Machine Learning Project

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Packages Required

In [4]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns


sns.set(style="whitegrid")
```

In [28]:
```
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix,accuracy_score,roc_cu
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB
from xgboost import XGBClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
from mlxtend.classifier import StackingCVClassifier
from collections import Counter
```

In [8]:
```
df = pd.read_csv('heart.csv')
```

In [14]:
```
df.head()
```

Out[14]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	targe
0	52	1	0	125	212	0	1	168	0	1.0	2	2	3	(
1	53	1	0	140	203	1	0	155	1	3.1	0	0	3	(
2	70	1	0	145	174	0	1	125	1	2.6	0	0	3	(
3	61	1	0	148	203	0	1	161	0	0.0	2	1	3	(
4	62	0	0	138	294	1	1	106	0	1.9	1	3	2	(

In [16]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1025 entries, 0 to 1024
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       1025 non-null   int64  
 1   sex       1025 non-null   int64  
 2   cp        1025 non-null   int64  
 3   trestbps  1025 non-null   int64  
 4   chol      1025 non-null   int64  
 5   fbs       1025 non-null   int64  
 6   restecg   1025 non-null   int64  
 7   thalach   1025 non-null   int64  
 8   exang     1025 non-null   int64  
 9   oldpeak   1025 non-null   float64
 10  slope     1025 non-null   int64  
 11  ca        1025 non-null   int64  
 12  thal      1025 non-null   int64  
 13  target    1025 non-null   int64  
dtypes: float64(1), int64(13)
memory usage: 112.2 KB
```

In [9]:
```
print(df.isnull().sum())

```

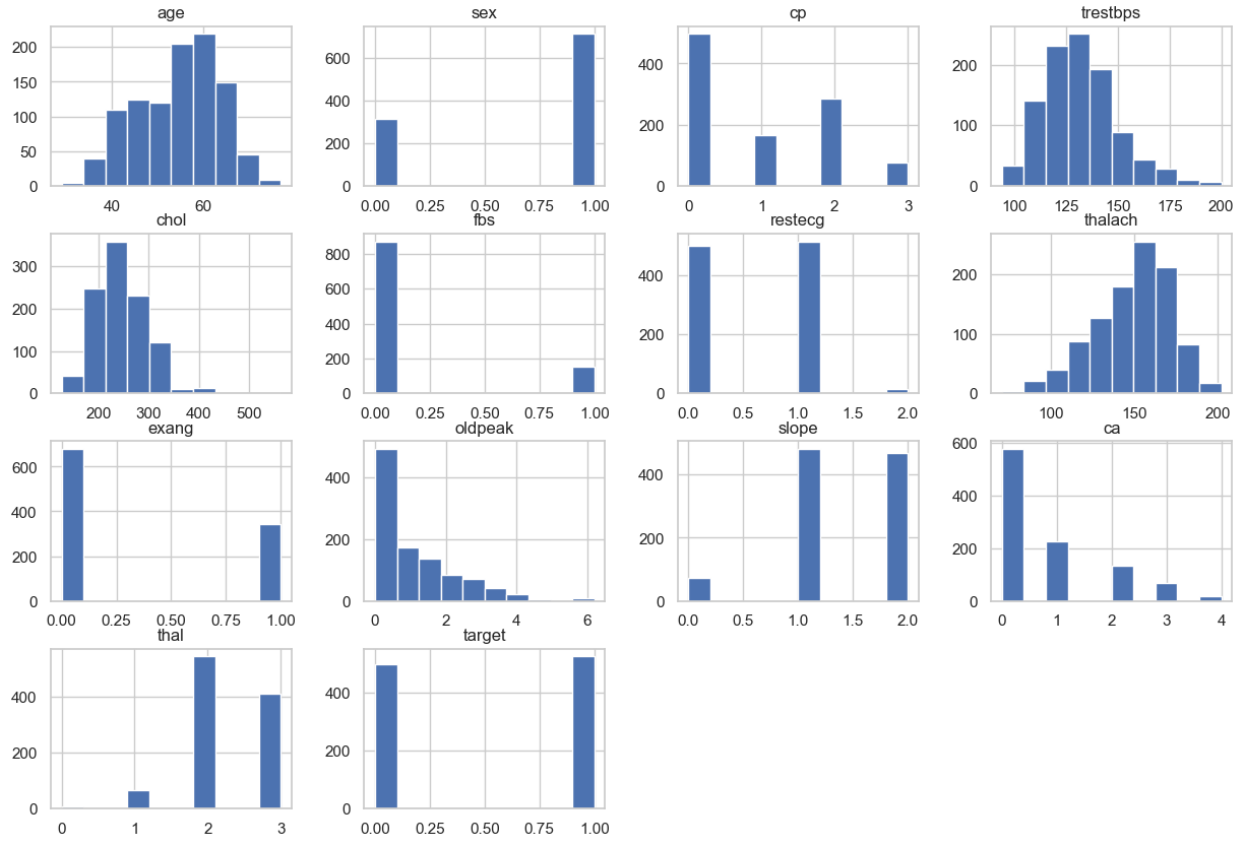
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

In [10]:
```
print(df.describe())

```

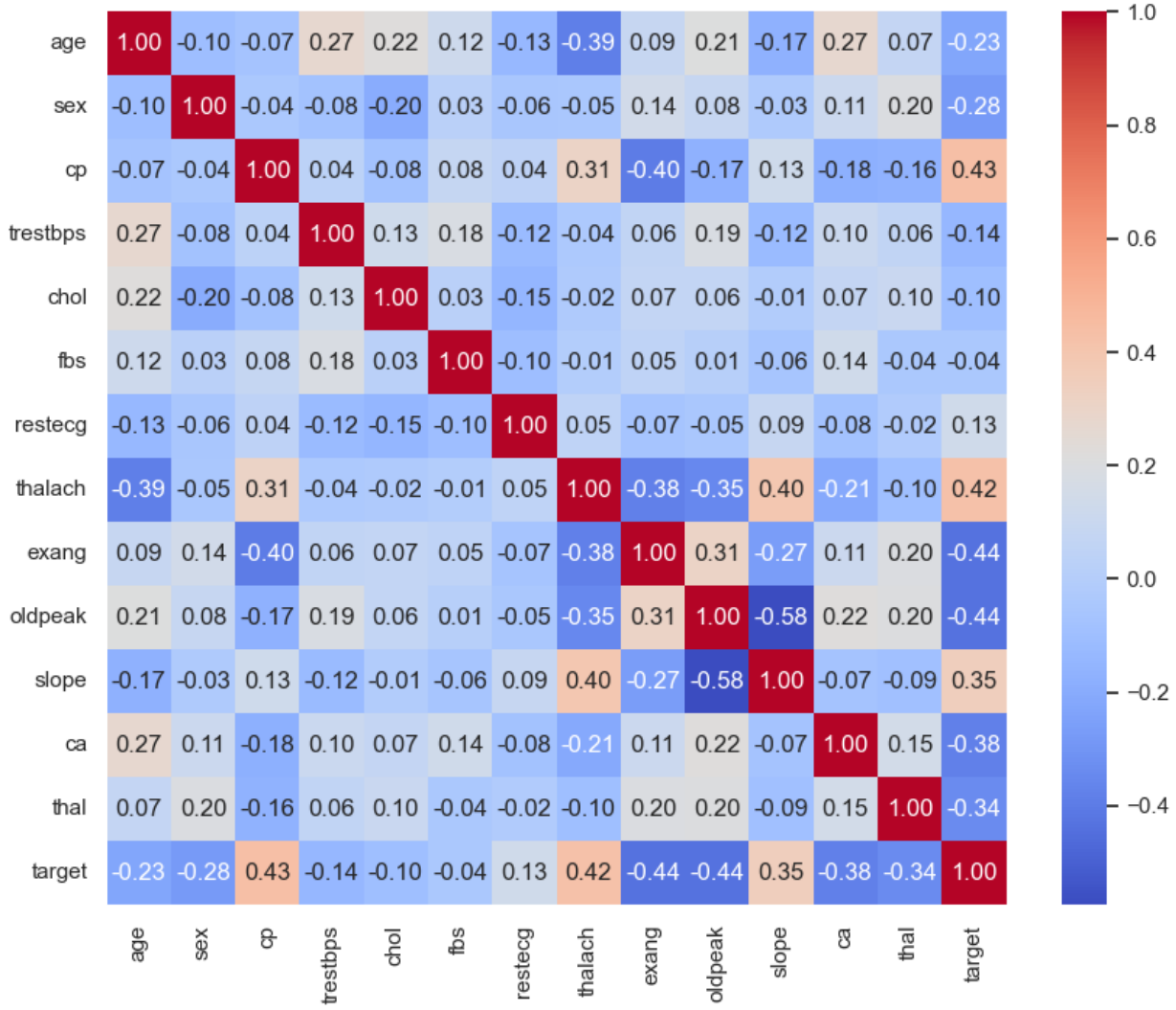
```
                age          sex           cp     trestbps         chol
\
count  1025.000000  1025.000000  1025.000000  1025.000000  1025.00000
mean     54.434146     0.695610     0.942439   131.611707   246.00000
std       9.072290     0.460373     1.029641    17.516718    51.59251
min      29.000000     0.000000     0.000000    94.000000   126.00000
25%      48.000000     0.000000     0.000000   120.000000   211.00000
50%      56.000000     1.000000     1.000000   130.000000   240.00000
75%      61.000000     1.000000     2.000000   140.000000   275.00000
max      77.000000     1.000000     3.000000   200.000000   564.00000

               fbs      restecg      thalach        exang      oldpea
k  \
count  1025.000000  1025.000000  1025.000000  1025.000000  1025.00000
0
mean      0.149268     0.529756   149.114146     0.336585     1.07151
2
std       0.356527     0.527878    23.005724     0.472772     1.17505
3
min       0.000000     0.000000    71.000000     0.000000     0.00000
0
25%       0.000000     0.000000   132.000000     0.000000     0.00000
0
50%       0.000000     1.000000   152.000000     0.000000     0.80000
0
75%       0.000000     1.000000   166.000000     1.000000     1.80000
0
max       1.000000     2.000000   202.000000     1.000000     6.20000
0

             slope           ca         thal       target
count  1025.000000  1025.000000  1025.000000  1025.000000
mean      1.385366     0.754146     2.323902     0.513171
std       0.617755     1.030798     0.620660     0.500070
min       0.000000     0.000000     0.000000     0.000000
25%       1.000000     0.000000     2.000000     0.000000
50%       1.000000     0.000000     2.000000     1.000000
75%       2.000000     1.000000     3.000000     1.000000
max       2.000000     4.000000     3.000000     1.000000
```

EDA

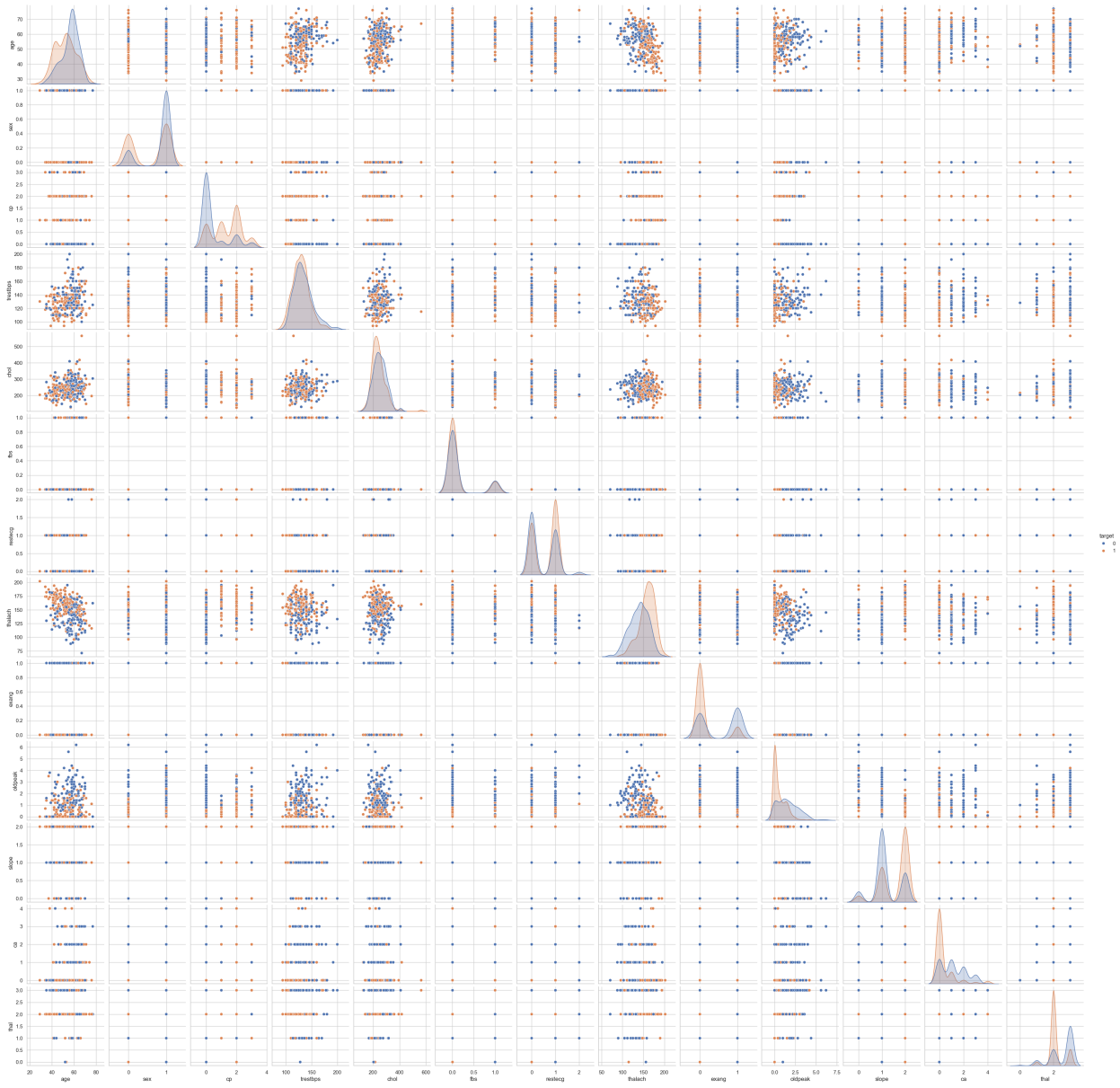
In [11]:
```
df.hist(figsize=(15, 10))
plt.show()
```



In [12]:
```
plt.figure(figsize=(10, 8))
sns.heatmap(df.corr(), annot=True, fmt=".2f", cmap="coolwarm")
plt.show()
```



In [13]:
```
sns.pairplot(df, hue='target')
plt.show()
```



Model prepration

In [22]:
```
y = df["target"]
X = df.drop('target',axis=1)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_siz
```

In [29]:
```
print(y_test.unique())
Counter(y_train)
```

```
[1 0]
```

Out[29]:
```
Counter({1: 419, 0: 401})
```

In [30]:
```
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

ML models

Logistic Regression

Naive Bayes

Random Forest Classifier

Extreme Gradient Boost

K-Nearest Neighbour

Decision Tree

Support Vector Machine

In [31]:
```
m1 = 'Logistic Regression'
lr = LogisticRegression()
model = lr.fit(X_train, y_train)
lr_predict = lr.predict(X_test)
lr_conf_matrix = confusion_matrix(y_test, lr_predict)
lr_acc_score = accuracy_score(y_test, lr_predict)
print("confussion matrix")
print(lr_conf_matrix)
print("\n")
print("Accuracy of Logistic Regression:",lr_acc_score*100,'\n')
print(classification_report(y_test,lr_predict))
```

```
confussion matrix
[[ 77  21]
 [  7 100]]


Accuracy of Logistic Regression: 86.34146341463415

              precision    recall  f1-score   support

           0       0.92      0.79      0.85        98
           1       0.83      0.93      0.88       107

    accuracy                           0.86       205
   macro avg       0.87      0.86      0.86       205
weighted avg       0.87      0.86      0.86       205
```

In [32]:
```
m2 = 'Naive Bayes'
nb = GaussianNB()
nb.fit(X_train,y_train)
nbpred = nb.predict(X_test)
nb_conf_matrix = confusion_matrix(y_test, nbpred)
nb_acc_score = accuracy_score(y_test, nbpred)
print("confussion matrix")
print(nb_conf_matrix)
print("\n")
print("Accuracy of Naive Bayes model:",nb_acc_score*100,'\n')
print(classification_report(y_test,nbpred))
```

```
confussion matrix
[[79 19]
 [11 96]]


Accuracy of Naive Bayes model: 85.36585365853658

              precision    recall  f1-score   support

           0       0.88      0.81      0.84        98
           1       0.83      0.90      0.86       107

    accuracy                           0.85       205
   macro avg       0.86      0.85      0.85       205
weighted avg       0.86      0.85      0.85       205
```

In [33]:
```
m3 = 'Random Forest Classfier'
rf = RandomForestClassifier(n_estimators=20, random_state=12,max_d
rf.fit(X_train,y_train)
rf_predicted = rf.predict(X_test)
rf_conf_matrix = confusion_matrix(y_test, rf_predicted)
rf_acc_score = accuracy_score(y_test, rf_predicted)
print("confussion matrix")
print(rf_conf_matrix)
print("\n")
print("Accuracy of Random Forest:",rf_acc_score*100,'\n')
print(classification_report(y_test,rf_predicted))
```

```
confussion matrix
[[ 88  10]
 [  3 104]]


Accuracy of Random Forest: 93.65853658536587

              precision    recall  f1-score   support

           0       0.97      0.90      0.93        98
           1       0.91      0.97      0.94       107

    accuracy                           0.94       205
   macro avg       0.94      0.93      0.94       205
weighted avg       0.94      0.94      0.94       205
```

In [34]:
```
m4 = 'Extreme Gradient Boost'
xgb = XGBClassifier(learning_rate=0.01, n_estimators=25, max_depth
                    reg_lambda=2, booster='dart', colsample_byleve
xgb.fit(X_train, y_train)
xgb_predicted = xgb.predict(X_test)
xgb_conf_matrix = confusion_matrix(y_test, xgb_predicted)
xgb_acc_score = accuracy_score(y_test, xgb_predicted)
print("confussion matrix")
print(xgb_conf_matrix)
print("\n")
print("Accuracy of Extreme Gradient Boost:",xgb_acc_score*100,'\n'
print(classification_report(y_test,xgb_predicted))
```

```
confussion matrix
[[ 84  14]
 [  2 105]]


Accuracy of Extreme Gradient Boost: 92.19512195121952

              precision    recall  f1-score   support

           0       0.98      0.86      0.91        98
           1       0.88      0.98      0.93       107

    accuracy                           0.92       205
   macro avg       0.93      0.92      0.92       205
weighted avg       0.93      0.92      0.92       205
```

In [35]:
```
m5 = 'K-NeighborsClassifier'
knn = KNeighborsClassifier(n_neighbors=10)
knn.fit(X_train, y_train)
knn_predicted = knn.predict(X_test)
knn_conf_matrix = confusion_matrix(y_test, knn_predicted)
knn_acc_score = accuracy_score(y_test, knn_predicted)
print("confussion matrix")
print(knn_conf_matrix)
print("\n")
print("Accuracy of K-NeighborsClassifier:",knn_acc_score*100,'\n')
print(classification_report(y_test,knn_predicted))
```

```
confussion matrix
[[84 14]
 [11 96]]


Accuracy of K-NeighborsClassifier: 87.8048780487805

              precision    recall  f1-score   support

           0       0.88      0.86      0.87        98
           1       0.87      0.90      0.88       107

    accuracy                           0.88       205
   macro avg       0.88      0.88      0.88       205
weighted avg       0.88      0.88      0.88       205
```

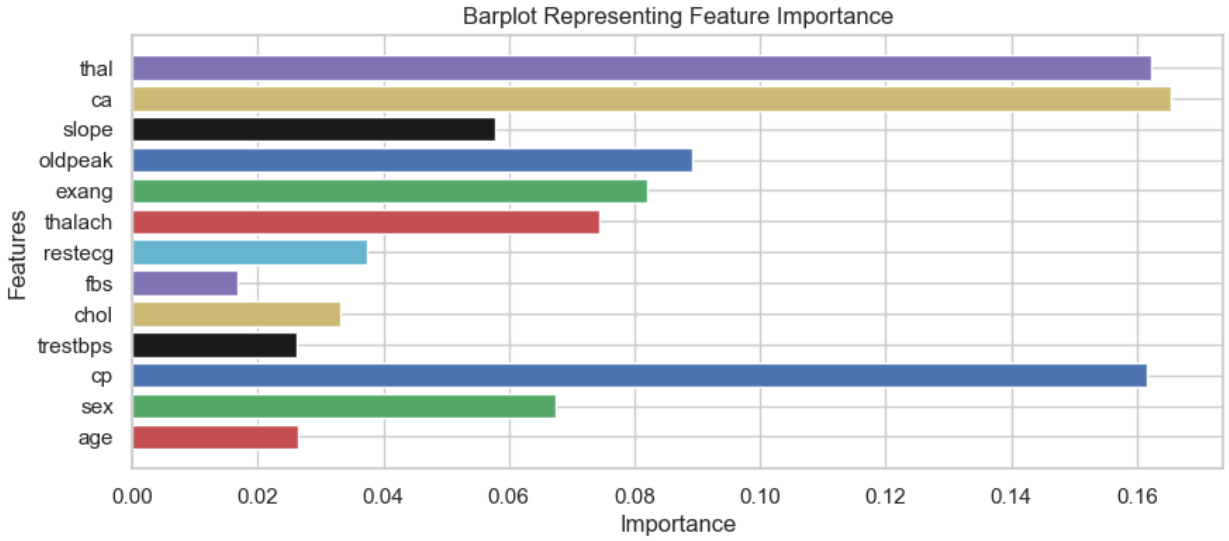
In [36]:
```
m6 = 'DecisionTreeClassifier'
dt = DecisionTreeClassifier(criterion = 'entropy',random_state=0,m
dt.fit(X_train, y_train)
dt_predicted = dt.predict(X_test)
dt_conf_matrix = confusion_matrix(y_test, dt_predicted)
dt_acc_score = accuracy_score(y_test, dt_predicted)
print("confussion matrix")
print(dt_conf_matrix)
print("\n")
print("Accuracy of DecisionTreeClassifier:",dt_acc_score*100,'\n')
print(classification_report(y_test,dt_predicted))
```

```
confussion matrix
[[95  3]
 [ 8 99]]


Accuracy of DecisionTreeClassifier: 94.6341463414634

              precision    recall  f1-score   support

           0       0.92      0.97      0.95        98
           1       0.97      0.93      0.95       107

    accuracy                           0.95       205
   macro avg       0.95      0.95      0.95       205
weighted avg       0.95      0.95      0.95       205
```

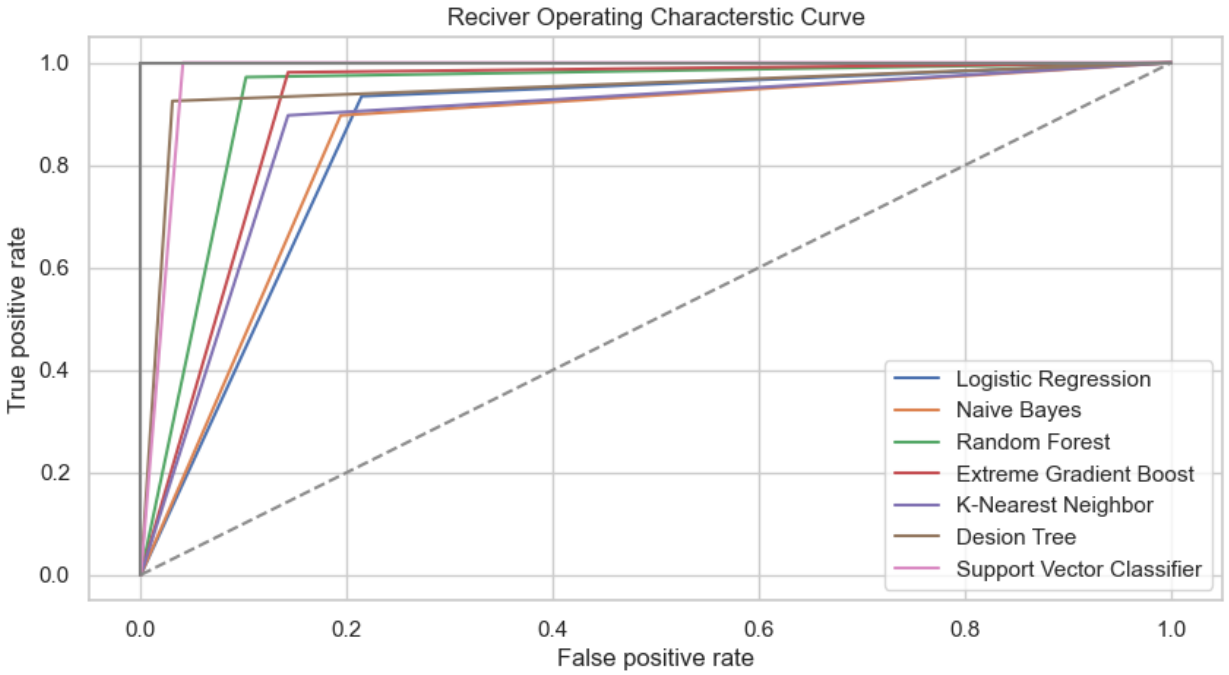
In [37]:
```
m7 = 'Support Vector Classifier'
svc =  SVC(kernel='rbf', C=2)
svc.fit(X_train, y_train)
svc_predicted = svc.predict(X_test)
svc_conf_matrix = confusion_matrix(y_test, svc_predicted)
svc_acc_score = accuracy_score(y_test, svc_predicted)
print("confussion matrix")
print(svc_conf_matrix)
print("\n")
print("Accuracy of Support Vector Classifier:",svc_acc_score*100,'
print(classification_report(y_test,svc_predicted))
```

```
confussion matrix
[[ 94   4]
 [  0 107]]


Accuracy of Support Vector Classifier: 98.04878048780488

              precision    recall  f1-score   support

           0       1.00      0.96      0.98        98
           1       0.96      1.00      0.98       107

    accuracy                           0.98       205
   macro avg       0.98      0.98      0.98       205
weighted avg       0.98      0.98      0.98       205
```

In [39]:
```
imp_feature = pd.DataFrame({
    'Feature': ['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 're
    'Importance': xgb.feature_importances_
})

# Plotting
plt.figure(figsize=(10, 4))
plt.title("Barplot Representing Feature Importance")
plt.xlabel("Importance")
plt.ylabel("Features")
plt.barh(imp_feature['Feature'], imp_feature['Importance'], color=
plt.show()
```



In [40]:
```
lr_false_positive_rate,lr_true_positive_rate,lr_threshold = roc_cu
nb_false_positive_rate,nb_true_positive_rate,nb_threshold = roc_cu
rf_false_positive_rate,rf_true_positive_rate,rf_threshold = roc_cu
xgb_false_positive_rate,xgb_true_positive_rate,xgb_threshold = roc
knn_false_positive_rate,knn_true_positive_rate,knn_threshold = roc
dt_false_positive_rate,dt_true_positive_rate,dt_threshold = roc_cu
svc_false_positive_rate,svc_true_positive_rate,svc_threshold = roc


sns.set_style('whitegrid')
plt.figure(figsize=(10,5))
plt.title('Reciver Operating Characterstic Curve')
plt.plot(lr_false_positive_rate,lr_true_positive_rate,label='Logis
plt.plot(nb_false_positive_rate,nb_true_positive_rate,label='Naive
plt.plot(rf_false_positive_rate,rf_true_positive_rate,label='Rando
plt.plot(xgb_false_positive_rate,xgb_true_positive_rate,label='Ext
plt.plot(knn_false_positive_rate,knn_true_positive_rate,label='K-N
plt.plot(dt_false_positive_rate,dt_true_positive_rate,label='Desic
plt.plot(svc_false_positive_rate,svc_true_positive_rate,label='Sup
plt.plot([0,1],ls='--')
plt.plot([0,0],[1,0],c='.5')
plt.plot([1,1],c='.5')
plt.ylabel('True positive rate')
plt.xlabel('False positive rate')
plt.legend()
plt.show()
```



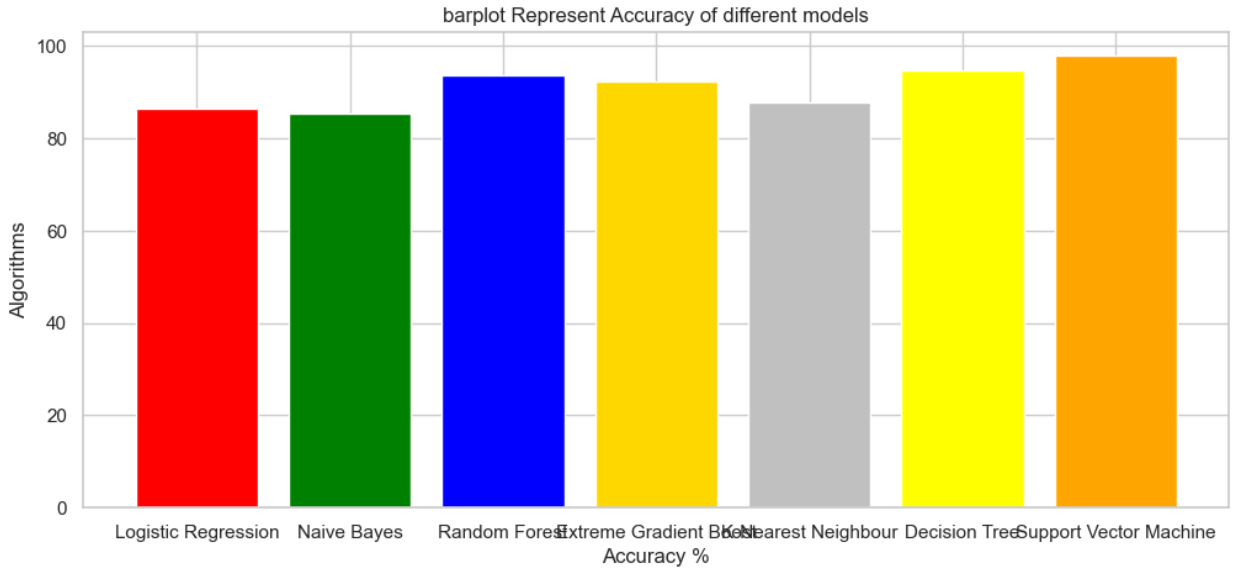
Model Evaluation

In [41]:
```
model_ev = pd.DataFrame({'Model': ['Logistic Regression','Naive Ba
                                   'K-Nearest Neighbour','Decision Tree','Support
                                   nb_acc_score*100,rf_acc_score*100,xgb_acc_scor
model_ev
```

Out[41]:

	Model	Accuracy
0	Logistic Regression	86.341463
1	Naive Bayes	85.365854
2	Random Forest	93.658537
3	Extreme Gradient Boost	92.195122
4	K-Nearest Neighbour	87.804878
5	Decision Tree	94.634146
6	Support Vector Machine	98.048780

In [42]:
```
colors = ['red','green','blue','gold','silver','yellow','orange',]
plt.figure(figsize=(12,5))
plt.title("barplot Represent Accuracy of different models")
plt.xlabel("Accuracy %")
plt.ylabel("Algorithms")
plt.bar(model_ev['Model'],model_ev['Accuracy'],color = colors)
plt.show()
```



Ensembling

In order to increase the accuracy of the model we use ensembling. Here we use stacking technique.

In [43]:
```
scv=StackingCVClassifier(classifiers=[xgb,knn,svc],meta_classifier
scv.fit(X_train,y_train)
scv_predicted = scv.predict(X_test)
scv_conf_matrix = confusion_matrix(y_test, scv_predicted)
scv_acc_score = accuracy_score(y_test, scv_predicted)
print("confussion matrix")
print(scv_conf_matrix)
print("\n")
print("Accuracy of StackingCVClassifier:",scv_acc_score*100,'\n')
print(classification_report(y_test,scv_predicted))
```

```
confussion matrix
[[ 94   4]
 [  0 107]]


Accuracy of StackingCVClassifier: 98.04878048780488

              precision    recall  f1-score   support

           0       1.00      0.96      0.98        98
           1       0.96      1.00      0.98       107

    accuracy                           0.98       205
   macro avg       0.98      0.98      0.98       205
weighted avg       0.98      0.98      0.98       205
```

Conclusion

1) The Support Vector Machine (SVM) and the StackingCVClassifier demonstrated the highest accuracy, each achieving an impressive 98.05%. The Decision Tree model also performed notably well, with an accuracy of 94.63%.

2) Exercise induced angina,Chest pain is major symptoms of heart attack.

3) Ensembling technique increase the accuracy of the model.

Type *Markdown* and LaTeX: α^2

In [ ]:
```
1
```