In [251…
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

Data Cleaning and Analysis, Feature Engineering

In [252…
```
df = pd.read_csv('Global_Space_Exploration_Dataset.csv')
pd.set_option('display.max_columns', None)
```

In [253…
```
df.head(20)
```

Out[253…

	Country	Year	Mission Name	Mission Type	Launch Site	Satellite Type	Budget (in Billion $)
0	China	2008	Sharable tertiary superstructure	Manned	Sheilatown	Communication	16.20
1	Japan	2018	Re-engineered composite flexibility	Manned	New Ericfurt	Communication	29.04
2	Israel	2013	Reactive disintermediate projection	Manned	Port Kaitlynstad	Communication	28.73
3	UAE	2010	Grass-roots 6thgeneration implementation	Unmanned	Mariastad	Spy	37.27
4	India	2006	Balanced discrete orchestration	Manned	North Jasonborough	Weather	18.95
5	USA	2011	Down-sized holistic methodology	Unmanned	North Kevin	Research	22.76
6	Germany	2011	Adaptive coherent definition	Manned	Wilsonburgh	Spy	9.33
7	India	2012	Innovative 6thgeneration algorithm	Unmanned	South William	Weather	6.62
8	Israel	2024	Business-focused exuding contingency	Manned	Edwardstad	Navigation	13.25
9	Israel	2011	Cross-group incremental function	Unmanned	Port Carla	Communication	23.76
10	France	2014	Reactive heuristic pricing structure	Unmanned	South Sarahton	Research	43.67
11	UK	2007	Innovative client-server matrix	Manned	Marcusborough	Spy	42.47
12	Russia	2023	Up-sized bifurcated conglomeration	Unmanned	North Shannon	Communication	11.68
13	China	2024	Public-key disintermediate matrix	Manned	Kathrynmouth	Research	29.52

	Country	Year	Mission Name	Mission Type	Launch Site	Satellite Type	Budget (in Billion $)
14	UAE	2002	Vision-oriented fresh-thinking pricing structure	Manned	Whiteside	Spy	37.86
15	India	2020	Enterprise-wide heuristic knowledge user	Unmanned	Rodriguezshire	Communication	25.79
16	Russia	2017	Innovative zero tolerance workforce	Unmanned	West Katherineville	Spy	21.53
17	USA	2013	Digitized intangible encryption	Manned	New Cassandraside	Navigation	4.22
18	Germany	2019	Organic tertiary access	Manned	Lamville	Spy	47.41
19	India	2020	Phased context-sensitive intranet	Unmanned	Popehaven	Research	35.59

In [254…
```
df.shape
```
Out[254…
```
(3000, 12)
```
In [255…
```
df.isna().sum()
```
Out[255…
```
Country                    0
Year                       0
Mission Name               0
Mission Type               0
Launch Site                0
Satellite Type             0
Budget (in Billion $)      0
Success Rate (%)           0
Technology Used            0
Environmental Impact       0
Collaborating Countries    0
Duration (in Days)         0
dtype: int64
```
In [256…
```
df.duplicated().sum()
```
Out[256…
```
0
```
In [257…
```
df['Collaborating Countries'] = df['Collaborating Countries'].str.split(', ')
```
In [258…
```
df = df.explode('Collaborating Countries')
```

In [259…

```
df = df.rename(columns={'Country': 'Main Country', 'Collaborating Countries': 'C
```

In [260…

```
df.head(10)
```

Out[260…

	Main Country	Year	Mission Name	Mission Type	Launch Site	Satellite Type	Budget (in Billion $)	Su
0	China	2008	Sharable tertiary superstructure	Manned	Sheilatown	Communication	16.20	
0	China	2008	Sharable tertiary superstructure	Manned	Sheilatown	Communication	16.20	
0	China	2008	Sharable tertiary superstructure	Manned	Sheilatown	Communication	16.20	
1	Japan	2018	Re-engineered composite flexibility	Manned	New Ericfurt	Communication	29.04	
1	Japan	2018	Re-engineered composite flexibility	Manned	New Ericfurt	Communication	29.04	
2	Israel	2013	Reactive disintermediate projection	Manned	Port Kaitlynstad	Communication	28.73	
2	Israel	2013	Reactive disintermediate projection	Manned	Port Kaitlynstad	Communication	28.73	
2	Israel	2013	Reactive disintermediate projection	Manned	Port Kaitlynstad	Communication	28.73	
3	UAE	2010	Grass-roots 6thgeneration implementation	Unmanned	Mariastad	Spy	37.27	
4	India	2006	Balanced discrete orchestration	Manned	North Jasonborough	Weather	18.95	

In [261…

```
df['Mission Name'].drop_duplicates()
print("There are 3000 rows and 3000 individual mission names wih drop duplicates
        "Each mission has a unique name so therefore, 'Mission Name' won't be us
        "our machine learning project and can be dropped\n"
     )
```

```
There are 3000 rows and 3000 individual mission names wih drop duplicates.
Each mission has a unique name so therefore, 'Mission Name' won't be useful in
our machine learning project and can be dropped
```

In [262…
```
df = df.drop('Mission Name', axis=1)
```

In [263…
```
df.head()
```

Out[263…

	Main Country	Year	Mission Type	Launch Site	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	E
0	China	2008	Manned	Sheilatown	Communication	16.20	90	Nuclear Propulsion	
0	China	2008	Manned	Sheilatown	Communication	16.20	90	Nuclear Propulsion	
0	China	2008	Manned	Sheilatown	Communication	16.20	90	Nuclear Propulsion	
1	Japan	2018	Manned	New Ericfurt	Communication	29.04	99	Solar Propulsion	
1	Japan	2018	Manned	New Ericfurt	Communication	29.04	99	Solar Propulsion	

In [264…
```
df['Launch Site'] = df['Launch Site'].str.strip()
df['Launch Site'].drop_duplicates()
```

Out[264…
```
0                 Sheilatown
1               New Ericfurt
2            Port Kaitlynstad
3                  Mariastad
4          North Jasonborough
                    ...
2994         East Elaineburgh
2995             East Shawna
2996           Douglasborough
2997               Bellhaven
2998              Deniseview
Name: Launch Site, Length: 2702, dtype: object
```

In [265…
```
print(
    "There are 3,000 rows and 2,999 unique mission names after dropping duplicat
    "All missions except one have a unique launch site, so 'Launch Site' is not 
    "for our machine learning project and can be dropped."
)
```

```
There are 3,000 rows and 2,999 unique mission names after dropping duplicates.
All missions except one have a unique launch site, so 'Launch Site' is not useful
for our machine learning project and can be dropped.
```

In [266…
```
df = df.drop('Launch Site', axis=1)
```

In [267…
```
df.head()
```

Out[267...

	Main Country	Year	Mission Type	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	Environmenta Impac
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig

In [268...

```
df['Duration (in Years)'] = (df['Duration (in Days)'] / 365.25)
```

In [269...

```
df['Budget per Year (in Billion $)'] = (df['Budget (in Billion $)'] / df['Durati
```

In [270...

```
df.head()
```

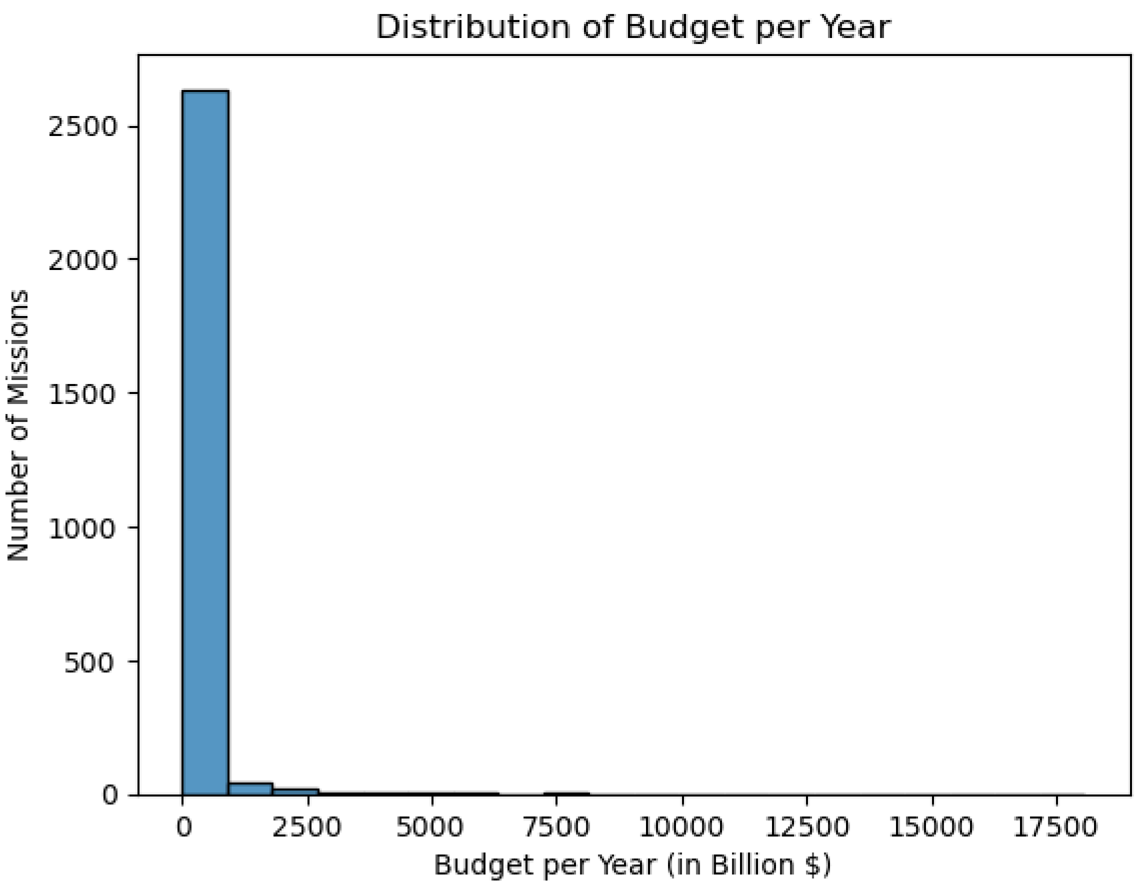
Out[270...

	Main Country	Year	Mission Type	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	Environmenta Impac
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig

Exploratory Data Analysis

In [271...

```
sns.histplot(df['Budget per Year (in Billion $)'].drop_duplicates(), bins=20)
plt.xlabel('Budget per Year (in Billion $)')
plt.ylabel('Number of Missions')
plt.title('Distribution of Budget per Year')
plt.show()
```



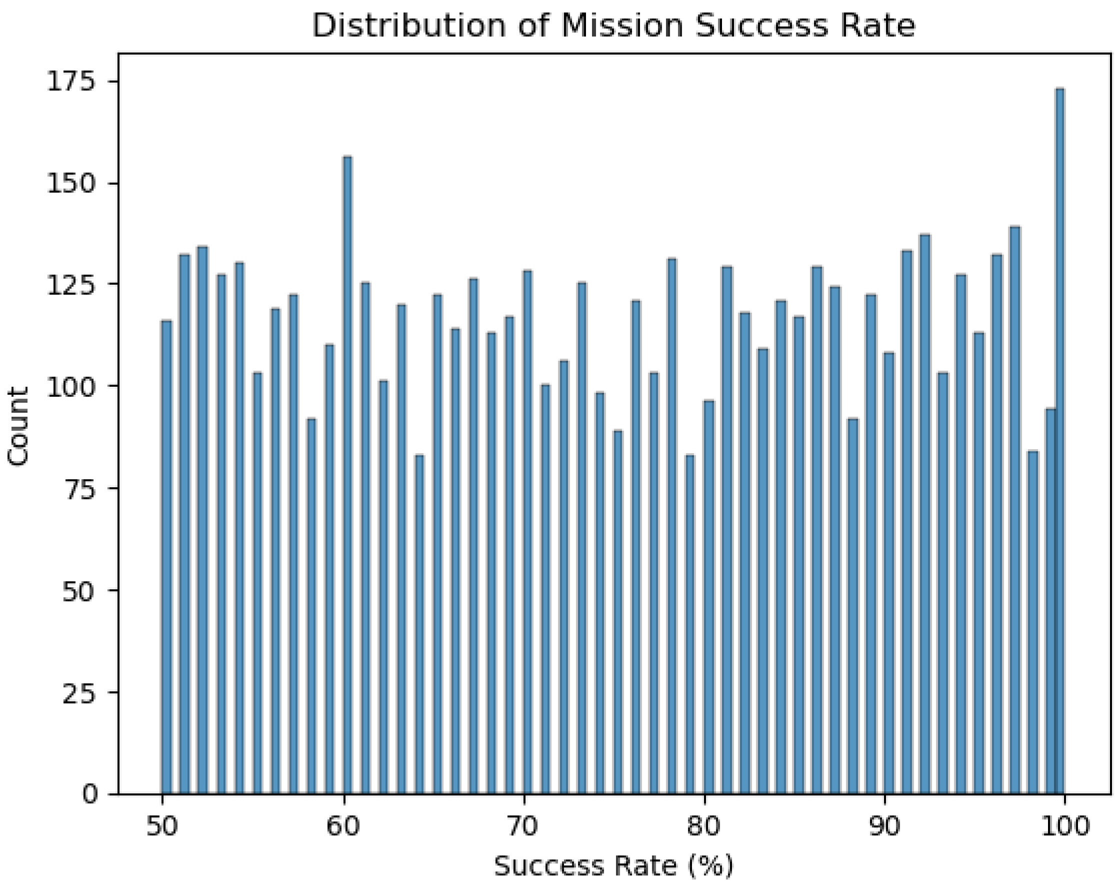
In [272…
```
df['Budget per Year (in Billion $)'].max()
```
Out[272…
```
18072.57
```
In [273…
```
df['Budget per Year (in Billion $)'].min()
```
Out[273…
```
0.62
```
In [274…
```
df['Budget Category'] = pd.cut(df['Budget per Year (in Billion $)'], bins=[0, 10
```
In [275…
```
df.head()
```

Out[275…

	Main Country	Year	Mission Type	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	Environmenta Impac
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig

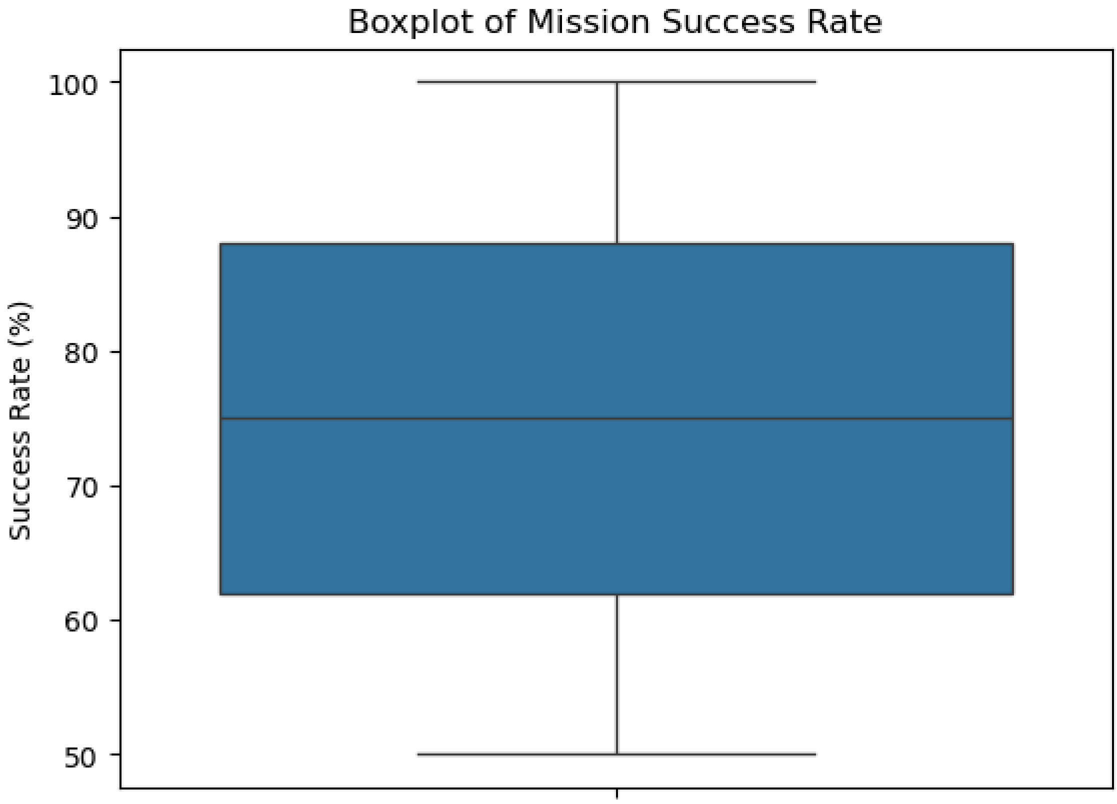
In [276…

```
sns.histplot(df['Success Rate (%)'], bins=100)
plt.title('Distribution of Mission Success Rate')
plt.show()
```

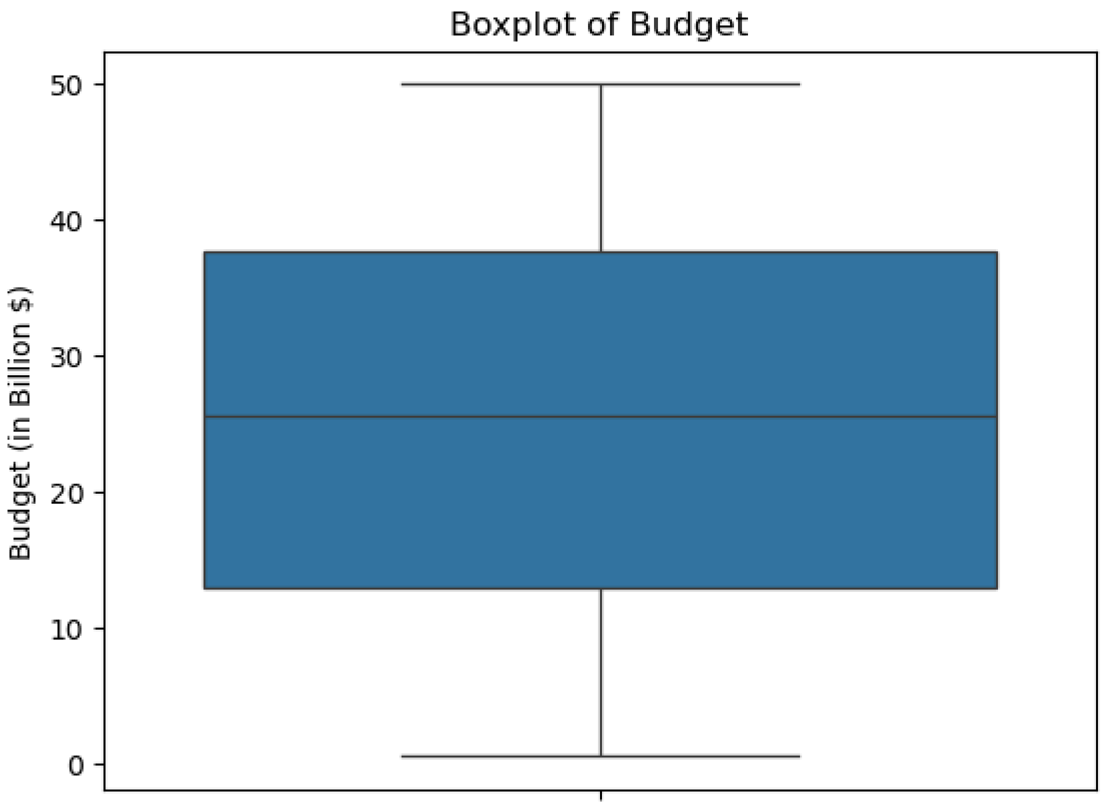


In [277…

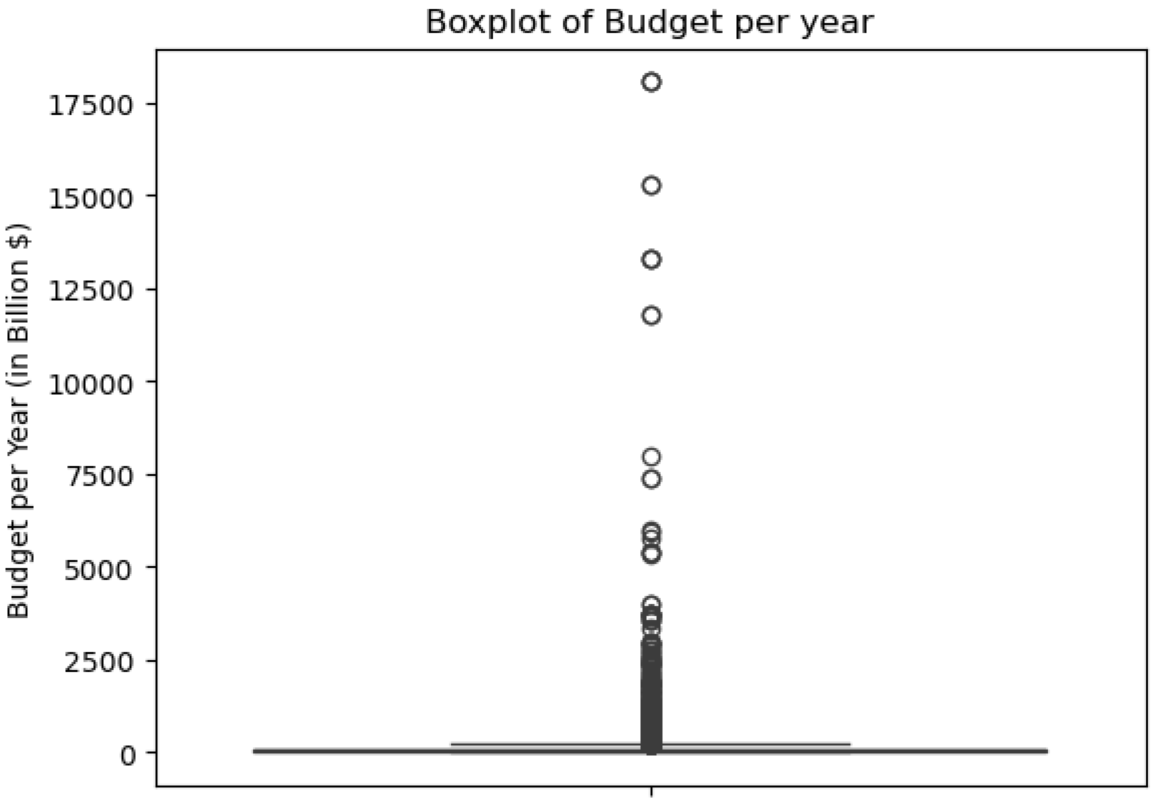
```
sns.boxplot(df['Success Rate (%)'])
plt.title('Boxplot of Mission Success Rate')
plt.show()
```



In [293…
```
sns.boxplot(df['Budget (in Billion $)'])
plt.title('Boxplot of Budget')
plt.show()
```



In [295…
```
sns.boxplot(df['Budget per Year (in Billion $)'])
plt.title('Boxplot of Budget per year')
plt.show()
```

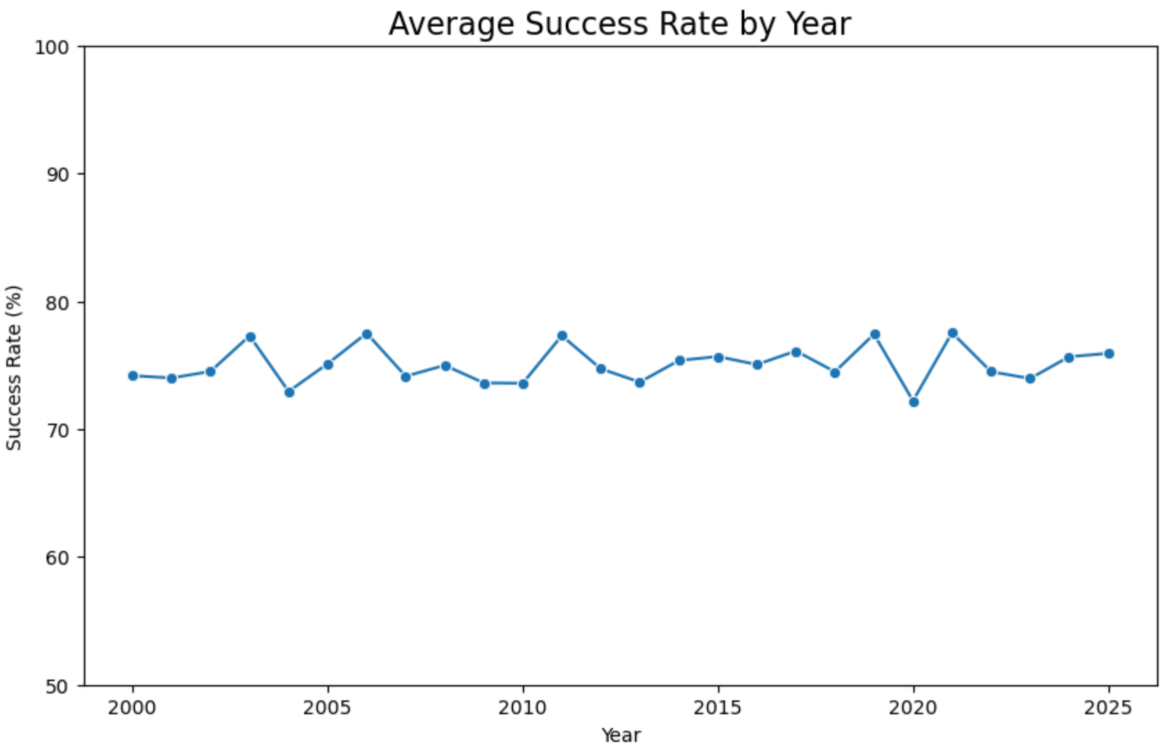


In [279…

```
avg_success_year = df.groupby('Year')['Success Rate (%)'].mean().reset_index()
```

In [280…

```
plt.figure(figsize=(10,6))
sns.lineplot(data=avg_success_year , x='Year', y='Success Rate (%)', marker='o')
plt.title('Average Success Rate by Year', fontsize=16)
plt.ylim(50, 100)
plt.show()
```

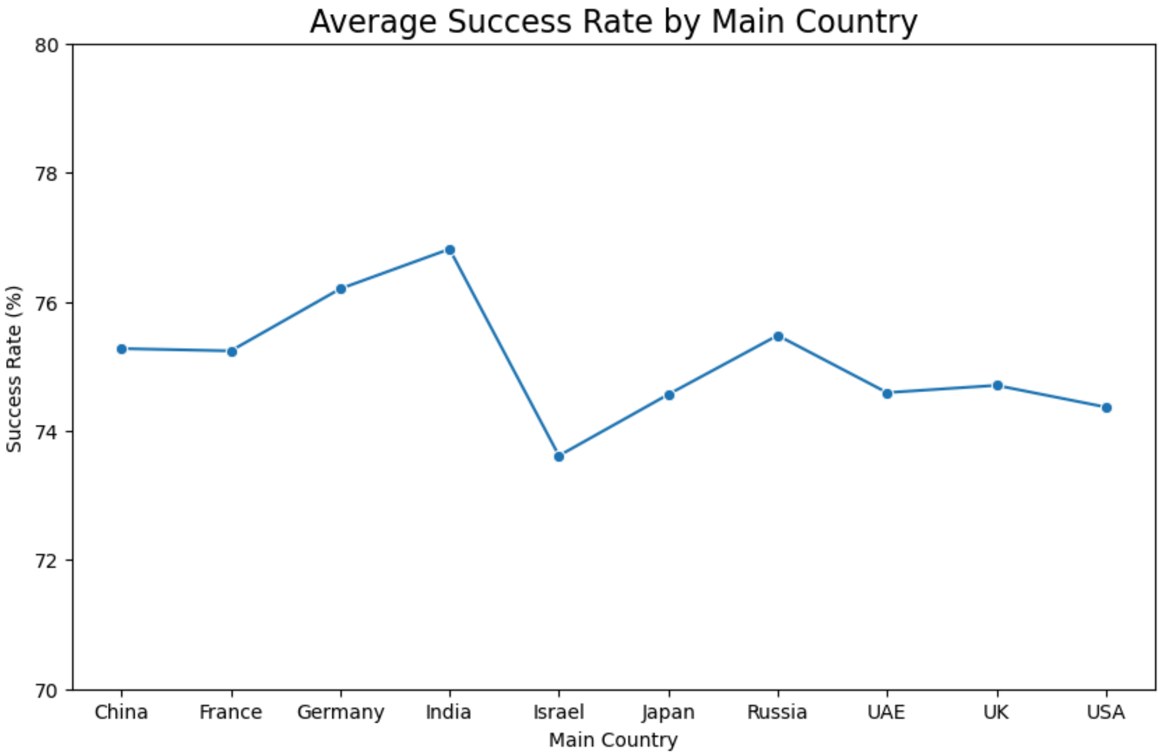


In [281…

```
avg_success_country = df.groupby('Main Country')['Success Rate (%)'].mean().rese
```

In [282…

```
plt.figure(figsize=(10,6))
sns.lineplot(data=avg_success_country , x='Main Country', y='Success Rate (%)',
plt.title('Average Success Rate by Main Country', fontsize=16)
plt.ylim(70, 80)
plt.show()
```

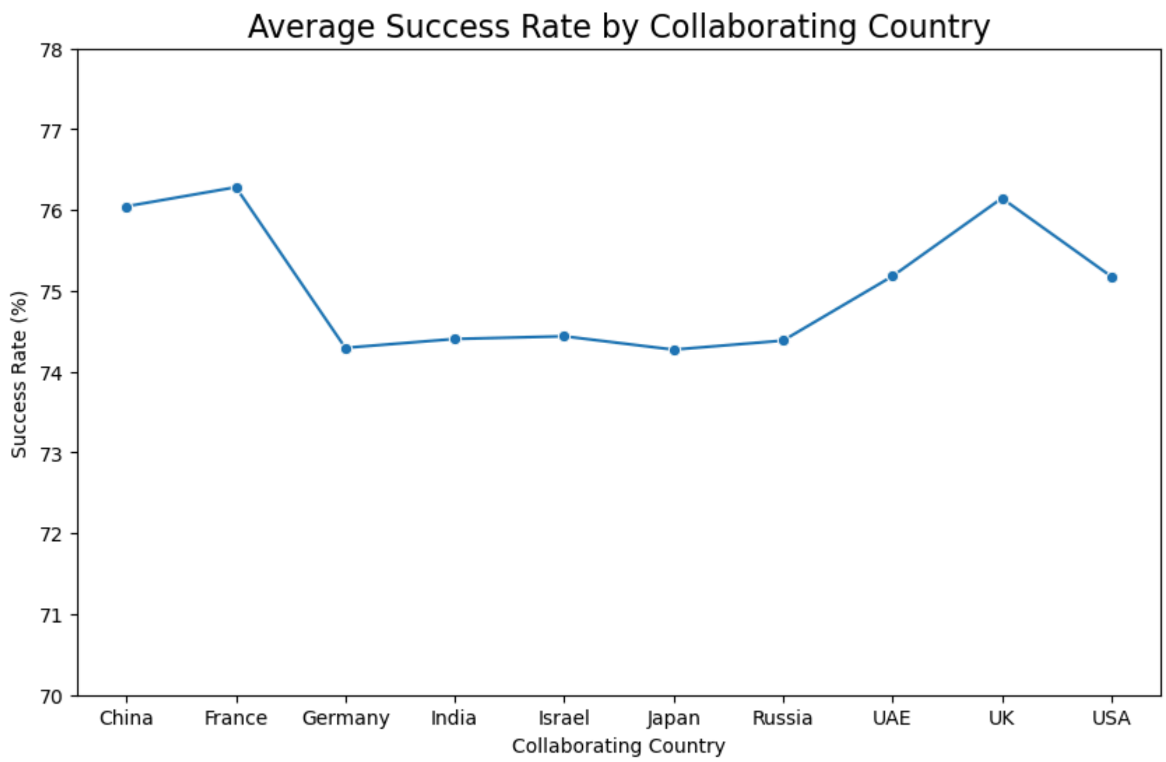


In [283…

```
avg_success_col_country = df.groupby('Collaborating Country')['Success Rate (%)'
```

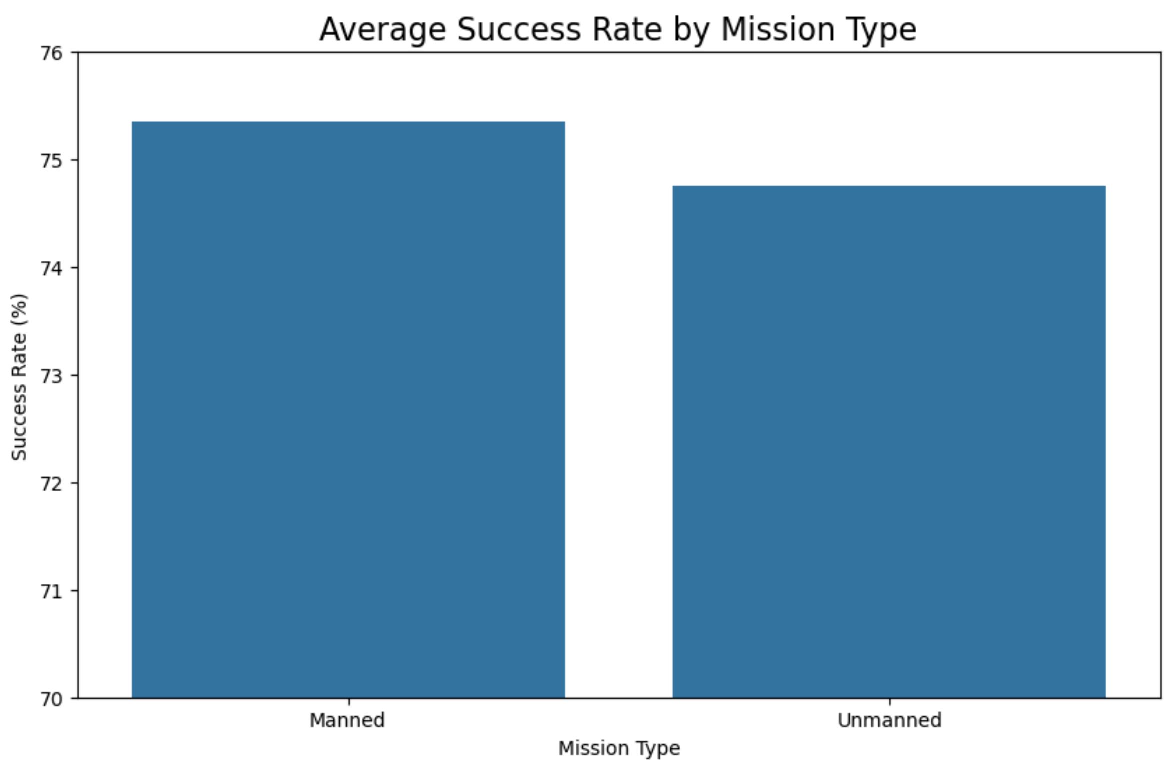
In [284…

```
plt.figure(figsize=(10,6))
sns.lineplot(data=avg_success_col_country , x='Collaborating Country', y='Succes
plt.title('Average Success Rate by Collaborating Country', fontsize=16)
plt.ylim(70, 78)
plt.show()
```



In [285…
```
avg_success_type = df.groupby('Mission Type')['Success Rate (%)'].mean().reset_i
```

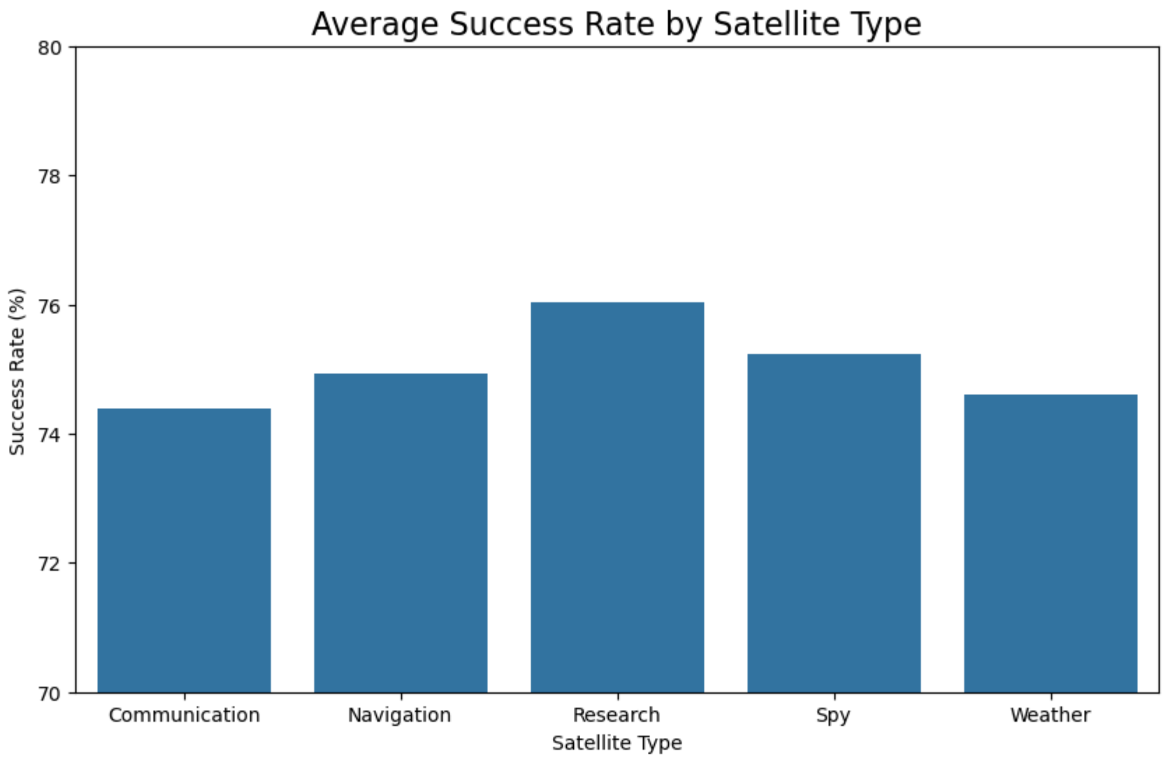
In [286…
```
plt.figure(figsize=(10,6))
sns.barplot(data=avg_success_type , x='Mission Type', y='Success Rate (%)')
plt.title('Average Success Rate by Mission Type', fontsize=16)
plt.ylim(70, 76)
plt.show()
```



In [287…
```
avg_success_satellite = df.groupby('Satellite Type')['Success Rate (%)'].mean().
```

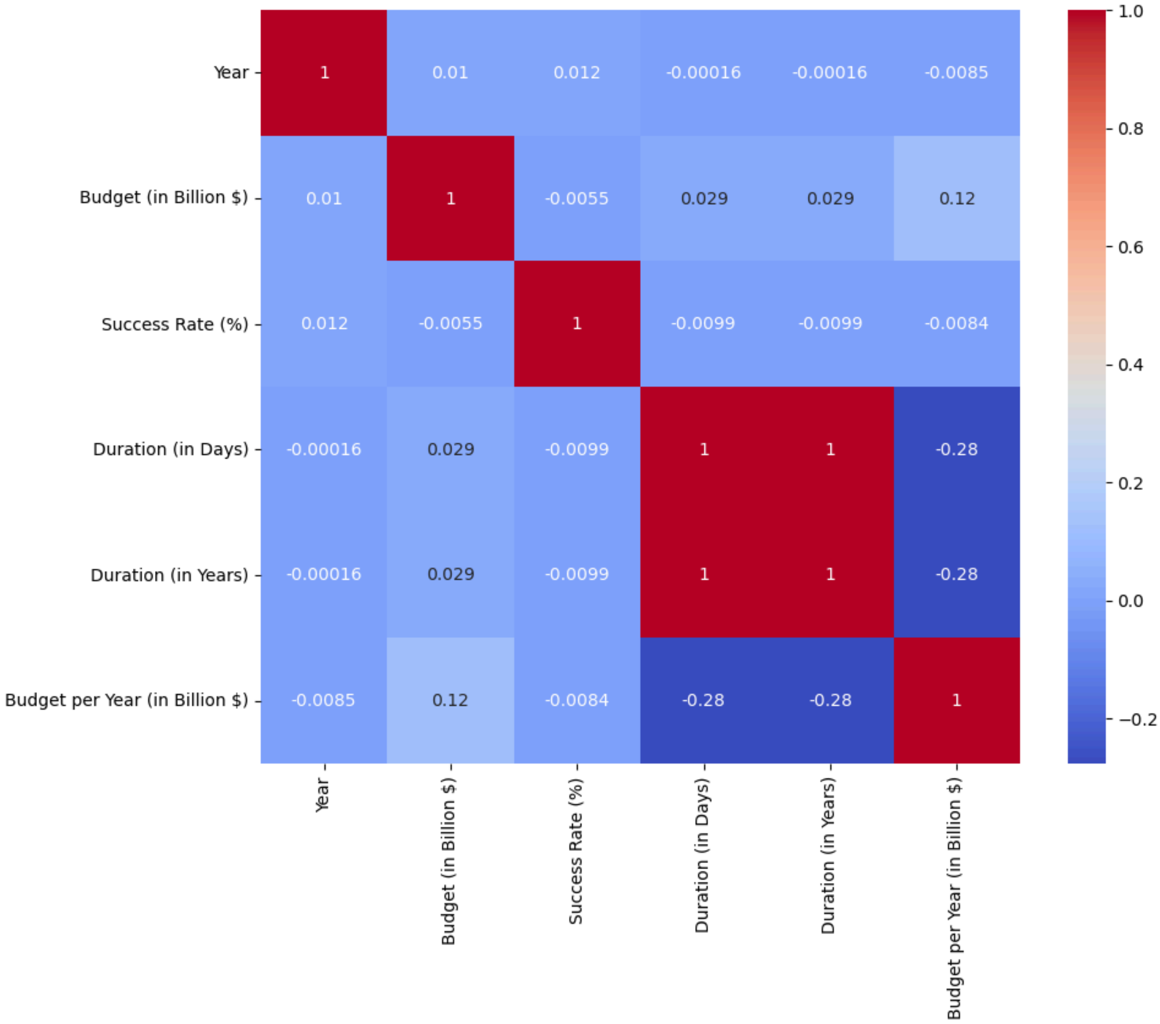
In [288…
```
plt.figure(figsize=(10,6))
sns.barplot(data=avg_success_satellite , x='Satellite Type', y='Success Rate (%)
```

```
plt.title('Average Success Rate by Satellite Type', fontsize=16)
plt.ylim(70, 80)
plt.show()
```



In [289…

```
numeric_df = df.select_dtypes(include='number')
plt.figure(figsize=(10,8))
sns.heatmap(numeric_df.corr(), annot=True, cmap='coolwarm')
plt.show()
```



In [290…

```
df.head()
```

Out[290…

	Main Country	Year	Mission Type	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	Environmenta Impac
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig

Preprocessing

In [291…
```
print("im going to drop the new columns i made because those are only to make th
```
```
im going to drop the new columns i made because those are only to make the eda lo
ok better and it just adds more filler to the machine
```

In [192…
```
df = df.drop('Budget per Year (in Billion $)', axis=1)
```

In [193…
```
df = df.drop('Duration (in Years)', axis=1)
```

In [194…
```
df = df.drop('Budget Category', axis=1)
```

In [195…
```
nominal_cols = df[['Main Country','Mission Type','Satellite Type','Technology Us
ordinal_cols = df[['Environmental Impact']]
```

In [196…
```
from sklearn.preprocessing import OneHotEncoder, OrdinalEncoder
```

In [197…
```
one_encoder = OneHotEncoder(sparse_output=False)
nominal = one_encoder.fit_transform(nominal_cols)
```

In [198…
```
ohe_f_names = one_encoder.get_feature_names_out(nominal_cols.columns)
```

In [199…
```
ohe_df = pd.DataFrame(nominal,columns=ohe_f_names,index=df.index)
```

In [200…
```
ohe_df.head()
```

Out[200…

	Main Country_China	Main Country_France	Main Country_Germany	Main Country_India	Main Country_Israel	Co
0	1.0	0.0	0.0	0.0	0.0	
0	1.0	0.0	0.0	0.0	0.0	
0	1.0	0.0	0.0	0.0	0.0	
1	0.0	0.0	0.0	0.0	0.0	
1	0.0	0.0	0.0	0.0	0.0	

In [201…
```
df_encoded = pd.concat([df,ohe_df],axis=1)
```

In [202…
```
df_encoded.head()
```

Out[202…

	Main Country	Year	Mission Type	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	Environmenta Impac
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig

In [203…

```
ord_encoder = OrdinalEncoder()
ordinal = ord_encoder.fit_transform(ordinal_cols)
```

In [204…

```
or_df = pd.DataFrame(ordinal,
             columns=[col + '_ord' for col in ordinal_cols],
            index=df.index)
or_df
```

Out[204…

	Environmental Impact_ord
0	2.0
0	2.0
0	2.0
1	0.0
1	0.0
...	...
2997	1.0
2998	1.0
2998	1.0
2998	1.0
2999	2.0

5946 rows × 1 columns

In [205…

```
df_final = pd.concat([df_encoded,or_df],axis=1)
```

In [206…

```
df_final.head()
```

Out[206…

	Main Country	Year	Mission Type	Satellite Type	Budget (in Billion $)	Success Rate (%)	Technology Used	Environmenta Impac
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
0	China	2008	Manned	Communication	16.20	90	Nuclear Propulsion	Mediur
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig
1	Japan	2018	Manned	Communication	29.04	99	Solar Propulsion	Hig

In [207…

```
df2 = df_final.select_dtypes(include='number')
```

In [208…

```
df2.head()
```

Out[208…

	Year	Budget (in Billion $)	Success Rate (%)	Duration (in Days)	Main Country_China	Main Country_France	Main Country_Germany
0	2008	16.20	90	112	1.0	0.0	0.0
0	2008	16.20	90	112	1.0	0.0	0.0
0	2008	16.20	90	112	1.0	0.0	0.0
1	2018	29.04	99	236	0.0	0.0	0.0
1	2018	29.04	99	236	0.0	0.0	0.0

Machine Learning (Regression)

In [209…

```
X = df2.drop(columns=['Success Rate (%)'])
y = df2['Success Rate (%)']
```

In [210…

```
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.tree import DecisionTreeClassifier, plot_tree
from sklearn.metrics import accuracy_score, classification_report, confusion_mat
from sklearn.metrics import ConfusionMatrixDisplay as cmd
```

In [211…

```
X_train,X_test, y_train, y_test = train_test_split(X,y,test_size=0.3,random_stat
```

In [212…

```
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
import joblib
```

In [213…
```
base_model = LinearRegression()
rf_model = RandomForestRegressor()
gr_model = GradientBoostingRegressor()
```

In [214…
```
base_model.fit(X_train, y_train)
rf_model.fit(X_train, y_train)
gr_model.fit(X_train, y_train)
```

Out[214…
```
▾ GradientBoostingRegressor
GradientBoostingRegressor()
```

In [215…
```
def evaluate_model(model,X_test,y_test,name='Model'):
    y_pred = model.predict(X_test)
    mse = mean_squared_error(y_test, y_pred)
    rmse = np.sqrt(mse)
    mae = mean_absolute_error(y_test,y_pred)
    r2 = r2_score(y_test,y_pred)

    print(f"--{name}--")
    print(f"MAE:{mae:.2f}")
    print(f"MSE:{mse:.2f}")
    print(f"RSME:{rmse:.2f}")
    print(f"R2:{r2:.2f}")
    print("-"*20)
    return r2
```

In [216…
```
evaluate_model(base_model,X_test,y_test,name='base_model')
```

```
--base_model--
MAE:13.17
MSE:228.67
RSME:15.12
R2:-0.00
--------------------
```

Out[216…
```
-0.0010606505956618495
```

In [217…
```
evaluate_model(rf_model,X_test,y_test,name='rf_model')
```

```
--rf_model--
MAE:8.34
MSE:110.51
RSME:10.51
R2:0.52
--------------------
```

Out[217…
```
0.5162247242325273
```

In [218…
```
evaluate_model(gr_model,X_test,y_test,name='gr_model')
```

```
--gr_model--
MAE:12.69
MSE:213.67
RSME:14.62
R2:0.06
--------------------
```

Out[218…
```
0.06456628417796806
```

In [301…
```
print("rf_model is the best model, we'll use that then")
```

```
rf_model is the best model, we'll use that then
```

In [219…
```
model = rf_model
```

In [220…
```
y_pred = model.predict(X_test)
y_pred
```

Out[220…
```
array([64.19, 71.31, 67.72, ..., 63.69, 70.8 , 75.74])
```

Grid Search CV to improve the model

In [221…
```
param_grid = {
    'n_estimators': [100, 200, 300],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

grid_search = GridSearchCV(estimator=model, param_grid=param_grid, cv=5, n_jobs=
grid_search.fit(X_train, y_train)

best_model = grid_search.best_estimator_
evaluate_model(best_model,X_test,y_test,name='grid_model')
```

```
Fitting 5 folds for each of 108 candidates, totalling 540 fits
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=2, n_estimators=10
0; total time=   4.5s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=2, n_estimators=10
0; total time=   4.7s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=2, n_estimators=10
0; total time=   5.1s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=2, n_estimators=10
0; total time=   4.6s
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0; total time=   4.7s
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0; total time=   9.8s
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0; total time=   9.6s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=2, n_estimators=20
0; total time=   9.4s
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0; total time=   9.0s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=2, n_estimators=30
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0; total time=  13.9s
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0; total time=  13.8s
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0; total time=   3.9s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=10
0; total time=   3.8s
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0; total time=   3.9s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=10
0; total time=   3.6s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=20
0; total time=   7.5s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=20
0; total time=   7.7s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=20
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0; total time=   7.5s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=20
0; total time=   7.2s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=30
0; total time=  11.9s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=30
0; total time=  11.8s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=30
0; total time=  11.7s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=30
0; total time=  11.5s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=5, n_estimators=30
```

```
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00; total time=   3.4s
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00; total time=   3.6s
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00; total time=   3.1s
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00; total time=   7.0s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=10, n_estimators=2
00; total time=   7.0s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=10, n_estimators=2
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[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=10, n_estimators=2
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[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=10, n_estimators=3
00; total time=  10.2s
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00; total time=  10.9s
[CV] END max_depth=None, min_samples_leaf=1, min_samples_split=10, n_estimators=3
00; total time=  10.0s
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00; total time=   9.8s
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=10
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=10
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=20
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=20
0; total time=   7.8s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=20
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=20
0; total time=   7.2s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=30
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=30
0; total time=  11.4s
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0; total time=  11.9s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=30
0; total time=  11.7s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=2, n_estimators=30
```

```
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0; total time=   3.5s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=5, n_estimators=10
0; total time=   3.4s
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0; total time=   3.3s
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0; total time=   7.4s
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0; total time=   7.3s
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0; total time=  11.3s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=5, n_estimators=30
0; total time=  10.9s
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0; total time=  10.8s
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00; total time=   3.4s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=1
00; total time=   3.1s
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[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=1
00; total time=   3.2s
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00; total time=   3.1s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=2
00; total time=   6.5s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=2
00; total time=   6.2s
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00; total time=   6.1s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=2
00; total time=   6.1s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=2
00; total time=   6.4s
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00; total time=  10.0s
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00; total time=   9.6s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=3
00; total time=  10.0s
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00; total time=   9.9s
[CV] END max_depth=None, min_samples_leaf=2, min_samples_split=10, n_estimators=3
```

```
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0; total time=   3.1s
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0; total time=   2.9s
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0; total time=   3.0s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=2, n_estimators=20
0; total time=   6.1s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=2, n_estimators=20
0; total time=   5.9s
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0; total time=   6.3s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=2, n_estimators=20
0; total time=   6.2s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=2, n_estimators=20
0; total time=   6.1s
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0; total time=   9.9s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=2, n_estimators=30
0; total time=   9.4s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=2, n_estimators=30
0; total time=   9.6s
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0; total time=   9.4s
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0; total time=   9.2s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=10
0; total time=   3.0s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=10
0; total time=   3.0s
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0; total time=   3.1s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=10
0; total time=   3.0s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=10
0; total time=   3.0s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=20
0; total time=   6.4s
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0; total time=   6.7s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=20
0; total time=   6.8s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=20
0; total time=   6.1s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=20
0; total time=   6.7s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=30
0; total time=   9.7s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=30
0; total time=   9.9s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=30
0; total time=  10.3s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=30
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[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=5, n_estimators=30
```

```
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00; total time=   3.0s
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00; total time=   3.1s
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[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=10, n_estimators=1
00; total time=   2.9s
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00; total time=   5.9s
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00; total time=   6.2s
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00; total time=   6.2s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=10, n_estimators=2
00; total time=   5.8s
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00; total time=   6.0s
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00; total time=   9.5s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=10, n_estimators=3
00; total time=   9.3s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=10, n_estimators=3
00; total time=   9.3s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=10, n_estimators=3
00; total time=   9.1s
[CV] END max_depth=None, min_samples_leaf=4, min_samples_split=10, n_estimators=3
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total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   4.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   4.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   4.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   5.0s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=   7.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=   7.7s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=   7.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=   8.6s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
```

```
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total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   2.4s
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total time=   2.4s
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total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   4.6s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   4.7s
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total time=   4.6s
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total time=   4.6s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=   7.3s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=   7.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=   7.2s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=10
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[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=10
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[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=10
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[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=20
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[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   4.3s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=20
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0; total time=   4.3s
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0; total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=   6.8s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=   6.4s
[CV] END max_depth=10, min_samples_leaf=1, min_samples_split=10, n_estimators=30
```

```
0; total time=   6.4s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   4.7s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   4.7s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   5.1s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=   7.2s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=   7.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=   7.2s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=   7.5s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=   7.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   2.6s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   2.4s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   4.6s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   4.9s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   4.9s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   5.0s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=   7.5s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=   7.2s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=   7.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
```

```
total time=   7.3s
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0; total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   2.1s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   4.6s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   4.6s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   4.4s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   4.3s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   7.9s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   7.0s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   6.7s
[CV] END max_depth=10, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   7.0s
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total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   2.1s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   4.4s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   4.4s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   4.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   4.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   4.5s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   6.6s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   6.8s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   6.7s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
```

```
total time=   6.7s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   2.1s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   4.6s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   4.7s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   4.5s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   4.7s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   4.4s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   7.0s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   7.2s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   7.0s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   7.0s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   6.9s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.1s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.2s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.3s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   4.4s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   4.8s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   4.5s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   4.5s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   4.5s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   6.8s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   6.5s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   6.6s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   6.7s
[CV] END max_depth=10, min_samples_leaf=4, min_samples_split=10, n_estimators=30
```

```
0; total time=   7.1s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.1s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.1s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.2s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.5s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   9.2s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.7s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.1s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  12.7s
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total time=  12.7s
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total time=  13.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  11.8s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  12.2s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.8s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.7s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.2s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  10.9s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  10.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
```

```
total time=  11.2s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.2s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   7.1s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.9s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.8s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.3s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.4s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=   9.6s
[CV] END max_depth=20, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.1s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.6s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.9s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.6s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.4s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.3s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.2s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.0s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.1s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.0s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  10.8s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.0s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  10.8s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
```

```
total time=  10.8s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.7s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.4s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.4s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   6.9s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   6.9s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   6.9s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   7.0s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   6.7s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  10.6s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  10.4s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  10.8s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  10.7s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  10.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.0s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.4s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.3s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.3s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.4s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.5s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.3s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.9s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.8s
[CV] END max_depth=20, min_samples_leaf=2, min_samples_split=10, n_estimators=30
```

```
0; total time=   9.4s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   2.9s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.5s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.7s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.1s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.6s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.1s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.4s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.5s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.5s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.1s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.6s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.6s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
```

```
total time=   9.1s
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0; total time=   3.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.9s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   3.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.7s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   5.9s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   6.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   6.1s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   6.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   5.8s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.3s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.2s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.0s
[CV] END max_depth=20, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   8.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.4s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.3s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.4s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.4s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=100;
total time=   4.4s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   9.2s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   9.2s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=200;
total time=   8.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  13.3s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  13.4s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  13.7s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
total time=  13.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=2, n_estimators=300;
```

```
total time=  13.4s
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total time=   3.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=100;
total time=   3.7s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   8.0s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   8.1s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=200;
total time=   7.7s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=5, n_estimators=300;
total time=  11.5s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.6s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.3s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.3s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.4s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=10
0; total time=   3.3s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.8s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.9s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=20
0; total time=   6.6s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.5s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.2s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.6s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=30
0; total time=  10.1s
[CV] END max_depth=30, min_samples_leaf=1, min_samples_split=10, n_estimators=30
```

```
0; total time=  10.0s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.8s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.7s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.8s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.7s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=100;
total time=   3.7s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.8s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.7s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.8s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.6s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=200;
total time=   7.4s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.5s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.6s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.8s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.7s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=2, n_estimators=300;
total time=  11.0s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.9s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.6s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.7s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.5s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=100;
total time=   3.5s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   7.2s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   7.3s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   7.3s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   7.3s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=200;
total time=   7.1s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  11.2s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  11.0s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  11.0s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
total time=  10.9s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=5, n_estimators=300;
```

```
total time=  10.8s
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0; total time=   3.2s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.2s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.1s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=10
0; total time=   3.3s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   7.0s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.5s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.6s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.4s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=20
0; total time=   6.3s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=  10.1s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.9s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=  10.2s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.8s
[CV] END max_depth=30, min_samples_leaf=2, min_samples_split=10, n_estimators=30
0; total time=   9.6s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.1s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=100;
total time=   3.1s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.7s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.4s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.6s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.3s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=200;
total time=   6.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.3s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
total time=   9.3s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=2, n_estimators=300;
```

```
total time=   9.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.1s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=100;
total time=   3.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.4s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=200;
total time=   6.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.4s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.5s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.5s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   9.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=5, n_estimators=300;
total time=   8.8s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.9s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.8s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.9s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.9s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=10
0; total time=   2.8s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   6.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   6.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   6.1s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   5.8s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=20
0; total time=   5.8s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.2s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=30
0; total time=   9.0s
[CV] END max_depth=30, min_samples_leaf=4, min_samples_split=10, n_estimators=30
```

```
0; total time=   9.0s
--grid_model--
MAE:8.44
MSE:112.01
RSME:10.58
R2:0.51
--------------------
```

Out[221…

```
0.5096277139329124
```

In [222…

```python
best_model = grid_search.best_estimator_
evaluate_model(best_model,X_test,y_test,name='grid_model')
```

```
--grid_model--
MAE:8.44
MSE:112.01
RSME:10.58
R2:0.51
--------------------
```

Out[222…

```
0.5096277139329124
```

In [223…

```python
y_pred = best_model.predict(X_test)
y_pred
```

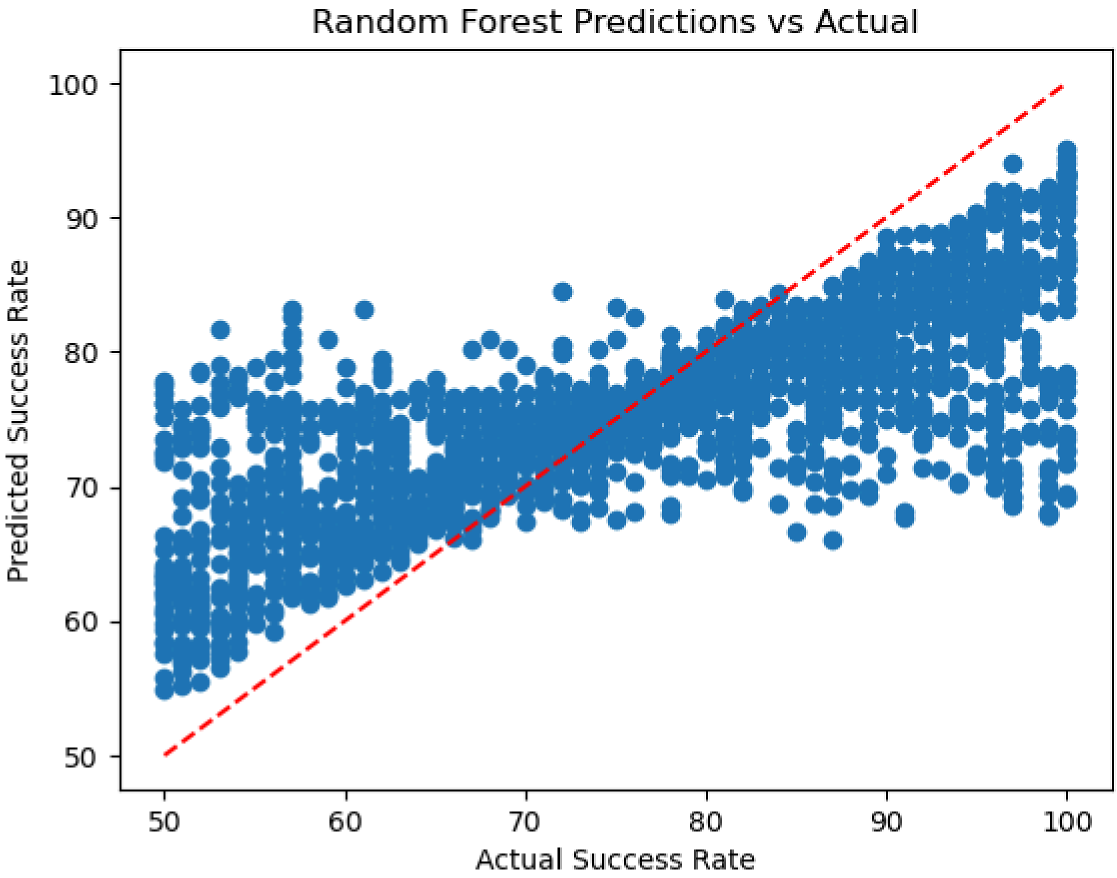
Out[223…

```
array([64.99819444, 71.11333333, 69.96666667, ..., 62.84481481,
       72.55666667, 75.69608696])
```

In [224…

```python
import matplotlib.pyplot as plt

plt.scatter(y_test, y_pred)
plt.plot([y_test.min(), y_test.max()], [y_test.min(), y_test.max()], 'r--')
plt.xlabel('Actual Success Rate')
plt.ylabel('Predicted Success Rate')
plt.title('Random Forest Predictions vs Actual')
plt.show()
```



Saving The Model

In [225…
```
joblib.dump(best_model, 'regression.joblib')
```
Out[225…
```
['regression.joblib']
```
In [225…
```
joblib.dump(best_model, 'regression.joblib')
```
Out[225…
```
['regression.joblib']
```
In [226…
```
joblib.dump(one_encoder, 'one_encoder.joblib')
joblib.dump(ord_encoder, 'ord_encoder.joblib')
```
Out[226…
```
['ord_encoder.joblib']
```

Gradio App

In [227…
```
import gradio as gr
```
In [228…
```
X.head()
```

Out[228…

	Year	Budget (in Billion $)	Duration (in Days)	Main Country_China	Main Country_France	Main Country_Germany	Country
0	2008	16.20	112	1.0	0.0	0.0	
0	2008	16.20	112	1.0	0.0	0.0	
0	2008	16.20	112	1.0	0.0	0.0	
1	2018	29.04	236	0.0	0.0	0.0	
1	2018	29.04	236	0.0	0.0	0.0	

In [240…

```
rf_model = joblib.load('regression.joblib')
one_encoder = joblib.load('one_encoder.joblib')
ord_encoder = joblib.load('ord_encoder.joblib')
```

In [299…

```
country_choices = ['UK', 'China', 'France', 'Israel', 'USA', 'UAE', 'India', 'Ja
mission_type_choices = ['Unmanned', 'Manned']
satellite_type_choices = ['Research', 'Weather', 'Communication', 'Navigation',
technology_choices = ['Traditional Rocket', 'Solar Propulsion', 'AI Navigation',
collab_country_choices = ['Germany', 'USA', 'Russia', 'Japan', 'UAE', 'Israel',
env_choices = ['Low', 'Medium', 'High']

nominal_cols = ['Main Country','Mission Type','Satellite Type','Technology Used'
ordinal_cols = ['Environmental Impact']
numeric_cols = ['Year', 'Budget (in Billion $)', 'Duration (in Days)']


# AI GENERATE STARTS FROM HERE BEEP BOOP
def predict_mission(Main_Country, Year, Mission_Type, Satellite_Type, Budget, Te
                    Environmental_Impact, Collaborating_Country, Duration_Days):

    # Create single-row DataFrame with numeric + single-valued nominal/ordinal c
    user_df = pd.DataFrame({
        'Main Country': [Main_Country],
        'Year': [Year],
        'Mission Type': [Mission_Type],
        'Satellite Type': [Satellite_Type],
        'Budget (in Billion $)': [Budget],
        'Technology Used': [Technology_Used],
        'Environmental Impact': [Environmental_Impact],
        'Collaborating Country': [Collaborating_Country[0]],  # temporary placeh
        'Duration (in Days)': [Duration_Days]
    })

    # Handle multiple collaborating countries by duplicating the row for each se
    collab_rows = []
    for country in Collaborating_Country:
        row_copy = user_df.copy()
        row_copy['Collaborating Country'] = country
        collab_rows.append(row_copy)

    multi_collab_df = pd.concat(collab_rows, axis=0)

    # Transform categorical columns
```

```
    nominal_encoded = one_encoder.transform(multi_collab_df[nominal_cols])
    ordinal_encoded = ord_encoder.transform(multi_collab_df[ordinal_cols])

    # Extract numeric values
    numeric = multi_collab_df[numeric_cols].values

    # Combine all features
    final_input = np.hstack([numeric, nominal_encoded, ordinal_encoded])

    # Predict and average if multiple collaborators
    predictions = rf_model.predict(final_input)
    prediction = predictions.mean()

    return round(prediction, 2)

# AI GENERATION ENDS HERE BEEP BOOP

inputs = [
    gr.Dropdown(label='Main Country', choices=country_choices),
    gr.Number(label='Year'),
    gr.Dropdown(label='Mission Type', choices=mission_type_choices),
    gr.Dropdown(label='Satellite Type', choices=satellite_type_choices),
    gr.Number(label='Budget (in Billion $)'),
    gr.Dropdown(label='Technology Used', choices=technology_choices),
    gr.Dropdown(label='Environmental Impact', choices=env_choices),
    gr.CheckboxGroup(label='Collaborating Country', choices=collab_country_choic
    gr.Number(label='Duration (in Days)'),
]

outputs = gr.Number(label='Predicted Success Rate (%)')

app = gr.Interface(fn=predict_mission,inputs=inputs,outputs=outputs,title='Globa

app.launch(share=True)
```

```
* Running on local URL:  http://127.0.0.1:7876

Could not create share link. Please check your internet connection or our status
page: https://status.gradio.app.
```

Out[299…

In [ ]: