results dataframe will append the FIFA ranking data to the right-most columns for the away team for each specific date while making sure to not add redundant columns.

In [10]:
```
df_wc_ranked = df_wc_ranked.merge(ranks[['country_full',
                                         'total_points',
                                         'previous_points',
                                         'rank',
                                         'rank_change',
                                         'rank_date']],
                                  left_on=['date',
                                           'away_team'],
                                  right_on=['rank_date',
                                            'country_full'],
                                  suffixes=('_home', '_away'))\
                          .drop(['rank_date',
                                 'country_full'],
                                axis=1)
```

In [11]:
```
df_wc_ranked
```

Out[11]:

	date	home_team	away_team	home_score	away_score	tournament	total_points_home	prev
0	2018-06-14	Russia	Saudi Arabia	5	0	FIFA World Cup	457.00	
1	2018-06-15	Egypt	Uruguay	0	1	FIFA World Cup	649.00	
2	2018-06-15	Morocco	Iran	0	1	FIFA World Cup	686.00	
3	2018-06-15	Portugal	Spain	3	3	FIFA World Cup	1274.00	
4	2018-06-16	France	Australia	2	1	FIFA World Cup	1198.00	
...	...	...	...	...	...	...	...	
3617	2022-09-27	Albania	Iceland	1	1	UEFA Nations League	1361.81	
3618	2022-09-27	Norway	Serbia	0	2	UEFA Nations League	1488.57	
3619	2022-09-27	Sweden	Slovenia	1	1	UEFA Nations League	1563.44	
3620	2022-09-27	Kosovo	Cyprus	5	1	UEFA Nations League	1183.90	
3621	2022-09-27	Greece	Northern Ireland	3	1	UEFA Nations League	1441.45	

3622 rows × 14 columns

Renaming dataframe post-cleaning.

In [12]:
```
df = df_wc_ranked
```

Feature Engineering

New columns will be added to the dataframe to help create more features. \ \ **Columns:**

- *Result*
  - Type
    - 0 for home team win

        - 1 for away team win
        - 2 for draw
    - Home Team Points Gained
        - 3 for home team win
        - 0 for away team win
        - 1 for draw
    - Away Team Points Gained
        - 0 for home team win
        - 3 for away team win
        - 1 for draw
- *Difference In Rank*
    - Home Team Rank - Away Team Rank
- *Home Team Goal Difference*
    - Home Team Score - Away Team Score
- *Home Team Points Gained Per Opponent Rank*
    - Home Team Points Gained / Away Team Rank
- *Away Team Points Gained Per Opponent Rank*
    - Away Team Points Gained / Home Team Rank

Add *Result* columns.

In [13]:
```
def result_finder(home_goals_scored, away_goals_scored):
    if home_goals_scored > away_goals_scored:
        return pd.Series([0, 3, 0]) # home team win
    if home_goals_scored < away_goals_scored:
        return pd.Series([1, 0, 3]) # away team win
    else:
        return pd.Series([2, 1, 1]) # draw

results = df.apply(lambda x: result_finder(x["home_score"],
                                           x["away_score"]),
                                           axis=1)
df[["result", "home_team_points", "away_team_points"]] = results
```

Add *Difference in Rank* column.

In [14]:
```
df["rank_dif"] = df["rank_home"] - df["rank_away"]
```

Add *Home Team Goal Difference* column.

In [15]:
```
df["goal_dif"] = df["home_score"] - df["away_score"]
```

Add *Home Team Points Gained Per Opponent Rank* column.

In [16]:
```
df["points_home_by_rank"] = df["home_team_points"]/df["rank_away"]
```

Add *Away Team Points Gained Per Opponent Rank* column.

In [17]:
```
df["points_away_by_rank"] = df["away_team_points"]/df["rank_home"]
```

In order to calculate more features, the home team data will be separated from the away team data.

In [18]:
```
home_team = df[["date",
                "home_team",
                "home_score",
                "away_score",
                "rank_home",
                "rank_away",
                "rank_change_home",
                "total_points_home",
                "result",
                "rank_dif",
                "points_home_by_rank",
                "home_team_points"]]

away_team = df[["date",
                "away_team",
                "away_score",
                "home_score",
                "rank_away",
                "rank_home",
                "rank_change_away",
                "total_points_away",
                "result",
                "rank_dif",
                "points_away_by_rank",
                "away_team_points"]]
```

The *home* and *away* prefix and suffix will now be temporarily removed in order to generically generate more features. The *suf* previx and suffix is applied when refering to data of the opponent.

In [19]:
```
home_team.columns = [col.replace("home_", "")\
                     .replace("_home", "")\
                     .replace("away_", "suf_")\
                     .replace("_away", "_suf") \
                     for col in home_team.columns]

away_team.columns = [col.replace("away_", "")\
                     .replace("_away", "")\
                     .replace("home_", "suf_")\
                     .replace("_home", "_suf")\
                     for col in away_team.columns]
```

The data will now be combined into one large dataset to create features with ease specific to each team.

In [20]:
```
team_stats = home_team.append(away_team)
```

In [21]:
```
team_stats
```

Out[21]:

	date	team	score	suf_score	rank	rank_suf	rank_change	total_points	result	rank_dif
0	2018-06-14	Russia	5	0	70.0	67.0	4.0	457.00	0	3.0
1	2018-06-15	Egypt	0	1	45.0	14.0	-1.0	649.00	1	31.0
2	2018-06-15	Morocco	0	1	41.0	37.0	-1.0	686.00	1	4.0
3	2018-06-15	Portugal	3	3	4.0	10.0	0.0	1274.00	2	-6.0
4	2018-06-16	France	2	1	7.0	36.0	0.0	1198.00	0	-29.0
...	...	...	...	...	...	...	...	...	...	...
3617	2022-09-27	Iceland	1	1	63.0	66.0	0.0	1379.61	2	3.0
3618	2022-09-27	Serbia	2	0	25.0	36.0	0.0	1549.53	1	11.0
3619	2022-09-27	Slovenia	1	1	65.0	20.0	0.0	1372.48	2	-45.0
3620	2022-09-27	Cyprus	1	5	108.0	106.0	1.0	1180.52	0	-2.0
3621	2022-09-27	Northern Ireland	1	3	58.0	49.0	0.0	1399.10	0	-9.0

7244 rows × 12 columns

New features will be created to hopefully help predict results.

- Average goals scored.
- Average goals scored in last 5 games.
- Average goals scored in last 15 games.
- Average goals conceeded.
- Average goals conceeded in last 5 games.
- Average goals conceeded in last 15 games.
- Average FIFA Ranking of opponents.
- Average FIFA Ranking of opponents in last 5 games.
- Average FIFA Ranking of opponents in last 15 games.
- FIFA Ranking points won.
- FIFA Ranking points won in last 5 games.
- FIFA Ranking points won in last 15 games.
- Average points earned.
- Average points earned in last 5 games.
- Average points earned in last 15 games.

- Average points earned per opponent FIFA Ranking.
- Average points earned per opponent FIFA Ranking in last 5 games.
- Average points earned per opponent FIFA Ranking in last 15 games.

In [22]:
```
stats_val = []

for index, row in team_stats.iterrows():
    # Extract the team's name that this iteration is for.
    team = row["team"]

    # Extract the date of the specific game.
    date = row["date"]

    # Collect the data on all games for this team.
    past_games = team_stats.loc[(team_stats["team"] == team) & \
                                (team_stats["date"] < date)]\
                                .sort_values(by=['date'],
                                             ascending=False)

    # Collect the data on the past 5 games.
    last5 = past_games.head(5)

    # Collect the data on the past 15 games.
    last15 = past_games.head(15)

    # Calculate the average goals scored.
    goals = past_games["score"].mean()

    # Calculate the average goals scored in last 5 games.
    goals_l5 = last5["score"].mean()

    # Calculate the average goals scored in last 15 games.
    goals_l15 = last15["score"].mean()

    # Calculate the average goals conceeded.
    goals_suf = past_games["suf_score"].mean()

    # Calculate the average goals conceeded in last 5 games.
    goals_suf_l5 = last5["suf_score"].mean()

    # Calculate the average goals conceeded in last 5 games.
    goals_suf_l15 = last15["suf_score"].mean()

    # Calculate the average FIFA ranking of opponent.
    rank = past_games["rank_suf"].mean()

    # Calculate the average FIFA ranking of opponent in last 5 games.
    rank_l5 = last5["rank_suf"].mean()

    # Calculate the average FIFA ranking of opponent in last 15 games.
    rank_l15 = last15["rank_suf"].mean()

    # If a team has played more than 1 game before this, calculate the change in:
    #    * FIFA Ranking points earned over the entire period.
    #    * FIFA Ranking points earned over the last 5 games.
    #    * FIFA Ranking points earned over the last 15 games.
    if len(last5) > 0:
        points = past_games["total_points"].values[0] - past_games["total_points"].val
```

```
            points_l5 = last5["total_points"].values[0] - last5["total_points"].values[-1]
            points_l15 = last15["total_points"].values[0] - last15["total_points"].values[
        else:
            points = 0
            points_l5 = 0
            points_l15 = 0

        # Calculate the average points earned.
        gp = past_games["team_points"].mean()

        # Calculate the average points earned in last 5 games.
        gp_l5 = last5["team_points"].mean()

        # Calculate the average points earned in last 15 games.
        gp_l15 = last15["team_points"].mean()

        # Calculate the average points earned per opponent rank.
        gp_rank = past_games["points_by_rank"].mean()

        # Calculate the average points earned per opponent rank in last 5 games.
        gp_rank_l5 = last5["points_by_rank"].mean()

        # Calculate the average points earned per opponent rank in last 15 games.
        gp_rank_l15 = last15["points_by_rank"].mean()

        # Add data to list for this iteration.
        stats_val.append([goals,
                          goals_l5,
                          goals_l15,
                          goals_suf,
                          goals_suf_l5,
                          goals_suf_l15,
                          rank,
                          rank_l5,
                          rank_l15,
                          points,
                          points_l5,
                          points_l15,
                          gp,
                          gp_l5,
                          gp_l15,
                          gp_rank,
                          gp_rank_l5,
                          gp_rank_l15])
```

The new feature data will be added to the individual team stats dataframe.

In [23]:
```
stats_cols = ["goals_mean",
              "goals_mean_l5",
              "goals_mean_l15",
              "goals_suf_mean",
              "goals_suf_mean_l5",
              "goals_suf_mean_l15",
              "rank_mean",
              "rank_mean_l5",
              "rank_mean_l15",
              "points_mean",
              "points_mean_l5",
              "points_mean_l15",
```

```
                "game_points_mean",
                "game_points_mean_l5",
                "game_points_mean_l15",
                "game_points_rank_mean",
                "game_points_rank_mean_l5",
                "game_points_rank_mean_l15"]

stats_df = pd.DataFrame(stats_val, columns=stats_cols)

full_df = pd.concat([team_stats.reset_index(drop=True), stats_df],
                    axis=1,
                    ignore_index=False)
```

The dataframe will again be separated into home team and away team data.

In [24]:
```
home_team_stats = full_df.iloc[:int(full_df.shape[0]/2),:]
away_team_stats = full_df.iloc[int(full_df.shape[0]/2):,:]
```

In [25]:
```
home_team_stats = home_team_stats[home_team_stats.columns[-18:]]
away_team_stats = away_team_stats[away_team_stats.columns[-18:]]
```

The original *home* and *away* suffixes and prefixes will be added back onto the respective columns.

In [26]:
```
home_team_stats.columns = ['home_'+str(col) for col in home_team_stats.columns]
away_team_stats.columns = ['away_'+str(col) for col in away_team_stats.columns]
```

The home and away team data will be merged.

In [27]:
```
match_stats = pd.concat([home_team_stats, away_team_stats.reset_index(drop=True)],
                        axis=1,
                        ignore_index=False)
```

The new statistics calculated will be added onto the original match data.

In [28]:
```
full_df = pd.concat([df, match_stats.reset_index(drop=True)],
                    axis=1,
                    ignore_index=False)
```

A new column will be added indicating if the game was friendly (0), semi-competitive (1), or competitive (2).

In [29]:
```
def find_friendly(x):
    competitives = ['AFC Asian Cup',
                    'AFC Asian Cup qualification',
                    'African Cup of Nations',
                    'African Cup of Nations qualification',
                    'African Nations Championship qualification',
                    'CONCACAF Nations League',
                    'CONCACAF Nations League qualification',
                    'Copa América',
                    'FIFA World Cup',
                    'FIFA World Cup qualification',
                    'Gold Cup',
                    'Gold Cup qualification',
```

```
                    'UEFA Euro',
                    'UEFA Euro qualification',
                    'UEFA Nations League']

    if x == "Friendly":
        return 0
    elif x in competitives:
        return 2
    else:
        return 1

full_df["is_friendly"] = full_df["tournament"].apply(lambda x: find_friendly(x))
```

The new added column indicating the type of match will be turned into one-hot-encoding.

In [30]:
```
full_df = pd.get_dummies(full_df, columns=["is_friendly"])
```

In [31]:
```
full_df.columns
```

Out[31]:
```
Index(['date', 'home_team', 'away_team', 'home_score', 'away_score',
       'tournament', 'total_points_home', 'previous_points_home', 'rank_home',
       'rank_change_home', 'total_points_away', 'previous_points_away',
       'rank_away', 'rank_change_away', 'result', 'home_team_points',
       'away_team_points', 'rank_dif', 'goal_dif', 'points_home_by_rank',
       'points_away_by_rank', 'home_goals_mean', 'home_goals_mean_l5',
       'home_goals_mean_l15', 'home_goals_suf_mean', 'home_goals_suf_mean_l5',
       'home_goals_suf_mean_l15', 'home_rank_mean', 'home_rank_mean_l5',
       'home_rank_mean_l15', 'home_points_mean', 'home_points_mean_l5',
       'home_points_mean_l15', 'home_game_points_mean',
       'home_game_points_mean_l5', 'home_game_points_mean_l15',
       'home_game_points_rank_mean', 'home_game_points_rank_mean_l5',
       'home_game_points_rank_mean_l15', 'away_goals_mean',
       'away_goals_mean_l5', 'away_goals_mean_l15', 'away_goals_suf_mean',
       'away_goals_suf_mean_l5', 'away_goals_suf_mean_l15', 'away_rank_mean',
       'away_rank_mean_l5', 'away_rank_mean_l15', 'away_points_mean',
       'away_points_mean_l5', 'away_points_mean_l15', 'away_game_points_mean',
       'away_game_points_mean_l5', 'away_game_points_mean_l15',
       'away_game_points_rank_mean', 'away_game_points_rank_mean_l5',
       'away_game_points_rank_mean_l15', 'is_friendly_0', 'is_friendly_1',
       'is_friendly_2'],
      dtype='object')
```

The columns that will help in feature analysis will be extracted from the full dataframe.

In [32]:
```
base_df = full_df[[
   "date",
   "home_team", "away_team",
   "rank_home", "rank_away",
   "home_score", "away_score", "result",
   "rank_dif", "rank_change_home", "rank_change_away",

   'home_goals_mean', 'home_goals_mean_l5', 'home_goals_mean_l15',
   'home_goals_suf_mean', 'home_goals_suf_mean_l5', 'home_goals_suf_mean_l15',
   'home_rank_mean', 'home_rank_mean_l5',  'home_rank_mean_l15',
   'home_points_mean', 'home_points_mean_l5', 'home_points_mean_l15',
   'away_goals_mean', 'away_goals_mean_l5', 'away_goals_mean_l15',
   'away_goals_suf_mean', 'away_goals_suf_mean_l5',  'away_goals_suf_mean_l15',
   'away_rank_mean', 'away_rank_mean_l5',  'away_rank_mean_l15',
```

```
   'away_points_mean', 'away_points_mean_l5', 'away_points_mean_l15',
   'home_game_points_mean', 'home_game_points_mean_l5', 'home_game_points_mean_l15',
   'home_game_points_rank_mean', 'home_game_points_rank_mean_l5', 'home_game_points_ra
   'away_game_points_mean', 'away_game_points_mean_l5',  'away_game_points_mean_l15',
   'away_game_points_rank_mean', 'away_game_points_rank_mean_l5', 'away_game_points_ra
   'is_friendly_0', 'is_friendly_1', 'is_friendly_2']]
```

The NA data where previous 5 or 15 games could not be calculated will be dropped.

In [33]:
```
base_df_no_fg = base_df.dropna()
```

Feature Analysis

The features will be analysed to see how well they predict.

In [34]:
```
df = base_df_no_fg
```

The result must be binary to compare if the features separate classes well. In this case, a draw for the home team will be counted as a loss (1), and a home team win will still be a win (0).

In [35]:
```
def no_draw(x):
    if x == 2:
        return 1
    else:
        return x

df["target"] = df["result"].apply(lambda x: no_draw(x))
```

```
C:\Users\jts1s\Anaconda3\lib\site-packages\ipykernel_launcher.py:7: SettingWithCopyWa
rning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
er_guide/indexing.html#returning-a-view-versus-a-copy
  import sys
```

The data will be split into three groups for visualization purposes only.

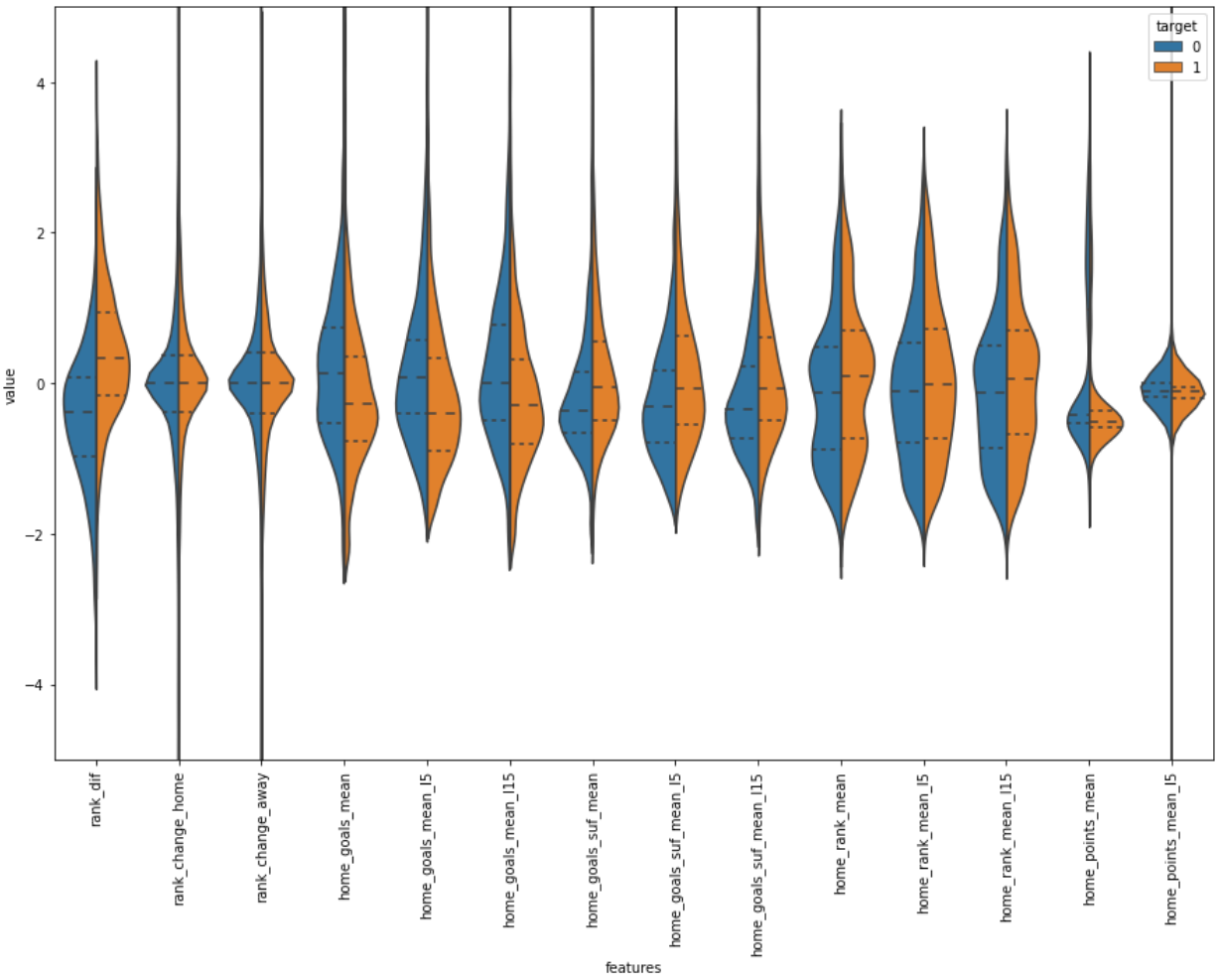
In [36]:
```
data1 = df[list(df.columns[8:22].values) + ["target"]]
data2 = df[list(df.columns[22:36].values) + ["target"]]
data3 = df[df.columns[36:]]
```

The data will be standardized and then plotted on a violin plot.

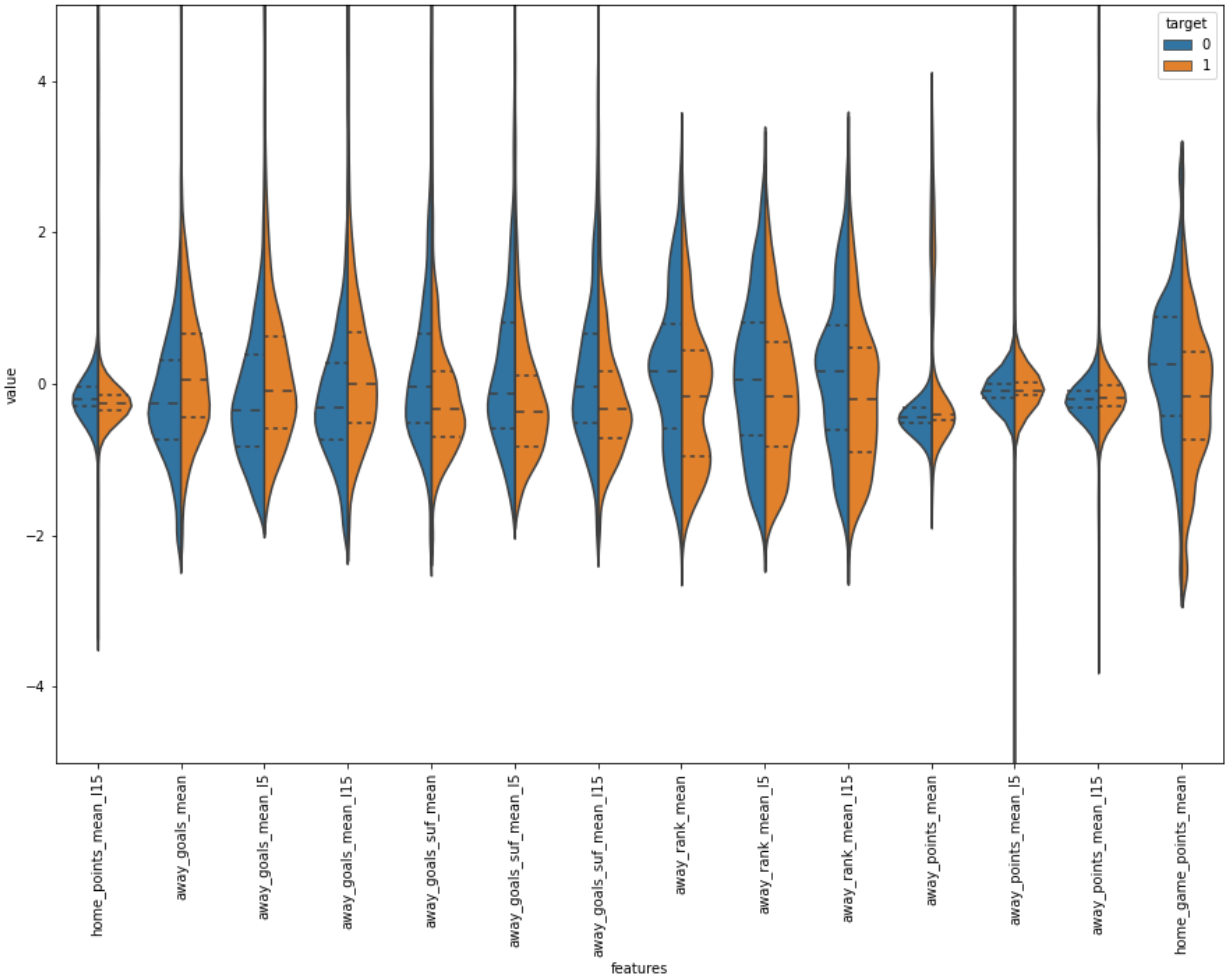
In [37]:
```
scaled = (data1[:-1] - data1[:-1].mean()) / data1[:-1].std()
scaled["target"] = data1["target"]
violin1 = pd.melt(scaled,id_vars="target", var_name="features", value_name="value")

scaled = (data2[:-1] - data2[:-1].mean()) / data2[:-1].std()
scaled["target"] = data2["target"]
violin2 = pd.melt(scaled,id_vars="target", var_name="features", value_name="value")
```

```
scaled = (data3[:-1] - data3[:-1].mean()) / data3[:-1].std()
scaled["target"] = data3["target"]
violin3 = pd.melt(scaled,id_vars="target", var_name="features", value_name="value")
```

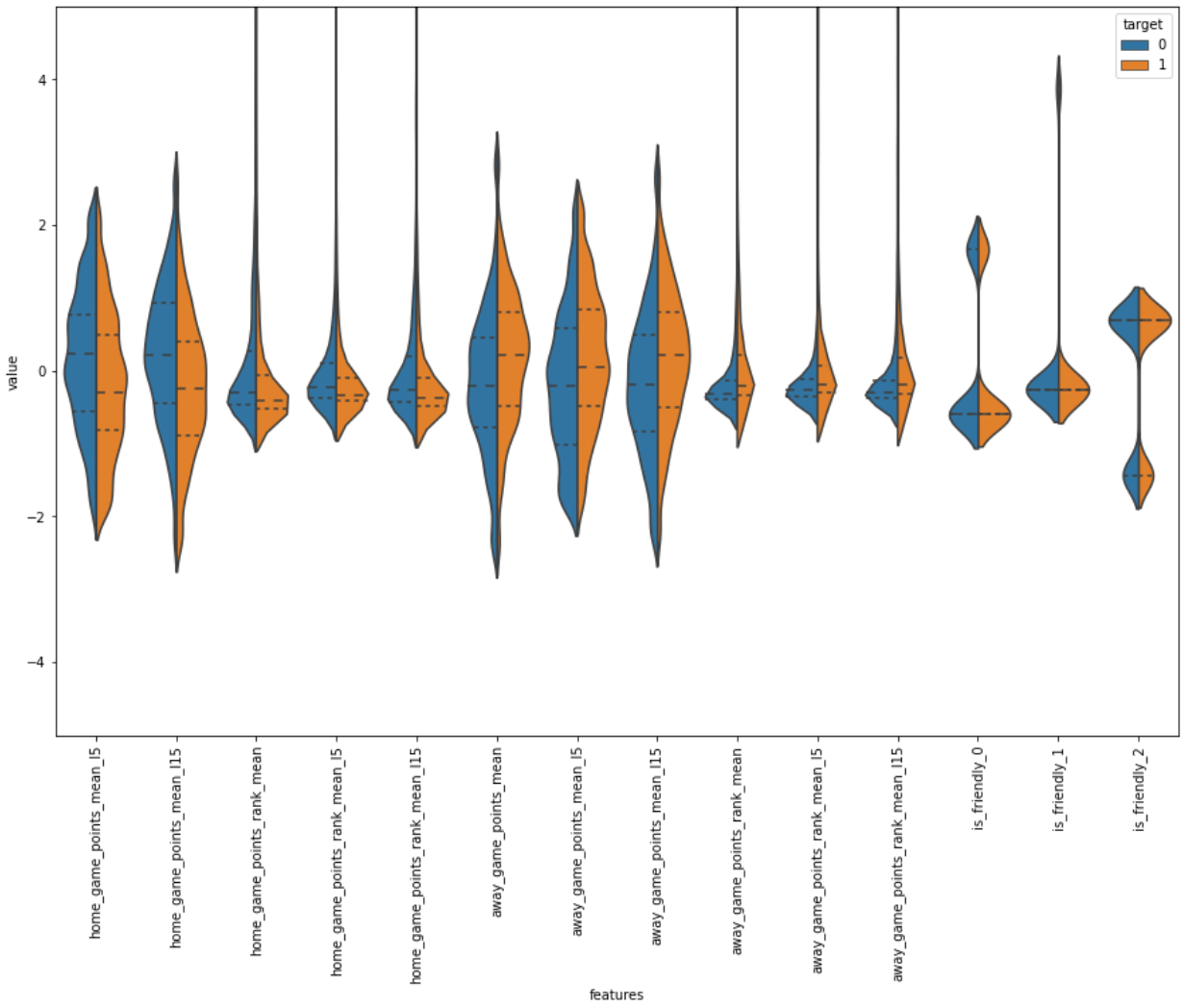
In [38]:
```
plt.figure(figsize=(15,10))
sns.violinplot(x="features", y="value", hue="target", data=violin1,split=True, inner='
plt.xticks(rotation=90)
plt.ylim([-5, 5]) # Uncomment to zoom in.
plt.show()
```



In [39]:
```
plt.figure(figsize=(15,10))
sns.violinplot(x="features", y="value", hue="target", data=violin2,split=True, inner='
plt.xticks(rotation=90)
plt.ylim([-5, 5]) # Uncomment to zoom in.
plt.show()
```



In [40]:
```
plt.figure(figsize=(15,10))
sns.violinplot(x="features", y="value", hue="target", data=violin3,split=True, inner='
plt.xticks(rotation=90)
plt.ylim([-5, 5]) # Uncomment to zoom in.
plt.show()
```



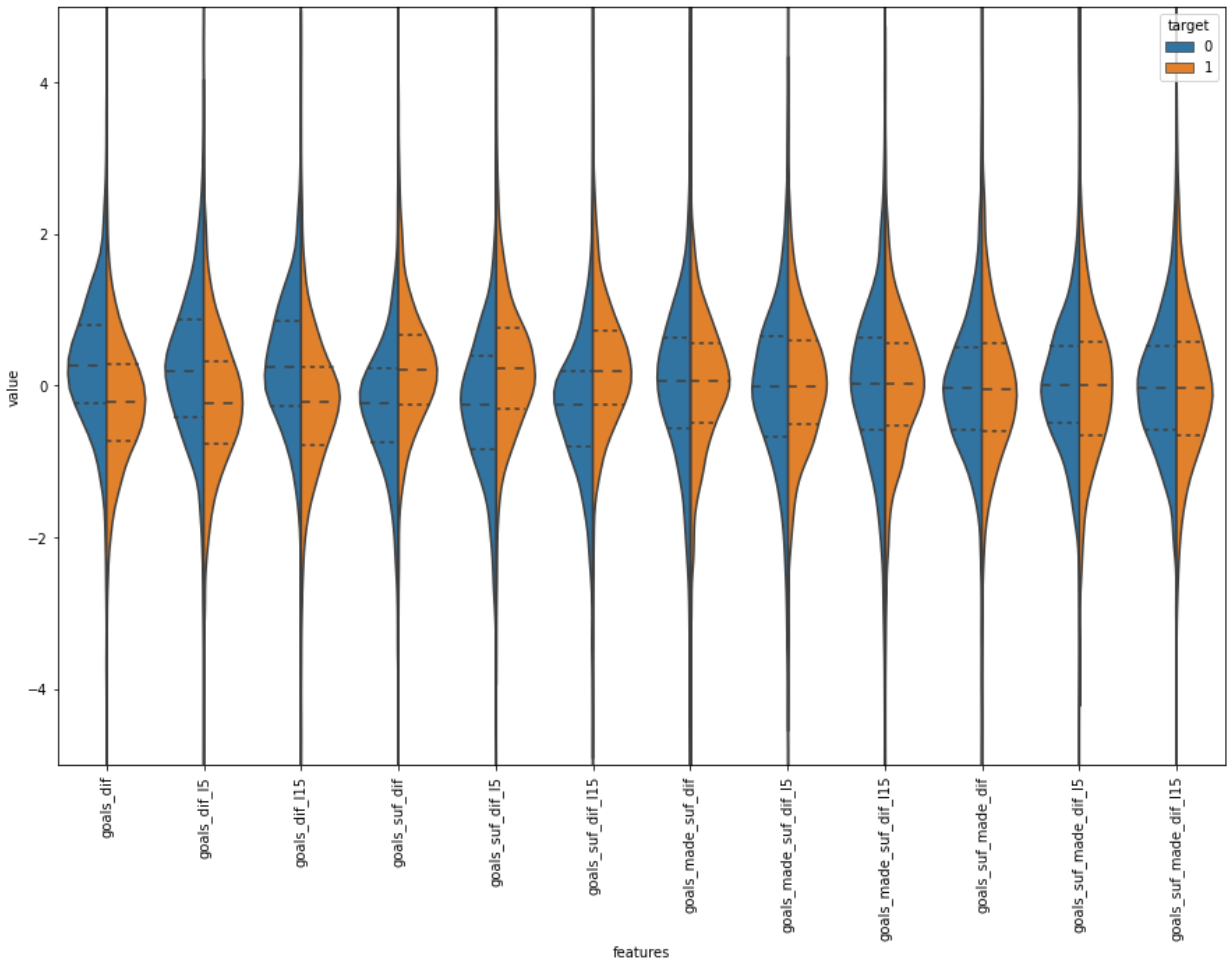
`rank_dif` was the only real feature where it looks like the labels are clearly separable. However, more features can still be calculated to test out.

In [41]:
```
dif = df.copy()
dif.loc[:, "goals_dif"] = dif["home_goals_mean"] - dif["away_goals_mean"]
dif.loc[:, "goals_dif_l5"] = dif["home_goals_mean_l5"] - dif["away_goals_mean_l5"]
dif.loc[:, "goals_dif_l15"] = dif["home_goals_mean_l15"] - dif["away_goals_mean_l15"]
dif.loc[:, "goals_suf_dif"] = dif["home_goals_suf_mean"] - dif["away_goals_suf_mean"]
dif.loc[:, "goals_suf_dif_l5"] = dif["home_goals_suf_mean_l5"] - dif["away_goals_suf_m
dif.loc[:, "goals_suf_dif_l15"] = dif["home_goals_suf_mean_l15"] - dif["away_goals_suf
dif.loc[:, "goals_made_suf_dif"] = dif["home_goals_mean"] - dif["away_goals_suf_mean"]
dif.loc[:, "goals_made_suf_dif_l5"] = dif["home_goals_mean_l5"] - dif["away_goals_suf_
dif.loc[:, "goals_made_suf_dif_l15"] = dif["home_goals_mean_l15"] - dif["away_goals_su
dif.loc[:, "goals_suf_made_dif"] = dif["home_goals_suf_mean"] - dif["away_goals_mean"]
dif.loc[:, "goals_suf_made_dif_l5"] = dif["home_goals_suf_mean_l5"] - dif["away_goals_
dif.loc[:, "goals_suf_made_dif_l15"] = dif["home_goals_suf_mean_l15"] - dif["away_goal
```

The new feature data will be scaled and violin plots analyzed.

In [42]:
```
data_difs = dif.iloc[:, -12:]
scaled = (data_difs - data_difs.mean()) / data_difs.std()
scaled["target"] = df["target"]
violin = pd.melt(scaled,id_vars="target", var_name="features", value_name="value")

plt.figure(figsize=(15,10))
```

```
sns.violinplot(x="features", y="value", hue="target", data=violin,split=True, inner="q
plt.xticks(rotation=90)
plt.ylim([-5, 5]) # Uncomment to zoom in.
plt.show()
```



Goal differences and goals suffered differences look to be good separators too.

The 7 good features found are:

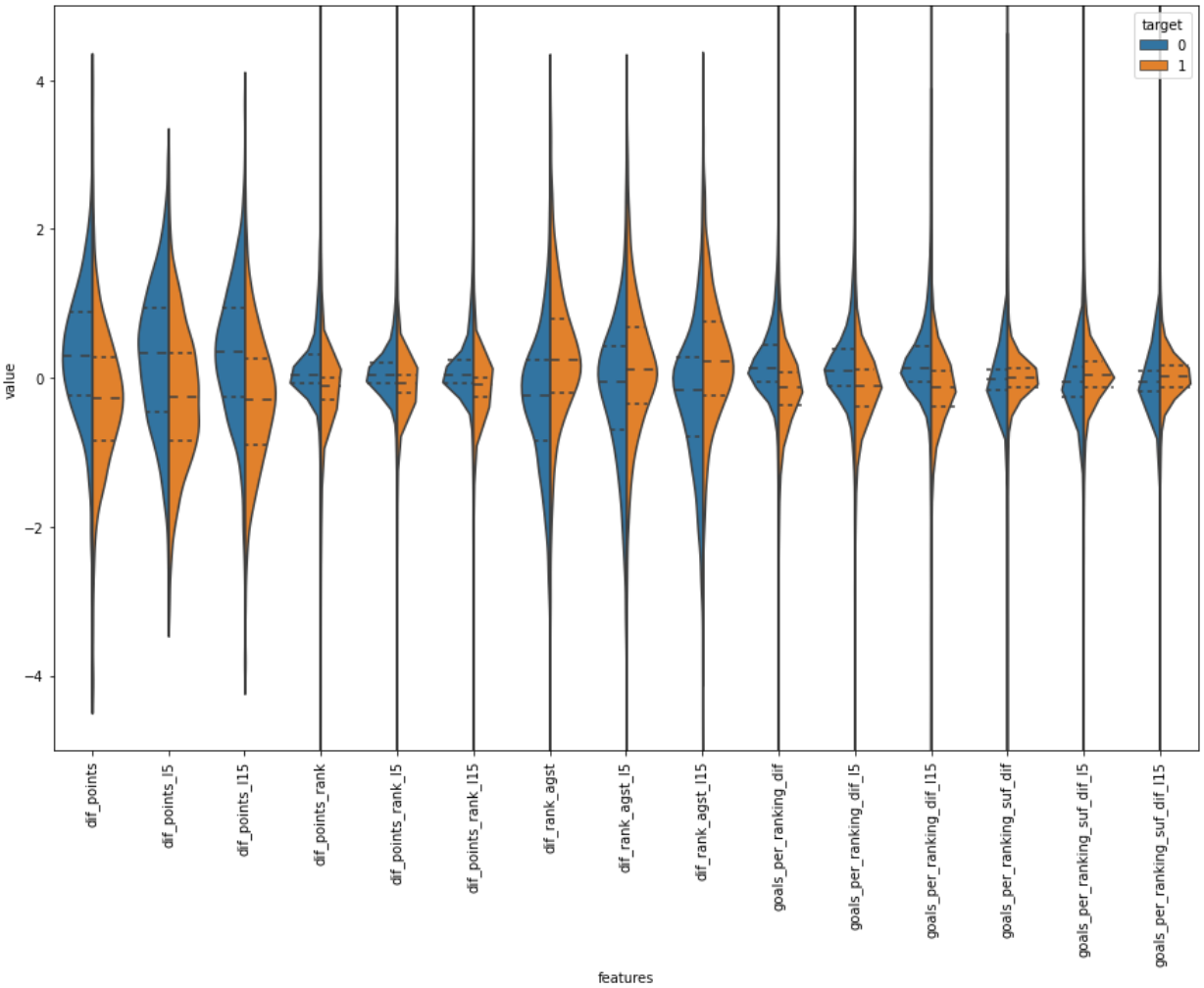
- `rank_dif`
- `goals_dif`
- `goals_dif_l5`
- `goals_dif_l15`
- `goals_suf_dif`
- `goals_suf_dif_l5`
- `goals_suf_dif_l15`

Some more features will be tested and analyzed.

In [43]:
```
dif.loc[:, "dif_points"] = dif["home_game_points_mean"] - dif["away_game_points_mean"]
dif.loc[:, "dif_points_l5"] = dif["home_game_points_mean_l5"] - dif["away_game_points_
dif.loc[:, "dif_points_l15"] = dif["home_game_points_mean_l15"] - dif["away_game_point
dif.loc[:, "dif_points_rank"] = dif["home_game_points_rank_mean"] - dif["away_game_poi
dif.loc[:, "dif_points_rank_l5"] = dif["home_game_points_rank_mean_l5"] - dif["away_ga
dif.loc[:, "dif_points_rank_l15"] = dif["home_game_points_rank_mean_l15"] - dif["away_
```

```
dif.loc[:, "dif_rank_agst"] = dif["home_rank_mean"] - dif["away_rank_mean"]
dif.loc[:, "dif_rank_agst_l5"] = dif["home_rank_mean_l5"] - dif["away_rank_mean_l5"]
dif.loc[:, "dif_rank_agst_l15"] = dif["home_rank_mean_l15"] - dif["away_rank_mean_l15"
dif.loc[:, "goals_per_ranking_dif"] = (dif["home_goals_mean"] / dif["home_rank_mean"])
dif.loc[:, "goals_per_ranking_dif_l5"] = (dif["home_goals_mean_l5"] / dif["home_rank_m
dif.loc[:, "goals_per_ranking_dif_l15"] = (dif["home_goals_mean_l15"] / dif["home_rank
dif.loc[:, "goals_per_ranking_suf_dif"] = (dif["home_goals_suf_mean"] / dif["home_rank
dif.loc[:, "goals_per_ranking_suf_dif_l5"] = (dif["home_goals_suf_mean_l5"] / dif["hom
dif.loc[:, "goals_per_ranking_suf_dif_l15"] = (dif["home_goals_suf_mean_l15"] / dif["h
```

In [44]:
```
data_difs = dif.iloc[:, -15:]
scaled = (data_difs - data_difs.mean()) / data_difs.std()
scaled["target"] = df["target"]
violin = pd.melt(scaled,id_vars="target", var_name="features", value_name="value")

plt.figure(figsize=(15,10))
sns.violinplot(x="features", y="value", hue="target", data=violin,split=True, inner="q
plt.xticks(rotation=90)
plt.ylim([-5, 5]) # Uncomment to zoom in.
plt.show()
```

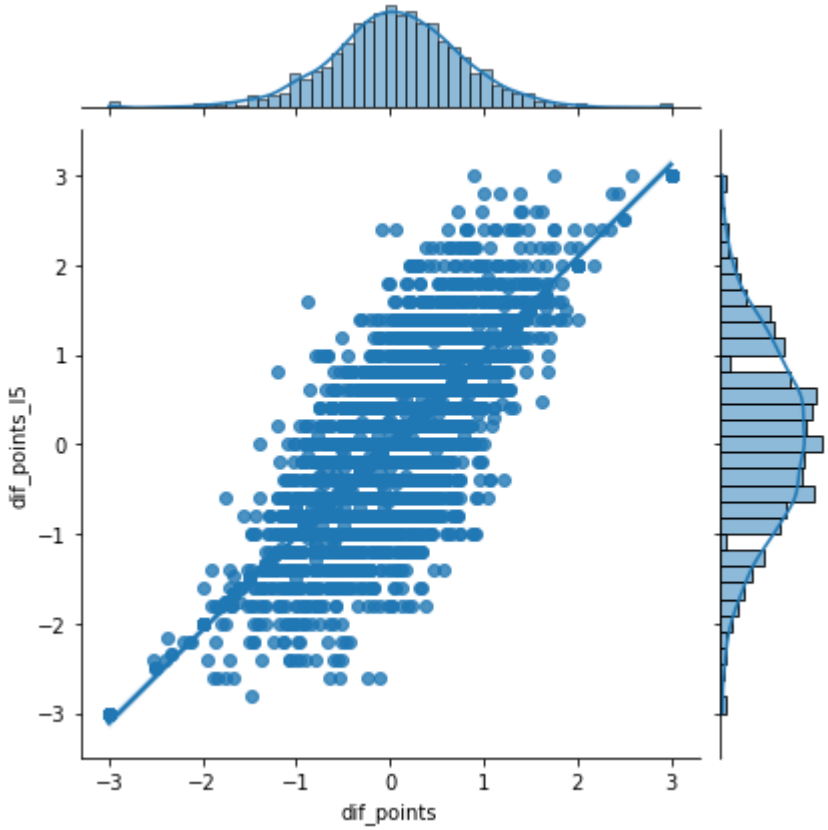


The difference in points, difference of points by opponent ranking, difference of opponents ranking, and goals per opponent ranking difference seem to separate the data well.

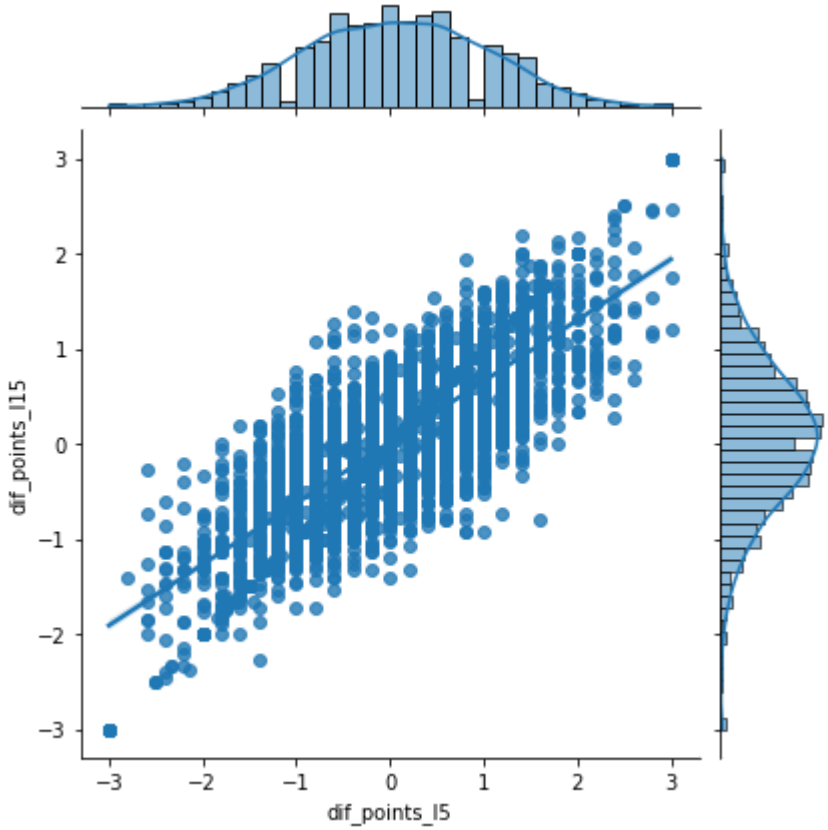
To ensure semi-duplicate distributions of features are not used, some will be compared.

Difference in mean points.

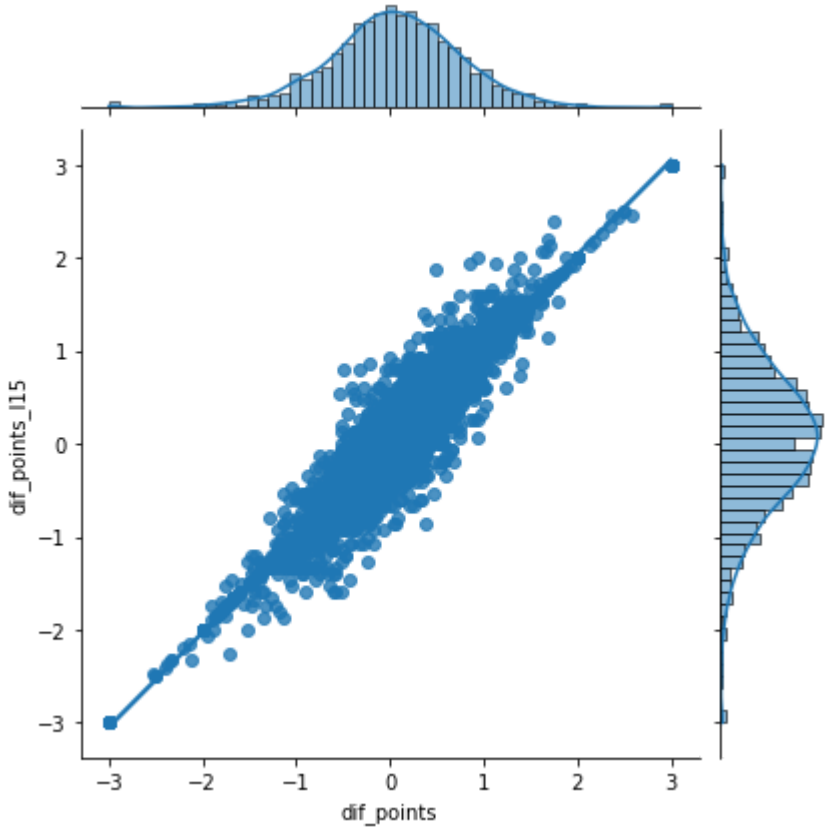
In [45]:
```
sns.jointplot(data = data_difs, x = 'dif_points', y = 'dif_points_l5', kind="reg")
plt.show()
```



In [46]:
```
sns.jointplot(data = data_difs, x = 'dif_points_l5', y = 'dif_points_l15', kind="reg")
plt.show()
```

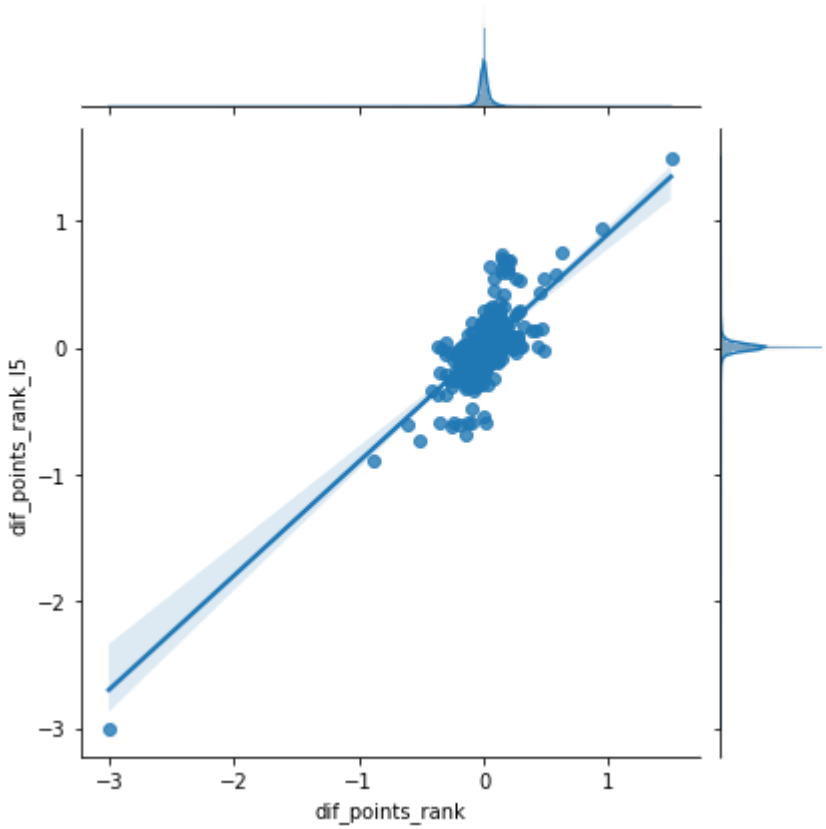


In [47]:
```
sns.jointplot(data = data_difs, x = 'dif_points', y = 'dif_points_l15', kind="reg")
plt.show()
```

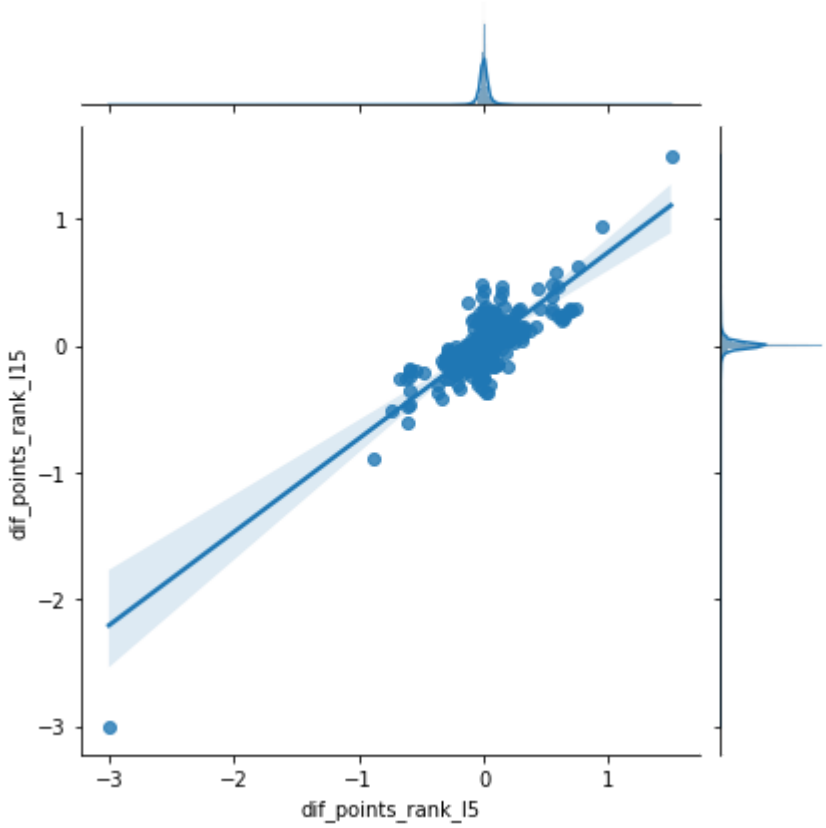


Difference in mean points by opponent's rank.

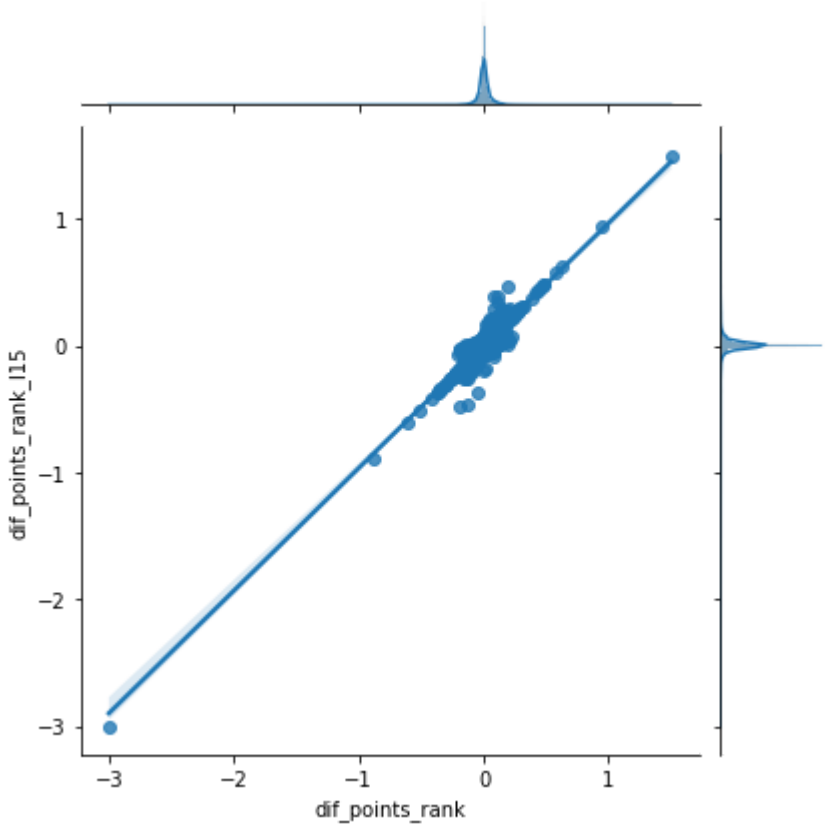
In [48]:
```
sns.jointplot(data = data_difs, x = 'dif_points_rank', y = 'dif_points_rank_l5', kind=
plt.show()
```



In [49]:
```
sns.jointplot(data = data_difs, x = 'dif_points_rank_l5', y = 'dif_points_rank_l15', k
plt.show()
```

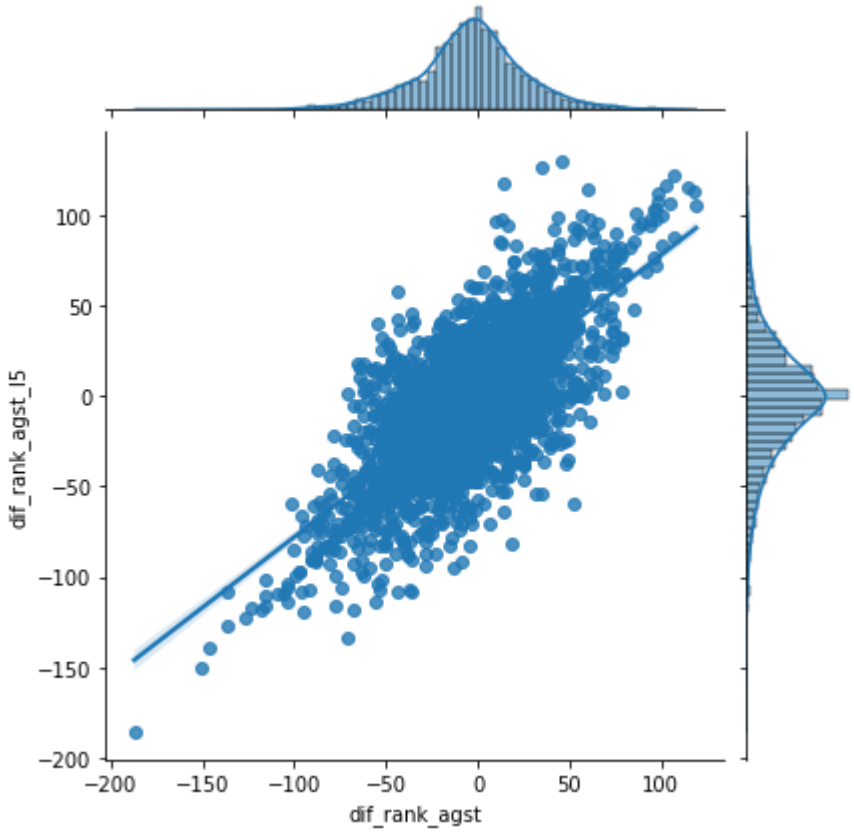


In [50]:
```
sns.jointplot(data = data_difs, x = 'dif_points_rank', y = 'dif_points_rank_l15', kind
plt.show()
```

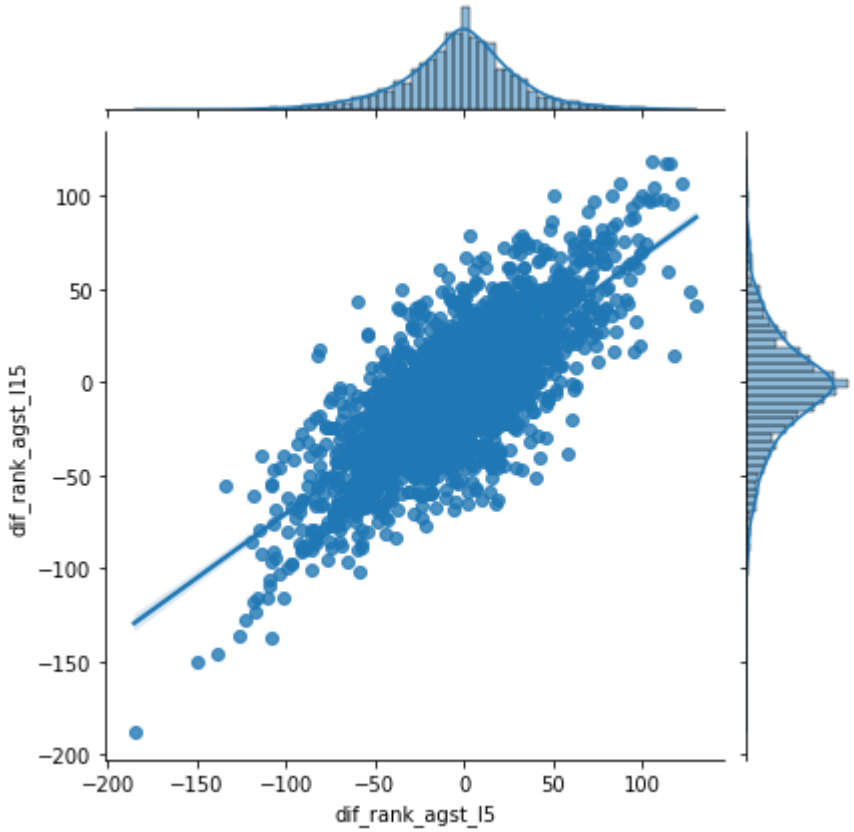


Difference in mean rank of opponents.

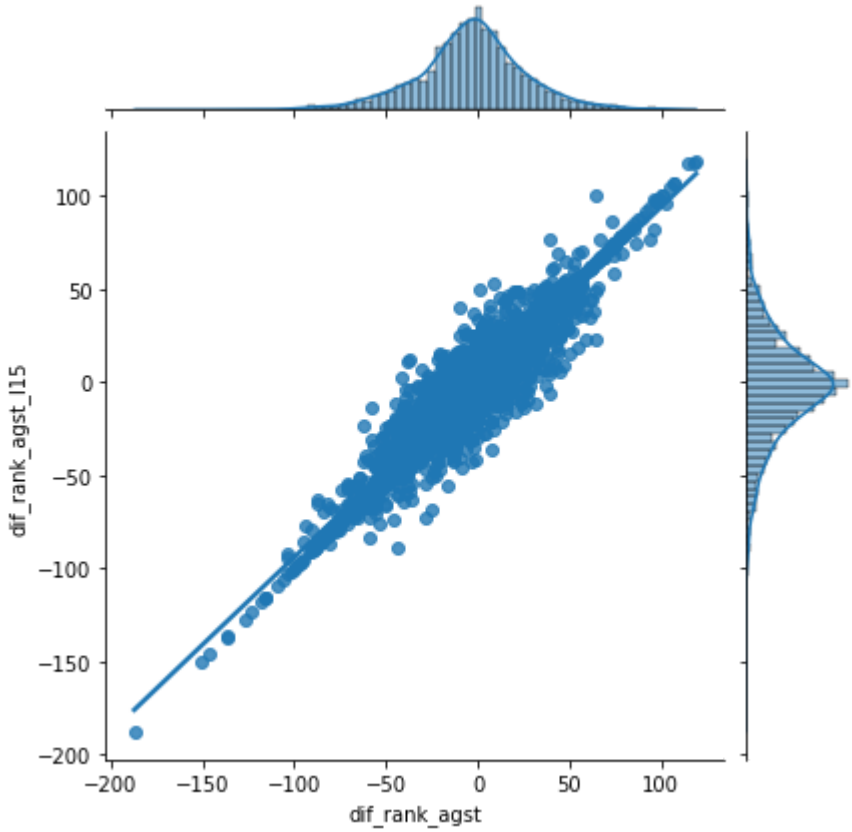
In [51]:
```
sns.jointplot(data = data_difs, x = 'dif_rank_agst', y = 'dif_rank_agst_l5', kind="reg
plt.show()
```



In [52]:
```
sns.jointplot(data = data_difs, x = 'dif_rank_agst_l5', y = 'dif_rank_agst_l15', kind=
plt.show()
```

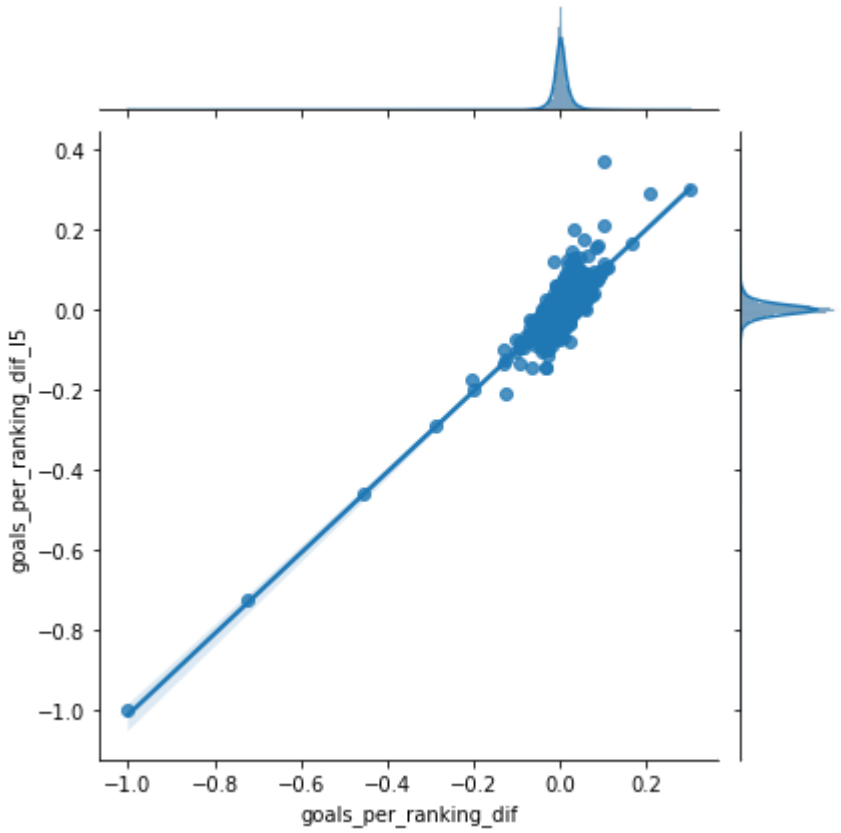


In [53]:
```
sns.jointplot(data = data_difs, x = 'dif_rank_agst', y = 'dif_rank_agst_l15', kind="re
plt.show()
```

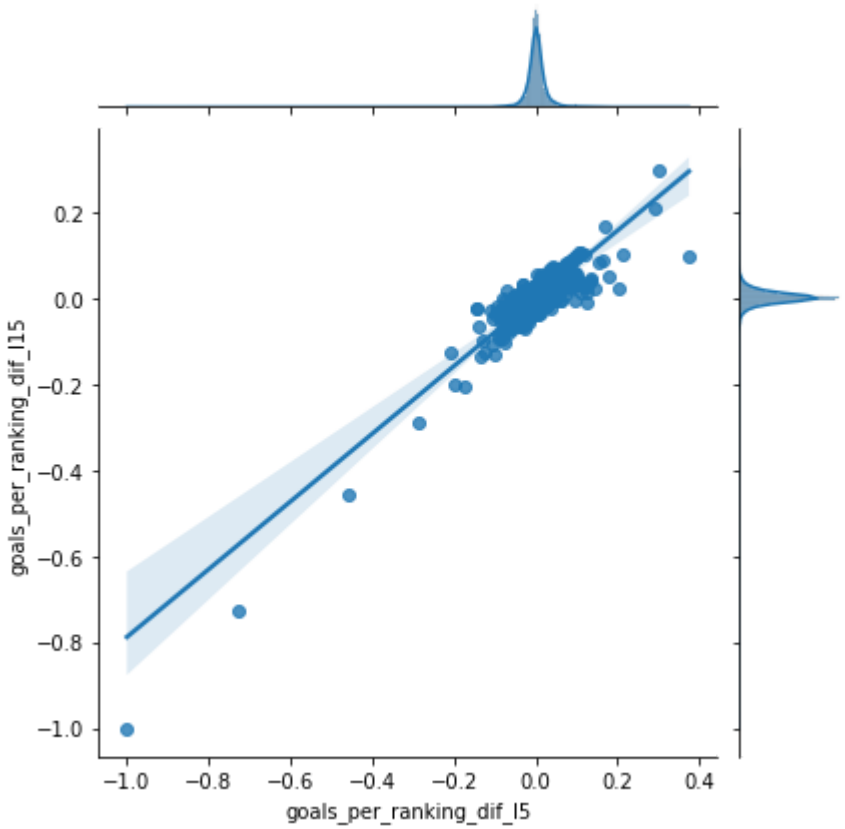


Difference in goals per opponent mean rank.

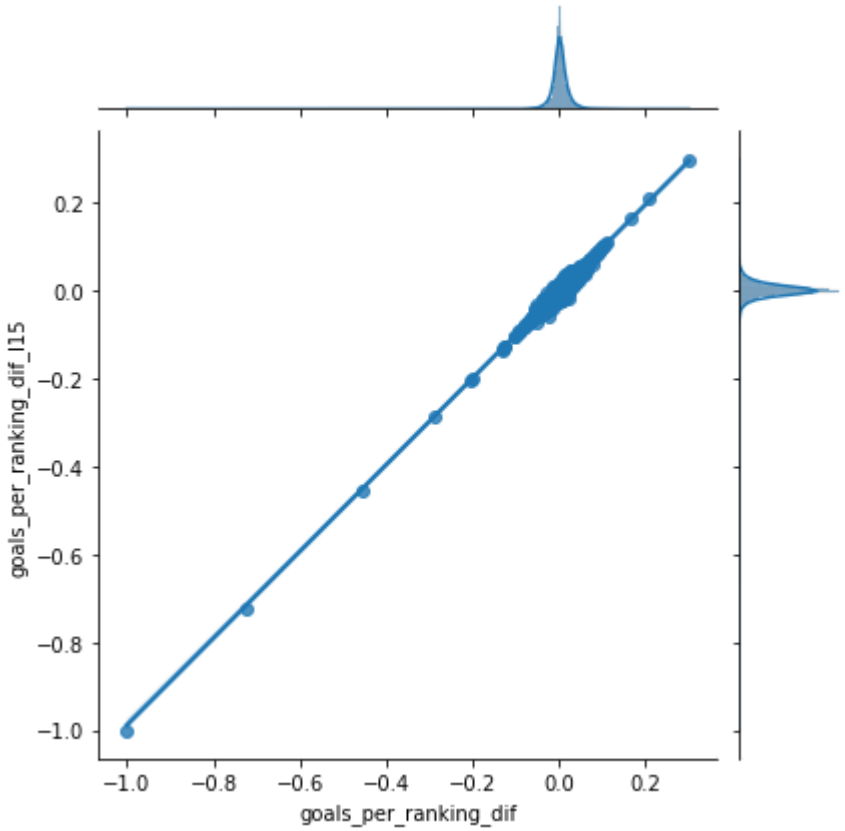
In [54]:
```
sns.jointplot(data = data_difs, x = 'goals_per_ranking_dif', y = 'goals_per_ranking_di
plt.show()
```



In [55]:
```
sns.jointplot(data = data_difs, x = 'goals_per_ranking_dif_l5', y = 'goals_per_ranking
plt.show()
```

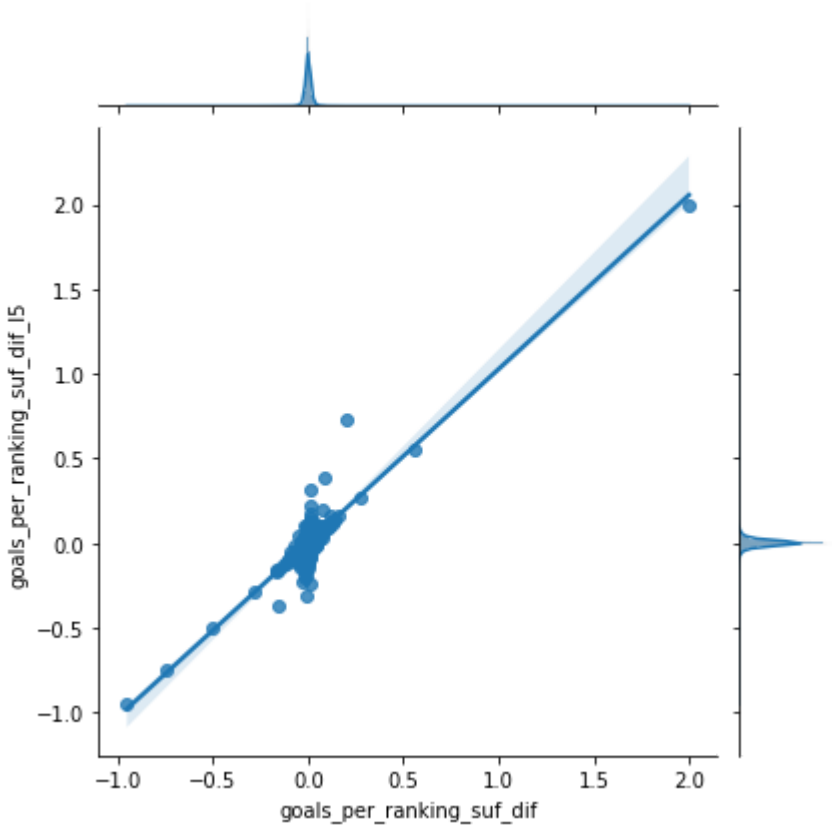


In [56]:
```
sns.jointplot(data = data_difs, x = 'goals_per_ranking_dif', y = 'goals_per_ranking_di
plt.show()
```

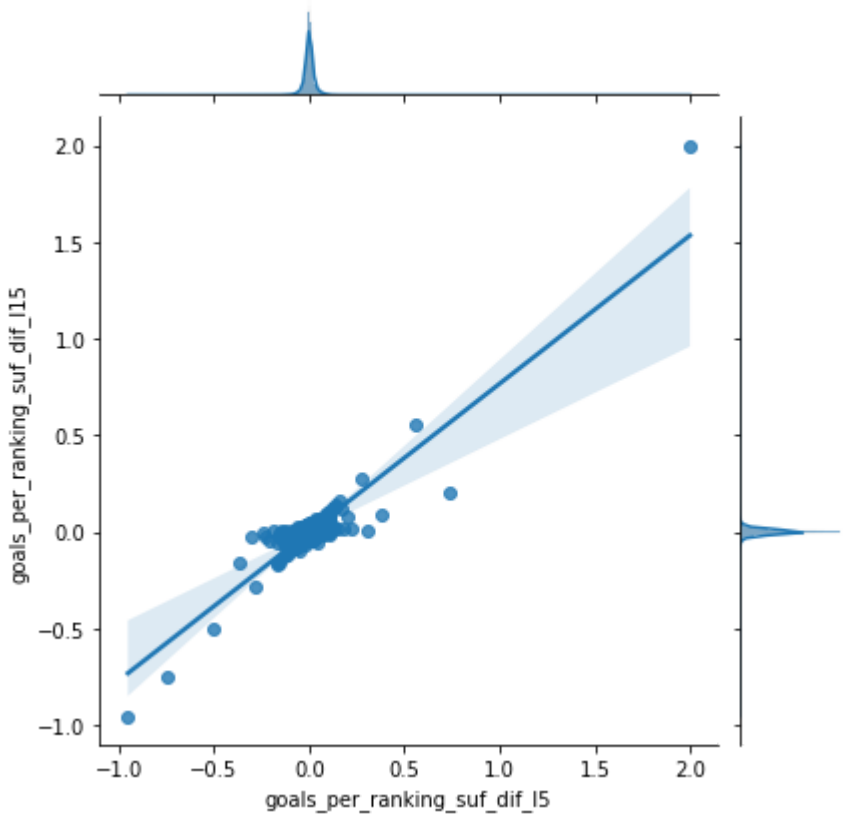


Difference in goals suffered per opponent mean rank.

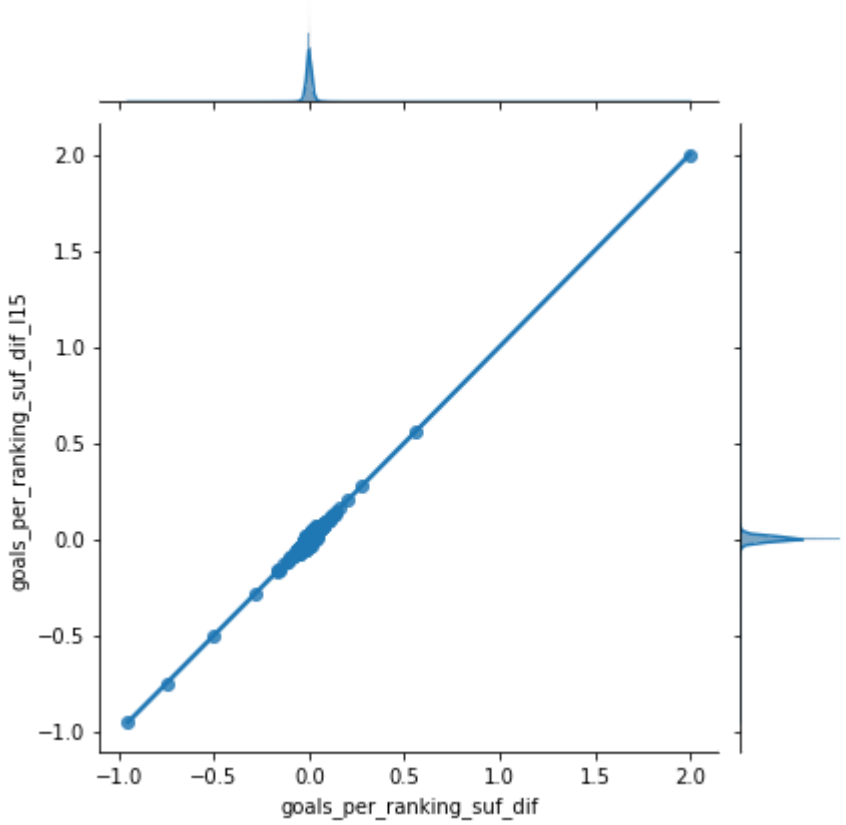
In [57]:
```
sns.jointplot(data = data_difs, x = 'goals_per_ranking_suf_dif', y = 'goals_per_rankir
plt.show()
```



In [58]:
```
sns.jointplot(data = data_difs, x = 'goals_per_ranking_suf_dif_l5', y = 'goals_per_rar
plt.show()
```



In [59]:
```
sns.jointplot(data = data_difs, x = 'goals_per_ranking_suf_dif', y = 'goals_per_rankir
plt.show()
```



The final features will now be:

- `rank_dif`
- `goals_dif`
- `goals_dif_l5`
- `goals_dif_l15`
- `goals_suf_dif`
- `goals_suf_dif_l5`
- `goals_suf_dif_l15`
- `dif_points`
- `dif_points_l5`
- `dif_points_rank`
- `dif_points_rank_l5`
- `goals_per_ranking_dif`
- `dif_rank_agst`
- `dif_rank_agst_l5`
- `is_friendly`

The following function will create the final dataframe for the model input based upon the needed columns and selected features.

In [60]:
```
def create_df(df):
    columns = ["home_team", "away_team", "target", "rank_dif", "home_goals_mean", "awa
               "home_rank_mean", "away_rank_mean", "home_rank_mean_l5", "away_rank_mea
               "home_game_points_mean", "home_game_points_mean_l5",
               "away_game_points_mean", "away_game_points_mean_l5",
               "home_rank_mean_l15", "away_rank_mean_l15",
               "home_goals_suf_mean", "away_goals_suf_mean", "home_goals_mean_l5", "aw
               "home_goals_mean_l15", "away_goals_mean_l15",
               "home_goals_suf_mean_l5", "away_goals_suf_mean_l5",
               "home_goals_suf_mean_l15", "away_goals_suf_mean_l15",
               "home_game_points_rank_mean", "home_game_points_rank_mean_l5", "home_ga
               "away_game_points_rank_mean", "away_game_points_rank_mean_l5", "away_ga
               "is_friendly_0", "is_friendly_1", "is_friendly_2"]
    base = df.loc[:, columns]
    base.loc[:, "goals_dif"] = base["home_goals_mean"] - base["away_goals_mean"]
    base.loc[:, "goals_dif_l5"] = base["home_goals_mean_l5"] - base["away_goals_mean_l
    base.loc[:, "goals_dif_l15"] = base["home_goals_mean_l15"] - base["away_goals_mean
    base.loc[:, "goals_suf_dif"] = base["home_goals_suf_mean"] - base["away_goals_suf_
    base.loc[:, "goals_suf_dif_l5"] = base["home_goals_suf_mean_l5"] - base["away_goal
    base.loc[:, "goals_suf_dif_l15"] = base["home_goals_suf_mean_l15"] - base["away_go
    base.loc[:, "dif_points"] = base["home_game_points_mean"] - base["away_game_points
    base.loc[:, "dif_points_l5"] = base["home_game_points_mean_l5"] - base["away_game_
    base.loc[:, "dif_points_rank"] = base["home_game_points_rank_mean"] - base["away_g
    base.loc[:, "dif_points_rank_l5"] = base["home_game_points_rank_mean_l5"] - base["
    base.loc[:, "goals_per_ranking_dif"] = (base["home_goals_mean"] / base["home_rank_
    base.loc[:, "dif_rank_agst"] = base["home_rank_mean"] - base["away_rank_mean"]
    base.loc[:, "dif_rank_agst_l5"] = base["home_rank_mean_l5"] - base["away_rank_mean

    model_df = base[["home_team", "away_team", "target", "rank_dif", "goals_dif", "goa
                     "goals_suf_dif", "goals_suf_dif_l5", "goals_suf_dif_l15", "dif_po
                     "dif_points_rank", "dif_points_rank_l5", "goals_per_ranking_dif",
                     "dif_rank_agst_l5",  "is_friendly_0", "is_friendly_1", "is_friend
    return model_df
```

The final dataframe for the model will now be created.

In [61]:
```
model_df = create_df(df)
model_df
```

Out[61]:

	home_team	away_team	target	rank_dif	goals_dif	goals_dif_l5	goals_dif_l15	goals_suf_dif
16	Russia	Egypt	0	25.0	5.000000	5.0	5.000000	-1.000000
17	Portugal	Morocco	0	-37.0	3.000000	3.0	3.000000	2.000000
18	Uruguay	Saudi Arabia	0	-53.0	1.000000	1.0	1.000000	-5.000000
19	Iran	Spain	1	27.0	-2.000000	-2.0	-2.000000	-3.000000
20	Denmark	Australia	1	-24.0	0.000000	0.0	0.000000	-2.000000
...	...	...	...	...	...	...	...	...
3617	Albania	Iceland	1	3.0	0.022089	-0.8	-0.266667	-0.578463
3618	Norway	Serbia	1	11.0	0.032738	-0.8	-0.066667	-0.244048
3619	Sweden	Slovenia	1	-45.0	0.020764	0.2	-0.333333	0.107143
3620	Kosovo	Cyprus	0	-2.0	0.667341	0.6	0.600000	-0.463094
3621	Greece	Northern Ireland	0	-9.0	0.067653	0.2	0.066667	-0.369979

3487 rows × 20 columns

Classifier Models: Random Forest & Gradient Boosting

The input data and targets for the model will be extracted.

In [62]:
```
X = model_df.iloc[:, 3:]
labels = np.squeeze(model_df[["target"]].to_numpy())
```

The type of competition will be the stratifying parameter.

In [63]:
```
strat = np.empty([len(labels)])
strat[X['is_friendly_0']==1]=0
strat[X['is_friendly_1']==1]=1
strat[X['is_friendly_2']==1]=2
```

The model will be split into a 80%-to-20% train-test-split.

In [64]:
```
X_train, X_test, t_train, t_test = train_test_split(X,
```

```
                                                    labels,
                                                    test_size= 0.2,
                                                    random_state=1,
                                                    stratify=strat)
```

The data will now be standardized for numeric columns.

In [65]:
```
scale_pipe = ColumnTransformer([('scale', StandardScaler(), list(range(0,14)))],
                               remainder='passthrough')
X_train_scaled = scale_pipe.fit_transform(X_train.values)
X_test_scaled = scale_pipe.transform(X_test.values)
X_train = X_train_scaled
X_test = X_test_scaled
```

Gradient Boosting

In [66]:
```
%%time
gb = GradientBoostingClassifier(random_state=7)

params = {"learning_rate": [0.001, 0.01, 0.1, 0.5],
          "min_samples_split": [3, 5, 10],
          "min_samples_leaf": [3, 5, 7],
          "max_depth":[3,5,10],
          "max_features":["sqrt"],
          "n_estimators":[100, 200]
         }

gb_cv = GridSearchCV(gb,
                     params,
                     cv=3,
                     n_jobs=-1)

# gb_cv.fit(X_train.values, np.ravel(t_train))
gb_cv.fit(X_train, t_train)
gb = gb_cv.best_estimator_

# 95% confidence interval
scores = cross_val_score(gb,
                         X_train,
                         t_train,
                         scoring='accuracy',
                         cv=5)
print(stats.t.interval(0.95,
      len(scores)-1,
      loc = scores.mean(),
      scale=scores.std(ddof=1)/np.sqrt(len(scores))))
gb
```

```
(0.6682883037807136, 0.7336704743638524)
Wall time: 1min 40s
```

Out[66]:
```
GradientBoostingClassifier(learning_rate=0.01, max_features='sqrt',
                           min_samples_leaf=7, min_samples_split=3,
                           random_state=7)
```

Random Forest

In [67]:
```
%%time
```

```
rf = RandomForestClassifier(random_state=7)

params_rf = {"max_depth": [5, 10, 20],
             "min_samples_split": [2, 3, 4, 5, 10],
             "max_leaf_nodes": [150, 175],
             "min_samples_leaf": [5, 10, 15],
             "n_estimators": [150, 250, 500],
             "max_features": ["sqrt"],
            }

rf_cv = GridSearchCV(rf,
                     params_rf,
                     cv=3,
                     n_jobs=-1)

# rf_cv.fit(X_train.values, np.ravel(t_train))
rf_cv.fit(X_train, np.ravel(t_train))
rf = rf_cv.best_estimator_

# 95% confidence interval
scores = cross_val_score(rf,
                         X_train,
                         t_train,
                         scoring='accuracy',
                         cv=5)
print(stats.t.interval(0.95,
      len(scores)-1,
      loc = scores.mean(),
      scale=scores.std(ddof=1)/np.sqrt(len(scores))))
rf
```

```
(0.6677231083331896, 0.7220428550008515)
Wall time: 3min 18s
```

Out[67]:
```
RandomForestClassifier(max_depth=5, max_features='sqrt', max_leaf_nodes=150,
                       min_samples_leaf=10, n_estimators=150, random_state=7)
```

Support Vector Machine

In [68]:
```
%%time
svm = SVC(random_state=7)

params_svm = {"C": np.logspace(-2,2,5),
              "kernel": ['rbf'],
              "gamma": list(np.logspace(-2,2,5))+['scale','auto'],
              "probability": [True]
             }

svm_cv = GridSearchCV(svm,
                      params_svm,
                      cv=3,
                      n_jobs=-1)

# svm_cv.fit(X_train.values, np.ravel(t_train))
svm_cv.fit(X_train, np.ravel(t_train))
svm = svm_cv.best_estimator_

# 95% confidence interval
scores = cross_val_score(svm,
                         X_train,
```

```
                         t_train,
                         scoring='accuracy',
                         cv=5)
print(stats.t.interval(0.95,
      len(scores)-1,
      loc = scores.mean(),
      scale=scores.std(ddof=1)/np.sqrt(len(scores))))
svm
```

```
(0.6661863143560298, 0.7300364097870049)
Wall time: 52.5 s
```

Out[68]:
```
SVC(gamma=0.01, probability=True, random_state=7)
```

Logistic Regression

In [69]:
```
%%time
lr = LogisticRegression(random_state=7)

params_lr = {"C": np.logspace(-2,2,5),
             "penalty": ['l2'],
             "solver": ['lbfgs', 'newton-cg', 'liblinear', 'sag', 'saga'],
             "max_iter": [2000]
            }

lr_cv = GridSearchCV(lr,
                     params_lr,
                     cv=3,
                     n_jobs=-1)

# lr_cv.fit(X_train.values, np.ravel(t_train))
lr_cv.fit(X_train, np.ravel(t_train))
lr = lr_cv.best_estimator_

# 95% confidence interval
scores = cross_val_score(lr,
                         X_train,
                         t_train,
                         scoring='accuracy',
                         cv=5)
print(stats.t.interval(0.95,
      len(scores)-1,
      loc = scores.mean(),
      scale=scores.std(ddof=1)/np.sqrt(len(scores))))
lr
```

```
(0.6633649326334179, 0.7400301112203043)
Wall time: 1.37 s
```

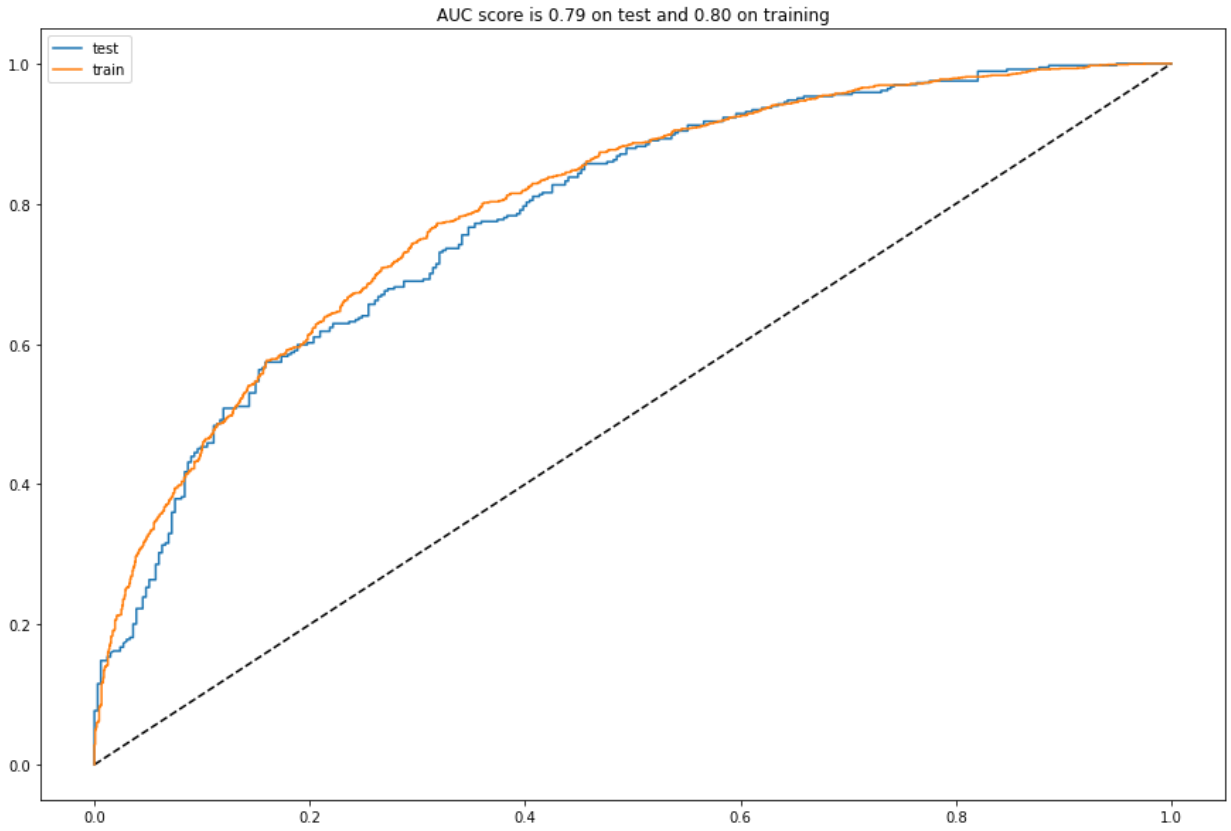
Out[69]:
```
LogisticRegression(C=0.01, max_iter=2000, random_state=7, solver='saga')
```

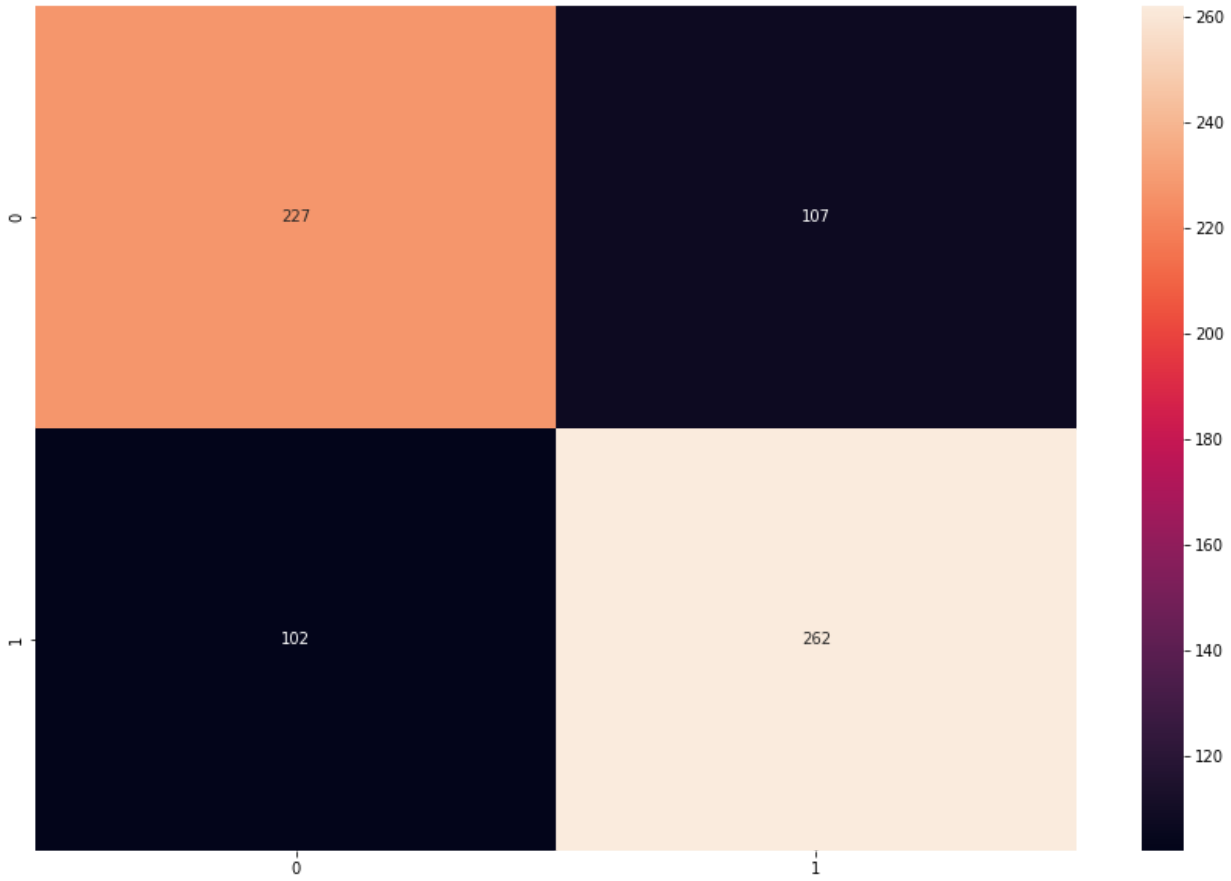
Analysis of Models

In [70]:
```
def analyze(model):
#     fpr, tpr, _ = roc_curve(t_test, model.predict_proba(X_test.values)[:,1]) #test A
    fpr, tpr, _ = roc_curve(t_test, model.predict_proba(X_test)[:,1]) #test AUC
    plt.figure(figsize=(15,10))
    plt.plot([0, 1], [0, 1], 'k--')
```

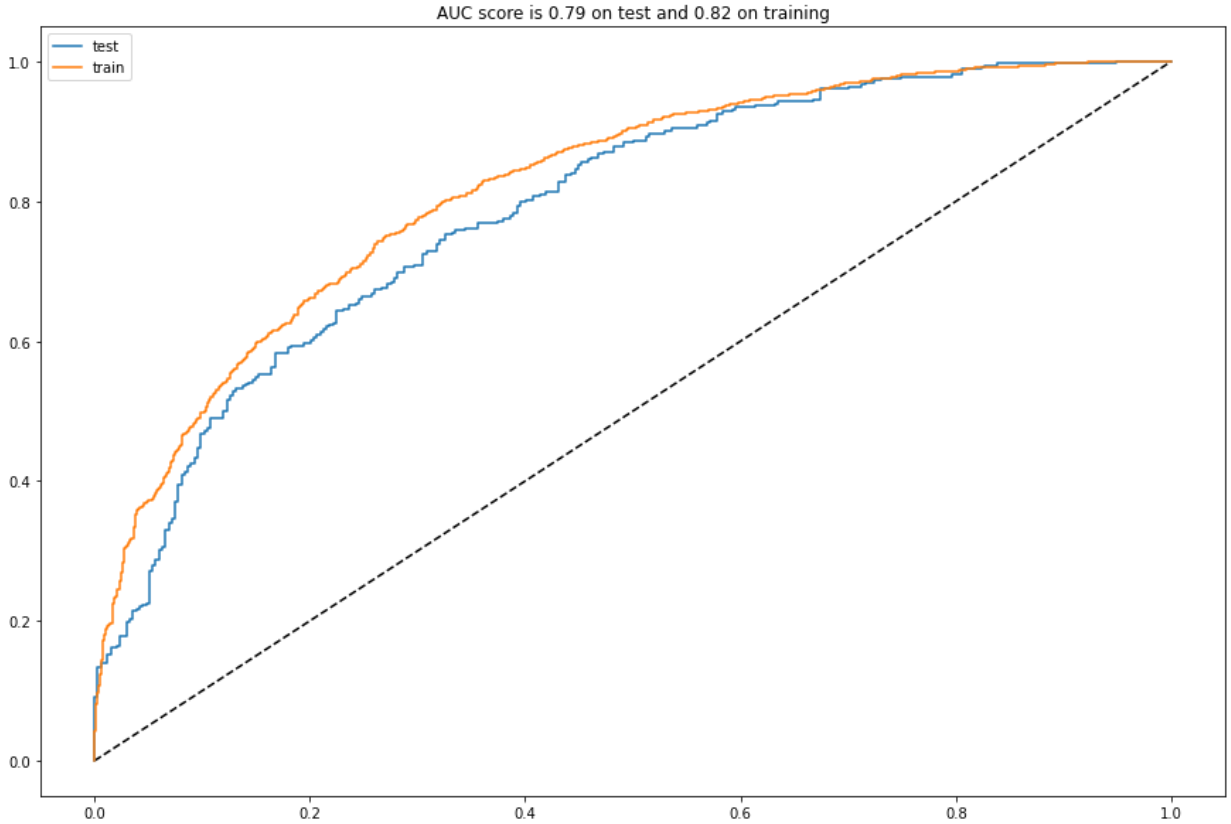
```
    plt.plot(fpr, tpr, label="test")

#     fpr_train, tpr_train, _ = roc_curve(t_train, model.predict_proba(X_train.values)
    fpr_train, tpr_train, _ = roc_curve(t_train, model.predict_proba(X_train)[:,1]) #t
    plt.plot(fpr_train, tpr_train, label="train")
#     auc_test = roc_auc_score(t_test, model.predict_proba(X_test.values)[:,1])
    auc_test = roc_auc_score(t_test, model.predict_proba(X_test)[:,1])
#     auc_train = roc_auc_score(t_train, model.predict_proba(X_train.values)[:,1])
    auc_train = roc_auc_score(t_train, model.predict_proba(X_train)[:,1])
    plt.legend()
    plt.title('AUC score is %.2f on test and %.2f on training'%(auc_test, auc_train))
    plt.show()

    plt.figure(figsize=(15, 10))
#     cm = confusion_matrix(t_test, model.predict(X_test.values))
    cm = confusion_matrix(t_test, model.predict(X_test))
    sns.heatmap(cm, annot=True, fmt="d")
```

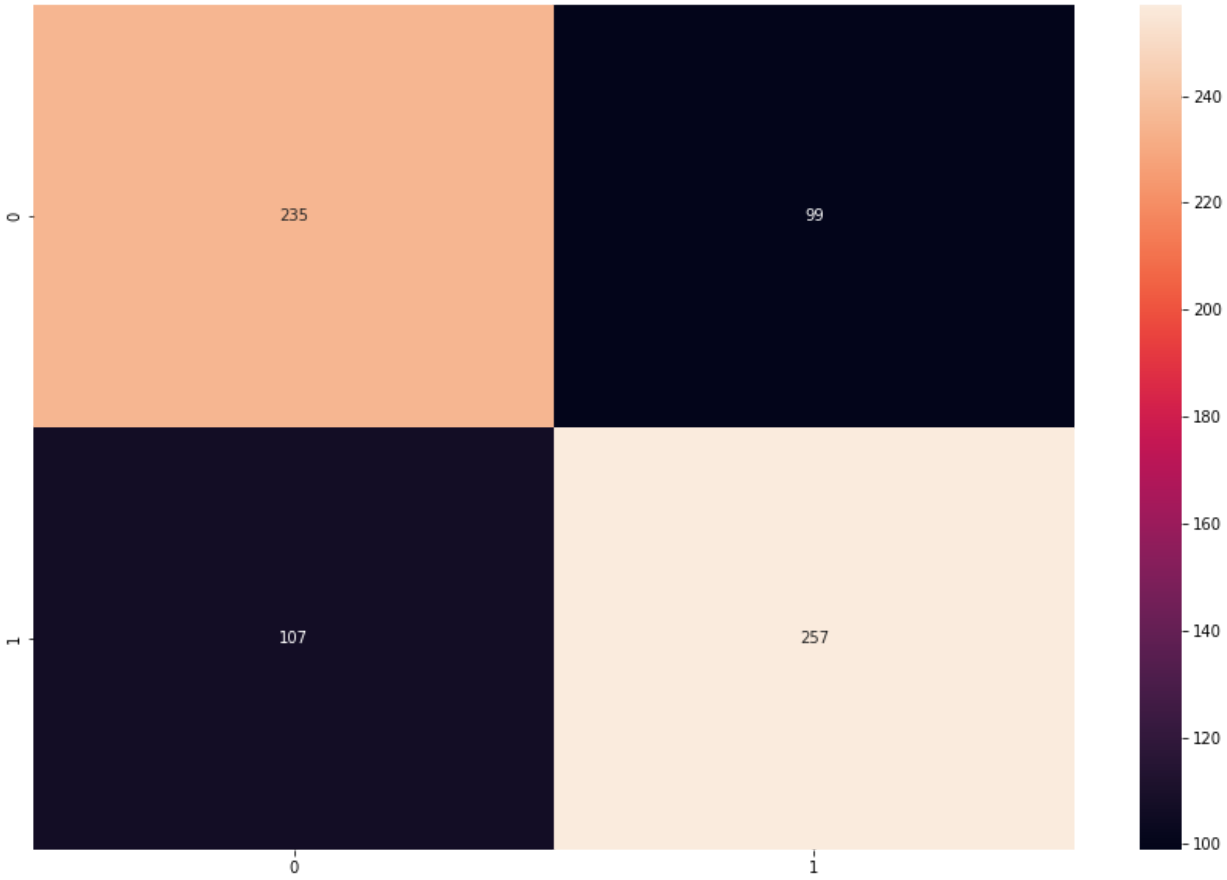
In [71]:
```
analyze(gb)
```



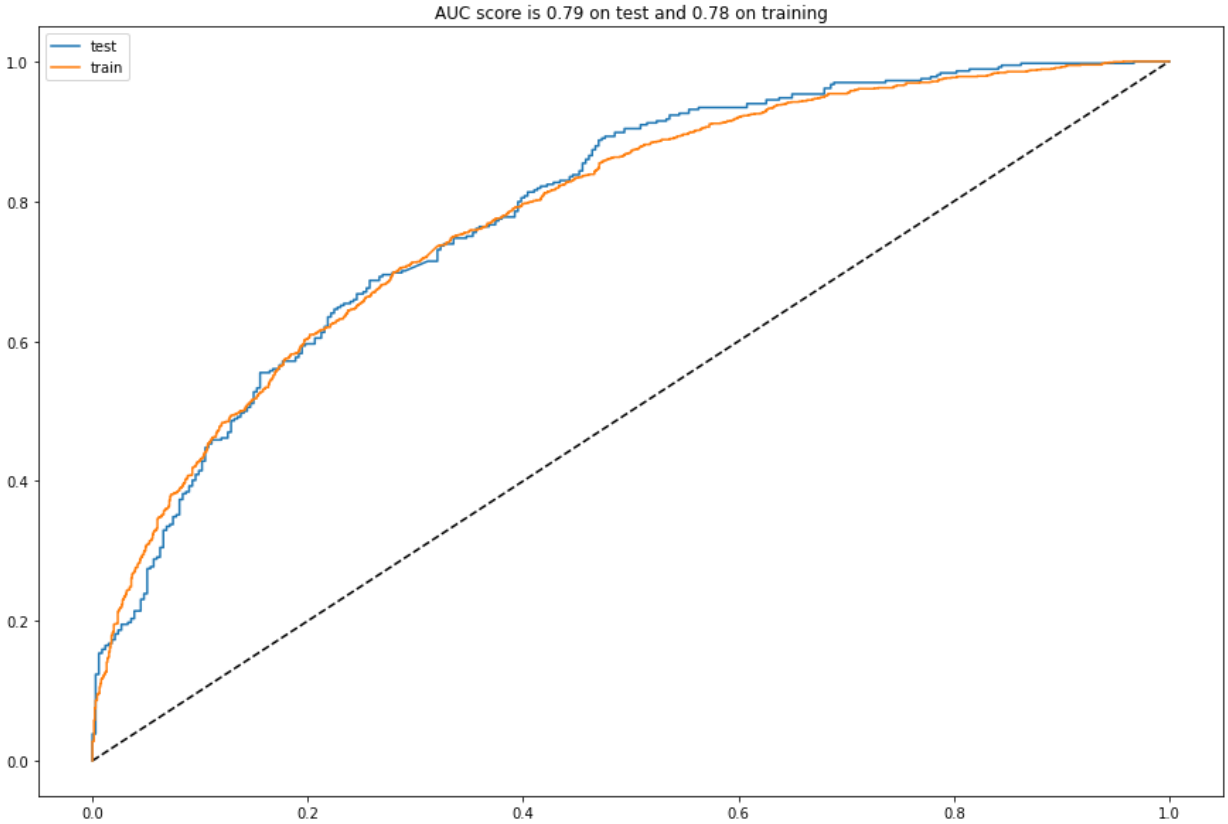


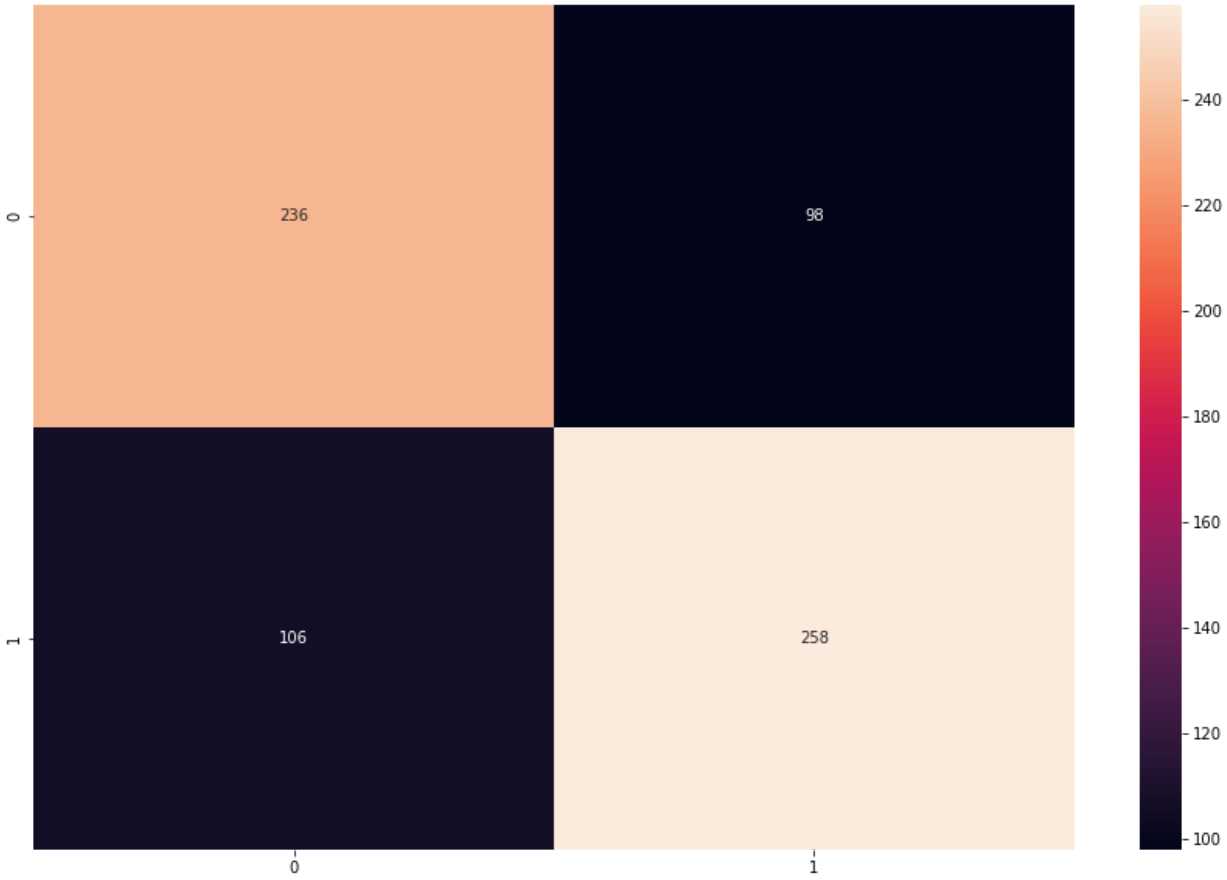
In [72]:
```
analyze(rf)
```



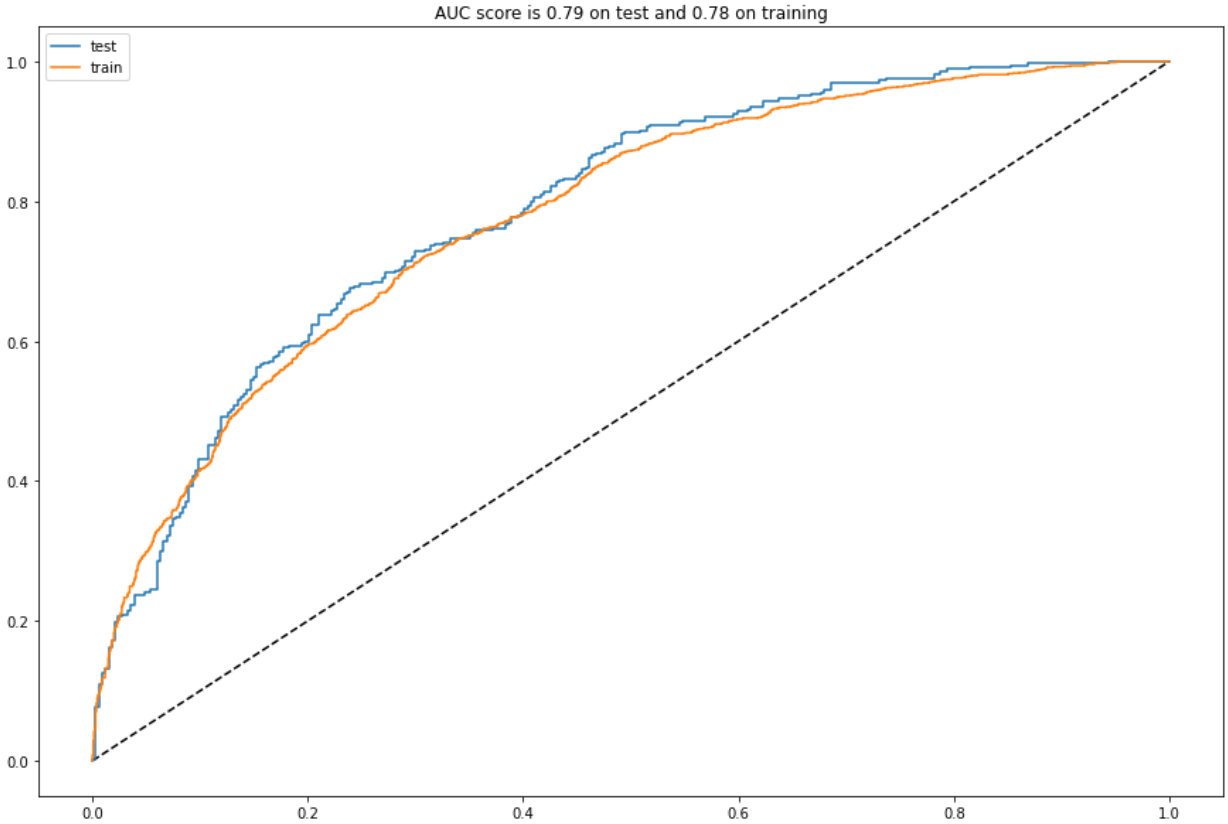


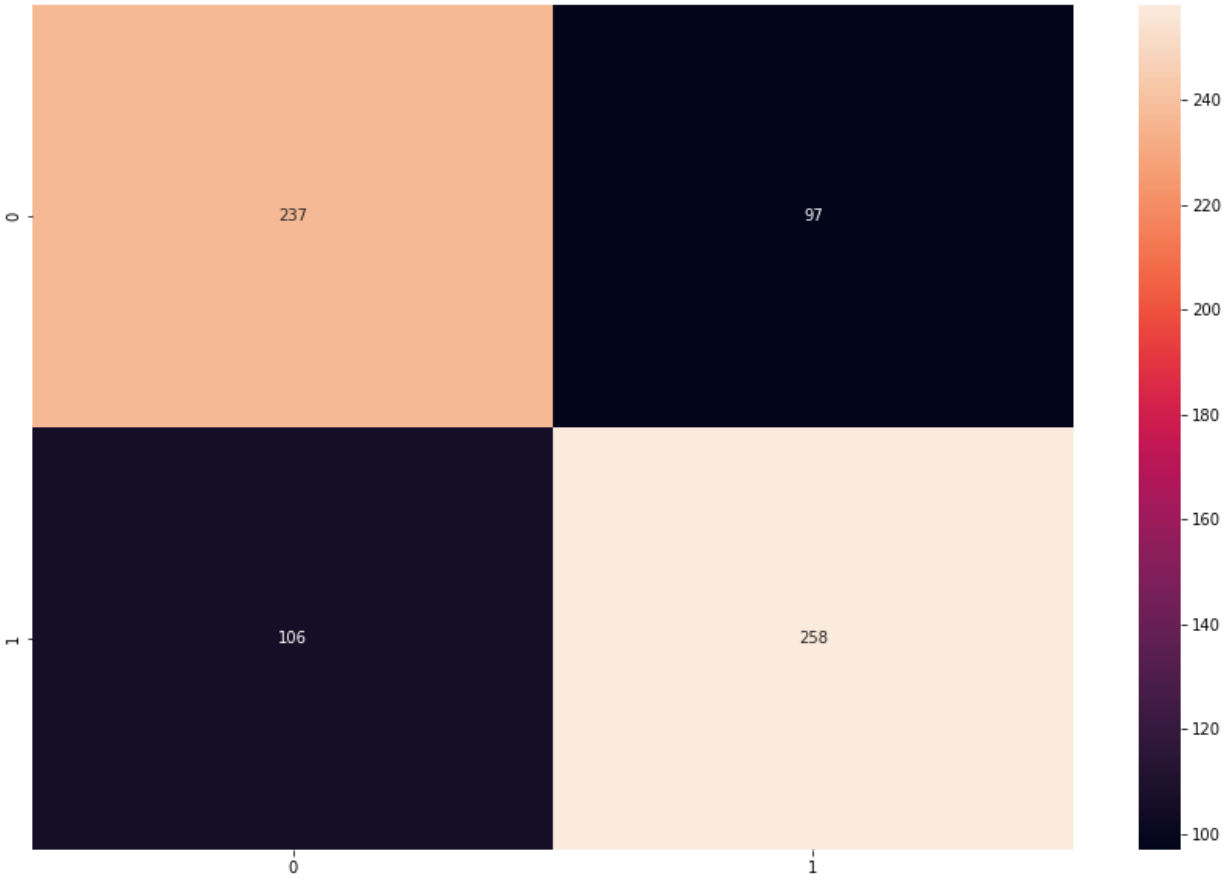
In [73]:
```
analyze(svm)
```





In [74]:
```
analyze(lr)
```





World Cup 2022

The final model will be trained here on all the data to predict the 2022 World Cup.

In [75]:
```
gb = GradientBoostingClassifier(learning_rate=0.01,
                                max_features='sqrt',
                                min_samples_leaf=7,
                                min_samples_split=3,
                                random_state=7)
gb.fit(scale_pipe.fit_transform(X.values), labels)
```

Out[75]:
```
GradientBoostingClassifier(learning_rate=0.01, max_features='sqrt',
                           min_samples_leaf=7, min_samples_split=3,
                           random_state=7)
```

In [76]:
```
rf = RandomForestClassifier(max_depth=5,
                            max_features='sqrt',
                            max_leaf_nodes=150,
                            min_samples_leaf=10,
                            n_estimators=150,
                            random_state=7)
rf.fit(scale_pipe.fit_transform(X.values), labels)
```

Out[76]:
```
RandomForestClassifier(max_depth=5, max_features='sqrt', max_leaf_nodes=150,
                       min_samples_leaf=10, n_estimators=150, random_state=7)
```

In [77]:
```
svm = SVC(gamma=0.01,
```

```
          probability=True,
          random_state=7)
svm.fit(scale_pipe.fit_transform(X.values), labels)
```

Out[77]:
```
SVC(gamma=0.01, probability=True, random_state=7)
```

In [78]:
```
lr = LogisticRegression(C=0.01,
                        max_iter=2000,
                        random_state=7,
                        solver='saga')
lr.fit(scale_pipe.fit_transform(X.values), labels)
```

Out[78]:
```
LogisticRegression(C=0.01, max_iter=2000, random_state=7, solver='saga')
```

CHOOSE THE FINAL MODEL HERE!

In [79]:
```
final_model = rf
```

The World Cup 2022 groups will be created.

In [80]:
```
#TABLE -> TEAM, POINTS, WIN PROBABILITIES (TIEBREAKER)
table = {'A': [['Qatar', 0, []],
               ['Ecuador', 0, []],
               ['Senegal', 0, []],
               ['Netherlands', 0, []]],
         'B': [['England', 0, []],
               ['Iran', 0, []],
               ['United States', 0, []],
               ['Wales', 0, []]],
         'C': [['Argentina', 0, []],
               ['Saudi Arabia', 0, []],
               ['Mexico', 0, []],
               ['Poland', 0, []]],
         'D': [['France', 0, []],
               ['Australia', 0, []],
               ['Denmark', 0, []],
               ['Tunisia', 0, []]],
         'E': [['Spain', 0, []],
               ['Costa Rica', 0, []],
               ['Germany', 0, []],
               ['Japan', 0, []]],
         'F': [['Belgium', 0, []],
               ['Canada', 0, []],
               ['Morocco', 0, []],
               ['Croatia', 0, []]],
         'G': [['Brazil', 0, []],
               ['Serbia', 0, []],
               ['Switzerland', 0, []],
               ['Cameroon', 0, []]],
         'H': [['Portugal', 0, []],
               ['Ghana', 0, []],
               ['Uruguay', 0, []],
               ['South Korea', 0, []]]}
```

A list of group stage matches will be created.

In [81]:
```
dfs = pd.read_html(r"https://en.wikipedia.org/wiki/2022_FIFA_World_Cup#Teams")
```

```
matches = []
groups = ["A", "B", "C", "D", "E", "F", "G", "H"]
group_count = 0

for i in range(13, 68, 1):
    if len(dfs[i].columns) == 3:
        team_1 = dfs[i].columns.values[0]
        team_2 = dfs[i].columns.values[-1]

        matches.append((groups[group_count], team_1, team_2))
    else:
        group_count+=1
```

In [82]:
```
matches
```

Out[82]:
```
[('A', 'Qatar', 'Ecuador'),
 ('A', 'Senegal', 'Netherlands'),
 ('A', 'Qatar', 'Senegal'),
 ('A', 'Netherlands', 'Ecuador'),
 ('A', 'Ecuador', 'Senegal'),
 ('A', 'Netherlands', 'Qatar'),
 ('B', 'England', 'Iran'),
 ('B', 'United States', 'Wales'),
 ('B', 'Wales', 'Iran'),
 ('B', 'England', 'United States'),
 ('B', 'Wales', 'England'),
 ('B', 'Iran', 'United States'),
 ('C', 'Argentina', 'Saudi Arabia'),
 ('C', 'Mexico', 'Poland'),
 ('C', 'Poland', 'Saudi Arabia'),
 ('C', 'Argentina', 'Mexico'),
 ('C', 'Poland', 'Argentina'),
 ('C', 'Saudi Arabia', 'Mexico'),
 ('D', 'Denmark', 'Tunisia'),
 ('D', 'France', 'Australia'),
 ('D', 'Tunisia', 'Australia'),
 ('D', 'France', 'Denmark'),
 ('D', 'Australia', 'Denmark'),
 ('D', 'Tunisia', 'France'),
 ('E', 'Germany', 'Japan'),
 ('E', 'Spain', 'Costa Rica'),
 ('E', 'Japan', 'Costa Rica'),
 ('E', 'Spain', 'Germany'),
 ('E', 'Japan', 'Spain'),
 ('E', 'Costa Rica', 'Germany'),
 ('F', 'Morocco', 'Croatia'),
 ('F', 'Belgium', 'Canada'),
 ('F', 'Belgium', 'Morocco'),
 ('F', 'Croatia', 'Canada'),
 ('F', 'Croatia', 'Belgium'),
 ('F', 'Canada', 'Morocco'),
 ('G', 'Switzerland', 'Cameroon'),
 ('G', 'Brazil', 'Serbia'),
 ('G', 'Cameroon', 'Serbia'),
 ('G', 'Brazil', 'Switzerland'),
 ('G', 'Serbia', 'Switzerland'),
 ('G', 'Cameroon', 'Brazil'),
 ('H', 'Uruguay', 'South Korea'),
 ('H', 'Portugal', 'Ghana'),
 ('H', 'South Korea', 'Ghana'),
 ('H', 'Portugal', 'Uruguay'),
 ('H', 'Ghana', 'Uruguay'),
 ('H', 'South Korea', 'Portugal')]
```

The stats for each team to predict how they will do against their opponent will have to be generated.

In [83]:
```
team_stats_raw = team_stats.copy()
```

In [84]:
```
def find_stats(team_1):
    past_games = team_stats_raw[(team_stats_raw["team"] == team_1)].sort_values("date'
    last5 = team_stats_raw[(team_stats_raw["team"] == team_1)].sort_values("date").tai
    last15 = team_stats_raw[(team_stats_raw["team"] == team_1)].sort_values("date").ta
```

```
    team_1_rank = past_games["rank"].values[-1]
    team_1_goals = past_games.score.mean()
    team_1_goals_l5 = last5.score.mean()
    team_1_goals_l15 = last15.score.mean()
    team_1_goals_suf = past_games.suf_score.mean()
    team_1_goals_suf_l5 = last5.suf_score.mean()
    team_1_goals_suf_l15 = last15.suf_score.mean()
    team_1_rank_suf = past_games.rank_suf.mean()
    team_1_rank_suf_l5 = last5.rank_suf.mean()
    team_1_rank_suf_l15 = last15.rank_suf.mean()
    team_1_gp_rank = past_games.points_by_rank.mean()
    team_1_gp_rank_l5 = last5.points_by_rank.mean()
    team_1_gp_rank_l15 = last15.points_by_rank.mean()
    team_1_gp = past_games.team_points.mean()
    team_1_gp_l5 = last5.team_points.mean()
    team_1_gp_l15 = last15.team_points.mean()

    return [team_1_rank, team_1_goals, team_1_goals_l5, team_1_goals_l15,
            team_1_goals_suf, team_1_goals_suf_l5, team_1_goals_suf_l15,
            team_1_rank_suf, team_1_rank_suf_l5, team_1_rank_suf_l15,
            team_1_gp_rank, team_1_gp_rank_l5, team_1_gp_rank_l15,
            team_1_gp, team_1_gp_l5, team_1_gp_l15]
```

In [85]:
```
def find_features(team_1, team_2):
    rank_dif = team_1[0] - team_2[0]
    goals_dif = team_1[1] - team_2[1]
    goals_dif_l5 = team_1[2] - team_2[2]
    goals_dif_l15 = team_1[3] - team_2[3]
    goals_suf_dif = team_1[4] - team_2[4]
    goals_suf_dif_l5 = team_1[5] - team_2[5]
    goals_suf_dif_l15 = team_1[6] - team_2[6]
    dif_points = team_1[13] - team_2[13]
    dif_points_l5 = team_1[14] - team_2[14]
    dif_points_rank = team_1[10] - team_2[10]
    dif_points_rank_l5 = team_1[11] - team_2[11]
    goals_per_ranking_dif = (team_1[1]/team_1[7]) - (team_2[1]/team_2[7])
    dif_rank_agst = team_1[7] - team_2[7]
    dif_rank_agst_l5 = team_1[8] - team_2[8]

    return [rank_dif, goals_dif, goals_dif_l5, goals_dif_l15,
            goals_suf_dif, goals_suf_dif_l5, goals_suf_dif_l15,
            dif_points, dif_points_l5,
            dif_points_rank, dif_points_rank_l5,
            goals_per_ranking_dif,
            dif_rank_agst, dif_rank_agst_l5,
            0, 0, 1]
```

Group Stage

The model will simulate whether team 1 wins or does not win.\ The World Cup does not have home and away teams. \ Therefore, the group stage games will simulate the probability of the home team winning twice. One for each team in a match being considered 'home'. \ A draw will be concluded if the probabilistic results conflict when switching team positions.

In [86]:
```
advanced_group = []
last_group = ""
```

```
for k in table.keys():
    for t in table[k]:
        t[1] = 0
        t[2] = []

for teams in matches:
    draw = False
    team_1 = find_stats(teams[1])
    team_2 = find_stats(teams[2])

    features_g1 = find_features(team_1, team_2)
    features_g2 = find_features(team_2, team_1)

    probs_g1 = final_model.predict_proba(scale_pipe.transform(np.array(features_g1).re
    probs_g2 = final_model.predict_proba(scale_pipe.transform(np.array(features_g2).re

    team_1_prob_g1 = probs_g1[0][0]
    team_1_prob_g2 = probs_g2[0][1]
    team_2_prob_g1 = probs_g1[0][1]
    team_2_prob_g2 = probs_g2[0][0]

    team_1_prob = (probs_g1[0][0] + probs_g2[0][1])/2
    team_2_prob = (probs_g2[0][0] + probs_g1[0][1])/2

    if ((team_1_prob_g1 > team_2_prob_g1) & (team_2_prob_g2 > team_1_prob_g2)) | ((tea
        draw=True
        for i in table[teams[0]]:
            if i[0] == teams[1] or i[0] == teams[2]:
                i[1] += 1

    elif team_1_prob > team_2_prob:
        winner = teams[1]
        winner_proba = team_1_prob
        for i in table[teams[0]]:
            if i[0] == teams[1]:
                i[1] += 3

    elif team_2_prob > team_1_prob:
        winner = teams[2]
        winner_proba = team_2_prob
        for i in table[teams[0]]:
            if i[0] == teams[2]:
                i[1] += 3

    for i in table[teams[0]]: #adding tiebreaker data for group stage if needed
            if i[0] == teams[1]:
                i[2].append(team_1_prob)
            if i[0] == teams[2]:
                i[2].append(team_2_prob)

    if last_group != teams[0]:
        if last_group != "":
            print("\n")
            print("Group %s advanced: "%(last_group))

            for i in table[last_group]:
                i[2] = np.mean(i[2])

            final_points = table[last_group]
            final_table = sorted(final_points, key=itemgetter(1, 2), reverse = True)
```

```
            advanced_group.append([final_table[0][0], final_table[1][0]])
            for i in final_table:
                print("%s -------- %d"%(i[0], i[1]))
        print("\n")
        print("-"*10+" Starting Analysis for Group %s "%(teams[0])+"-"*10)


    if draw == False:
        print("Group %s - %s vs. %s: Winner %s with %.2f probability"%(teams[0], teams
    else:
        print("Group %s - %s vs. %s: Draw"%(teams[0], teams[1], teams[2]))
    last_group =  teams[0]

print("\n")
print("Group %s advanced: "%(last_group))

for i in table[last_group]:
    i[2] = np.mean(i[2])

final_points = table[last_group]
final_table = sorted(final_points, key=itemgetter(1, 2), reverse = True)
advanced_group.append([final_table[0][0], final_table[1][0]])
for i in final_table:
    print("%s -------- %d"%(i[0], i[1]))
```

```
---------- Starting Analysis for Group A ----------
Group A - Qatar vs. Ecuador: Winner Ecuador with 0.64 probability
Group A - Senegal vs. Netherlands: Winner Netherlands with 0.68 probability
Group A - Qatar vs. Senegal: Winner Senegal with 0.59 probability
Group A - Netherlands vs. Ecuador: Winner Netherlands with 0.74 probability
Group A - Ecuador vs. Senegal: Draw
Group A - Netherlands vs. Qatar: Winner Netherlands with 0.82 probability


Group A advanced:
Netherlands -------- 9
Ecuador -------- 4
Senegal -------- 4
Qatar -------- 0


---------- Starting Analysis for Group B ----------
Group B - England vs. Iran: Winner England with 0.66 probability
Group B - United States vs. Wales: Draw
Group B - Wales vs. Iran: Winner Wales with 0.55 probability
Group B - England vs. United States: Winner England with 0.64 probability
Group B - Wales vs. England: Winner England with 0.70 probability
Group B - Iran vs. United States: Winner United States with 0.56 probability


Group B advanced:
England -------- 9
United States -------- 4
Wales -------- 4
Iran -------- 0


---------- Starting Analysis for Group C ----------
Group C - Argentina vs. Saudi Arabia: Winner Argentina with 0.85 probability
Group C - Mexico vs. Poland: Draw
Group C - Poland vs. Saudi Arabia: Winner Poland with 0.68 probability
Group C - Argentina vs. Mexico: Winner Argentina with 0.70 probability
Group C - Poland vs. Argentina: Winner Argentina with 0.74 probability
Group C - Saudi Arabia vs. Mexico: Winner Mexico with 0.72 probability


Group C advanced:
Argentina -------- 9
Mexico -------- 4
Poland -------- 4
Saudi Arabia -------- 0


---------- Starting Analysis for Group D ----------
Group D - Denmark vs. Tunisia: Winner Denmark with 0.71 probability
Group D - France vs. Australia: Winner France with 0.75 probability
Group D - Tunisia vs. Australia: Draw
Group D - France vs. Denmark: Winner France with 0.56 probability
Group D - Australia vs. Denmark: Winner Denmark with 0.71 probability
Group D - Tunisia vs. France: Winner France with 0.70 probability


Group D advanced:
France -------- 9
```

```
Denmark -------- 6
Tunisia -------- 1
Australia -------- 1


---------- Starting Analysis for Group E ----------
Group E - Germany vs. Japan: Winner Germany with 0.66 probability
Group E - Spain vs. Costa Rica: Winner Spain with 0.74 probability
Group E - Japan vs. Costa Rica: Winner Japan with 0.64 probability
Group E - Spain vs. Germany: Draw
Group E - Japan vs. Spain: Winner Spain with 0.67 probability
Group E - Costa Rica vs. Germany: Winner Germany with 0.70 probability


Group E advanced:
Spain -------- 7
Germany -------- 7
Japan -------- 3
Costa Rica -------- 0


---------- Starting Analysis for Group F ----------
Group F - Morocco vs. Croatia: Winner Croatia with 0.65 probability
Group F - Belgium vs. Canada: Winner Belgium with 0.76 probability
Group F - Belgium vs. Morocco: Winner Belgium with 0.71 probability
Group F - Croatia vs. Canada: Winner Croatia with 0.70 probability
Group F - Croatia vs. Belgium: Winner Belgium with 0.63 probability
Group F - Canada vs. Morocco: Draw


Group F advanced:
Belgium -------- 9
Croatia -------- 6
Morocco -------- 1
Canada -------- 1


---------- Starting Analysis for Group G ----------
Group G - Switzerland vs. Cameroon: Winner Switzerland with 0.69 probability
Group G - Brazil vs. Serbia: Winner Brazil with 0.71 probability
Group G - Cameroon vs. Serbia: Winner Serbia with 0.68 probability
Group G - Brazil vs. Switzerland: Winner Brazil with 0.63 probability
Group G - Serbia vs. Switzerland: Winner Switzerland with 0.58 probability
Group G - Cameroon vs. Brazil: Winner Brazil with 0.85 probability


Group G advanced:
Brazil -------- 9
Switzerland -------- 6
Serbia -------- 3
Cameroon -------- 0


---------- Starting Analysis for Group H ----------
Group H - Uruguay vs. South Korea: Draw
Group H - Portugal vs. Ghana: Winner Portugal with 0.86 probability
Group H - South Korea vs. Ghana: Winner South Korea with 0.77 probability
Group H - Portugal vs. Uruguay: Winner Portugal with 0.61 probability
Group H - Ghana vs. Uruguay: Winner Uruguay with 0.81 probability
Group H - South Korea vs. Portugal: Winner Portugal with 0.61 probability
```

```
Group H advanced:
Portugal -------- 9
Uruguay -------- 4
South Korea -------- 4
Ghana -------- 0
```

Knockout Stage

In [87]:
```
advanced = advanced_group
playoffs = {"Round of 16": [], "Quarter-Final": [], "Semi-Final": [], "Final": []}
```

In [88]:
```
for p in playoffs.keys():
    playoffs[p] = []

actual_round = ""
next_rounds = []

for p in playoffs.keys():
    if p == "Round of 16":
        control = []
        for a in range(0, len(advanced*2), 1):
            if a < len(advanced):
                if a % 2 == 0:
                    control.append((advanced*2)[a][0])
                else:
                    control.append((advanced*2)[a][1])
            else:
                if a % 2 == 0:
                    control.append((advanced*2)[a][1])
                else:
                    control.append((advanced*2)[a][0])

        playoffs[p] = [[control[c], control[c+1]] for c in range(0, len(control)-1, 1)

        for i in range(0, len(playoffs[p]), 1):
            game = playoffs[p][i]

            home = game[0]
            away = game[1]
            team_1 = find_stats(home)
            team_2 = find_stats(away)

            features_g1 = find_features(team_1, team_2)
            features_g2 = find_features(team_2, team_1)

            probs_g1 = final_model.predict_proba([features_g1])
            probs_g2 = final_model.predict_proba([features_g2])

            team_1_prob = (probs_g1[0][0] + probs_g2[0][1])/2
            team_2_prob = (probs_g2[0][0] + probs_g1[0][1])/2

            if actual_round != p:
                print("-"*10)
                print("Starting simulation of %s"%(p))
                print("-"*10)
                print("\n")
```

```
            if team_1_prob < team_2_prob:
                print("%s vs. %s: %s advances with prob %.2f"%(home, away, away, team_
                next_rounds.append(away)
            else:
                print("%s vs. %s: %s advances with prob %.2f"%(home, away, home, team_
                next_rounds.append(home)

            game.append([team_1_prob, team_2_prob])
            playoffs[p][i] = game
            actual_round = p

    else:
        playoffs[p] = [[next_rounds[c], next_rounds[c+1]] for c in range(0, len(next_r
        next_rounds = []
        for i in range(0, len(playoffs[p])):
            game = playoffs[p][i]
            home = game[0]
            away = game[1]
            team_1 = find_stats(home)
            team_2 = find_stats(away)

            features_g1 = find_features(team_1, team_2)
            features_g2 = find_features(team_2, team_1)

            probs_g1 = final_model.predict_proba([features_g1])
            probs_g2 = final_model.predict_proba([features_g2])

            team_1_prob = (probs_g1[0][0] + probs_g2[0][1])/2
            team_2_prob = (probs_g2[0][0] + probs_g1[0][1])/2

            if actual_round != p:
                print("-"*10)
                print("Starting simulation of %s"%(p))
                print("-"*10)
                print("\n")

            if team_1_prob < team_2_prob:
                print("%s vs. %s: %s advances with prob %.2f"%(home, away, away, team_
                next_rounds.append(away)
            else:
                print("%s vs. %s: %s advances with prob %.2f"%(home, away, home, team_
                next_rounds.append(home)
            game.append([team_1_prob, team_2_prob])
            playoffs[p][i] = game
            actual_round = p
```

```
----------
Starting simulation of Round of 16
----------


Netherlands vs. United States: Netherlands advances with prob 0.76
Argentina vs. Denmark: Argentina advances with prob 0.71
Spain vs. Croatia: Spain advances with prob 0.66
Brazil vs. Uruguay: Brazil advances with prob 0.75
Ecuador vs. England: England advances with prob 0.67
Mexico vs. France: France advances with prob 0.77
Germany vs. Belgium: Belgium advances with prob 0.56
Switzerland vs. Portugal: Portugal advances with prob 0.71
----------
Starting simulation of Quarter-Final
----------


Netherlands vs. Argentina: Argentina advances with prob 0.63
Spain vs. Brazil: Brazil advances with prob 0.73
England vs. France: France advances with prob 0.57
Belgium vs. Portugal: Belgium advances with prob 0.57
----------
Starting simulation of Semi-Final
----------


Argentina vs. Brazil: Brazil advances with prob 0.72
France vs. Belgium: Belgium advances with prob 0.55
----------
Starting simulation of Final
----------


Brazil vs. Belgium: Brazil advances with prob 0.70
```