In [18]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib import cm
from sklearn.model_selection import train_test_split
import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
df = pd.read_csv('GEMIRAN0819.csv')
df
```

Out[2]:

	Unnamed: 0	yrsurv	age	gender	irstrata	fearfail	suskill	opport	knowent	discent	exre
0	3	2008	28	2	2	2	1	1	1	0	
1	20	2008	38	1	2	2	1	1	1	0	
2	25	2008	26	2	6	2	1	1	1	0	
3	30	2008	25	1	6	2	1	1	2	0	
4	35	2008	45	1	2	-1	2	-1	1	0	
...	...	...	...	...	...	...	...	...	...	...	
12095	39411	2019	54	2	6	1	1	2	1	0	
12096	39414	2019	21	2	6	1	2	2	1	0	
12097	39416	2019	24	2	6	2	1	1	1	0	
12098	39429	2019	31	2	6	2	1	2	2	0	
12099	39436	2019	32	2	6	2	2	2	1	0	

12100 rows × 12 columns

In [3]:
```
df=df.drop(['Unnamed: 0'],axis=1)
df
```

Out[3]:

	yrsurv	age	gender	irstrata	fearfail	suskill	opport	knowent	discent	exreason	bstart
0	2008	28	2	2	2	1	1	1	0	0	1
1	2008	38	1	2	2	1	1	1	0	0	1
2	2008	26	2	6	2	1	1	1	0	0	1
3	2008	25	1	6	2	1	1	2	0	0	2
4	2008	45	1	2	-1	2	-1	1	0	0	1
...	...	...	...	...	...	...	...	...	...	...	..
12095	2019	54	2	6	1	1	2	1	0	0	1
12096	2019	21	2	6	1	2	2	1	0	0	1
12097	2019	24	2	6	2	1	1	1	0	0	1
12098	2019	31	2	6	2	1	2	2	0	0	1
12099	2019	32	2	6	2	2	2	1	0	0	2

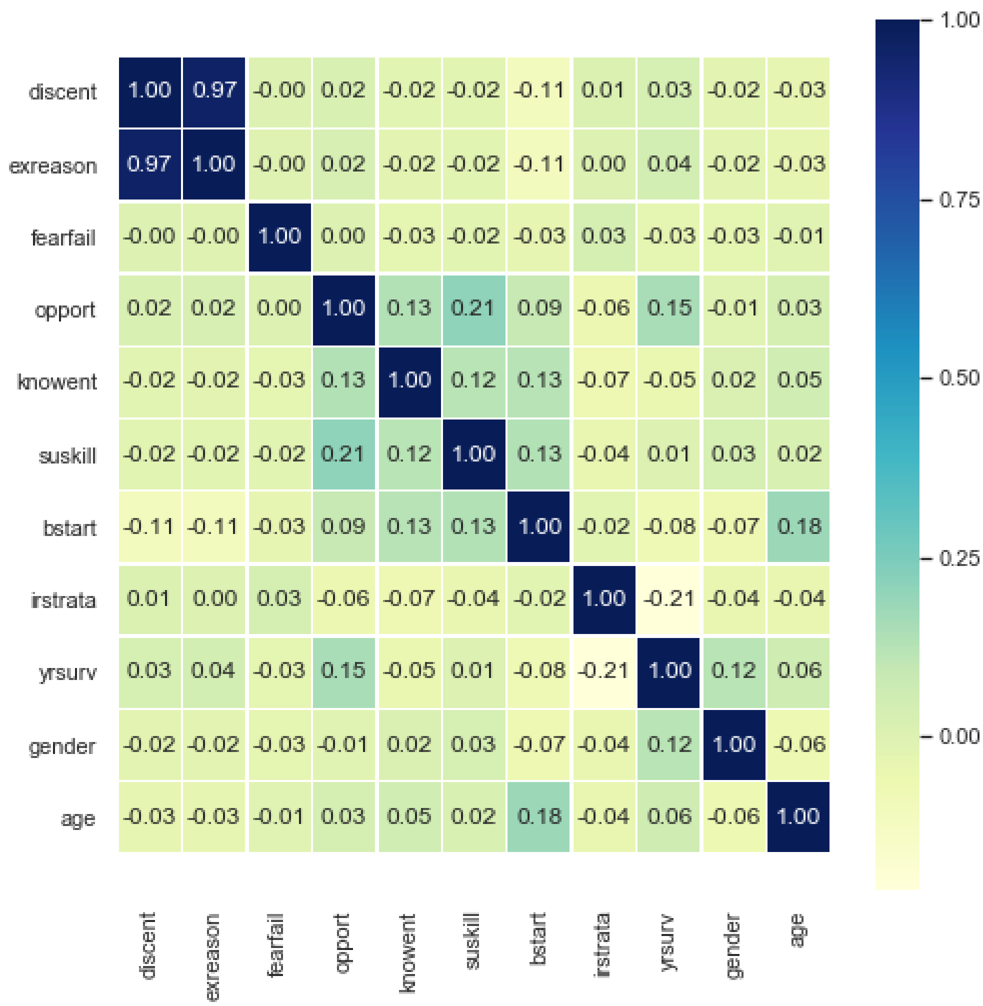
12100 rows × 11 columns

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12100 entries, 0 to 12099
Data columns (total 11 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   yrsurv    12100 non-null  int64
 1   age       12100 non-null  int64
 2   gender    12100 non-null  int64
 3   irstrata  12100 non-null  int64
 4   fearfail  12100 non-null  int64
 5   suskill   12100 non-null  int64
 6   opport    12100 non-null  int64
 7   knowent   12100 non-null  int64
 8   discent   12100 non-null  int64
 9   exreason  12100 non-null  int64
 10  bstart    12100 non-null  int64
dtypes: int64(11)
memory usage: 1.0 MB
```

In [129]:
```
#Let's make our correlation matrix a little prettier
corr_matrix = df[['discent','exreason', 'fearfail', 'opport','knowent','suskil
l','bstart','irstrata','yrsurv','gender','age']].corr(method='spearman')

fig, ax = plt.subplots(figsize=(8, 8))
ax = sns.heatmap(corr_matrix,
                 annot=True,
                 linewidths=0.5,
                 fmt=".2f",
                 cmap="YlGnBu");
bottom, top = ax.get_ylim()
ax.set_ylim(bottom + 0.5, top - 0.5)
```

Out[129]: (11.5, -0.5)



In [130]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['discent' ])
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])
irstrata_table.reset_index(inplace=True)
```

In [131]:
```
irstrata_table.style.background_gradient(cmap ='Blues')
```

Out[131]:

discent	irstrata	0	1
0	1	1991	172
1	2	2440	252
2	3	2167	200
3	4	1487	162
4	5	1765	190
5	6	1172	102

In [132]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['fearfail' ])
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])
irstrata_table.reset_index(inplace=True)
```

In [133]:
```
irstrata_table.style.background_gradient(cmap ='Blues')
```

Out[133]:

fearfail	irstrata	-2	-1	0	1	2
0	1	4	33	4	811	1311
1	2	23	60	33	921	1655
2	3	19	155	2	661	1530
3	4	9	110	7	512	1011
4	5	12	70	8	569	1296
5	6	8	28	2	382	854

In [134]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['bstart'])
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])
irstrata_table.reset_index(inplace=True)
```

In [135]:
```
irstrata_table.style.background_gradient(cmap ='Blues')
```

Out[135]:

bstart	irstrata	-2	-1	1	2
0	1	4	4	944	1211
1	2	4	3	1261	1424
2	3	1	6	1055	1305
3	4	0	3	737	909
4	5	6	13	930	1006
5	6	3	6	589	676

In [136]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['knowent' ], marg
ins_name="Total")
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])
irstrata_table.reset_index(inplace=True)
```

In [137]:
```
irstrata_table.style.background_gradient(cmap ='Blues')
```

Out[137]:

knowent	irstrata	-2	-1	0	1	2
0	1	5	15	0	1097	1046
1	2	12	45	2	1497	1136
2	3	14	54	0	1162	1137
3	4	6	28	1	943	671
4	5	13	39	1	1134	768
5	6	5	25	2	792	450

In [138]:
```
pd.crosstab(df.irstrata, df['knowent'], margins=True, margins_name="Total").st
yle.background_gradient(cmap ='Blues')
```

Out[138]:

knowent	-2	-1	0	1	2	Total
irstrata						
1	5	15	0	1097	1046	2163
2	12	45	2	1497	1136	2692
3	14	54	0	1162	1137	2367
4	6	28	1	943	671	1649
5	13	39	1	1134	768	1955
6	5	25	2	792	450	1274
Total	55	206	6	6625	5208	12100

In [139]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['suskill' ])
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])
irstrata_table.reset_index(inplace=True)
```

In [140]:
```
irstrata_table.style.background_gradient(cmap ='Blues')
```

Out[140]:

suskill	irstrata	-2	-1	0	1	2
0	1	9	19	9	1496	630
1	2	22	52	30	2001	587
2	3	21	245	6	1549	546
3	4	5	109	2	1204	329
4	5	11	60	10	1355	519
5	6	26	51	2	906	289

In [141]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['opport' ])
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])*100
irstrata_table.reset_index(inplace=True)
```

In [142]:
```
irstrata_table.style.background_gradient(cmap ='Blues')
```

Out[142]:

opport	irstrata	-2	-1	0	1	2
0	1	11	110	7	783	1252
1	2	18	254	43	1002	1375
2	3	41	409	7	824	1086
3	4	6	212	7	629	795
4	5	15	161	12	727	1040
5	6	19	183	3	465	604

In [143]:
```
irstrata_table= pd.crosstab(index=df['irstrata'], columns=df['gender' ])
#irstrata_table['ratio']=irstrata_table[1]/(irstrata_table[0]+irstrata_table
[1])*100
irstrata_table.reset_index(inplace=True)
```

In [144]:
```
pd.crosstab(df.opport, df['discent'], margins=True, margins_name="Total").styl
e.background_gradient(cmap ='Blues')
```

Out[144]:

discent	0	1	Total
opport			
-2	106	4	110
-1	1264	65	1329
0	71	8	79
1	3982	448	4430
2	5599	553	6152
Total	11022	1078	12100

In [145]:
```
pd.crosstab(df.gender, df['exreason'], margins=True, margins_name="Total").sty
le.background_gradient(cmap ='Blues')
```

Out[145]:

exreason	0	1	2	3	4	5	6	7	8	9	10	Total
gender												
1	8398	13	110	7	29	35	141	37	354	61	17	9202
2	2683	5	50	2	2	8	41	11	70	24	2	2898
Total	11081	18	160	9	31	43	182	48	424	85	19	12100

In [146]:
```
pd.crosstab(df.exreason, df['discent']).style.background_gradient(cmap ='Blue
s')
```

Out[146]:

discent	0	1
exreason		
0	11019	62
1	0	18
2	1	159
3	0	9
4	0	31
5	0	43
6	0	182
7	0	48
8	1	423
9	0	85
10	1	18

In [147]:
```
yrsurv_table= pd.crosstab(index=df['yrsurv'], columns=df['discent' ])
#yrsurv_table['ratio']=yrsurv_table[1]/(yrsurv_table[0]+yrsurv_table[1])
yrsurv_table.reset_index(inplace=True)
```

In [148]:
```
yrsurv_table.style.background_gradient(cmap ='Blues')
```

Out[148]:

discent	yrsurv	0	1
0	2008	621	56
1	2009	761	76
2	2010	1054	88
3	2011	1239	92
4	2012	687	56
5	2013	969	87
6	2014	860	88
7	2015	1036	116
8	2016	1202	140
9	2017	998	111
10	2018	877	77
11	2019	718	91

In [149]:
```
yrsurv_table= pd.crosstab(index=df['yrsurv'], columns=df['exreason' ])
#yrsurv_table['ratio']=yrsurv_table[1]/(yrsurv_table[0]+yrsurv_table[1])
yrsurv_table.reset_index(inplace=True)
```

In [150]:
```
yrsurv_table.style.background_gradient(cmap ='Blues')
```

Out[150]:

exreason	yrsurv	0	1	2	3	4	5	6	7	8	9	10
0	2008	622	0	6	1	4	4	10	1	19	8	2
1	2009	779	0	10	0	4	2	12	1	17	10	2
2	2010	1058	0	11	0	5	8	21	1	32	5	1
3	2011	1264	0	17	4	7	4	4	4	21	5	1
4	2012	688	0	11	0	0	2	9	6	19	8	0
5	2013	970	0	7	0	1	0	22	9	39	5	3
6	2014	860	0	17	0	1	0	15	4	45	4	2
7	2015	1039	3	21	1	3	3	18	4	52	7	1
8	2016	1203	3	25	1	3	8	16	5	63	10	5
9	2017	998	4	13	0	0	6	19	8	52	8	1
10	2018	878	0	10	0	0	4	22	2	28	9	1
11	2019	722	8	12	2	3	2	14	3	37	6	0

In [151]:
```
category = pd.cut(df.age,
                  bins=[18,25,35,45,55,65,99],
                  labels=['18-24','25-34','35-44','45-54','55-64', '65+'])
df.insert(5,'Age-Group',category)
```

In [152]:
```
df
```

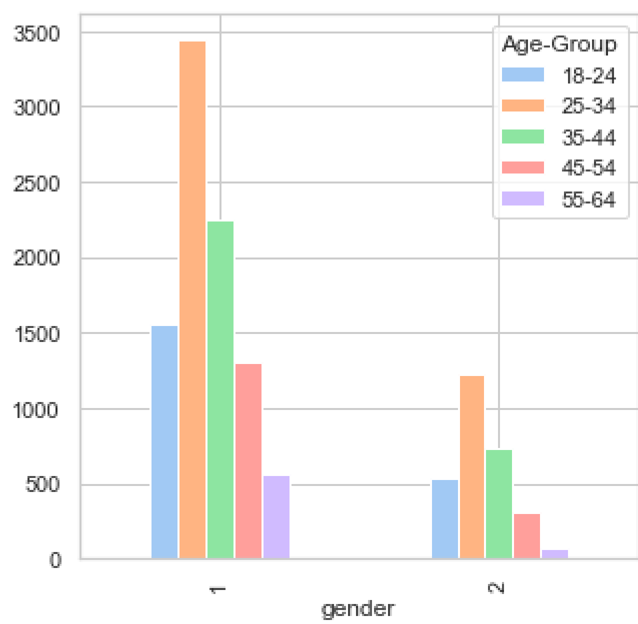
Out[152]:

	yrsurv	age	gender	irstrata	fearfail	Age-Group	suskill	opport	knowent	discent	exreaso
0	2008	28	2	2	2	25-34	1	1	1	0	(
1	2008	38	1	2	2	35-44	1	1	1	0	(
2	2008	26	2	6	2	25-34	1	1	1	0	(
3	2008	25	1	6	2	18-24	1	1	2	0	(
4	2008	45	1	2	-1	35-44	2	-1	1	0	(
...	...	...	...	...	...	...	...	...	...	...	..
12095	2019	54	2	6	1	45-54	1	2	1	0	(
12096	2019	21	2	6	1	18-24	2	2	1	0	(
12097	2019	24	2	6	2	18-24	1	1	1	0	(
12098	2019	31	2	6	2	25-34	1	2	2	0	(
12099	2019	32	2	6	2	25-34	2	2	1	0	(

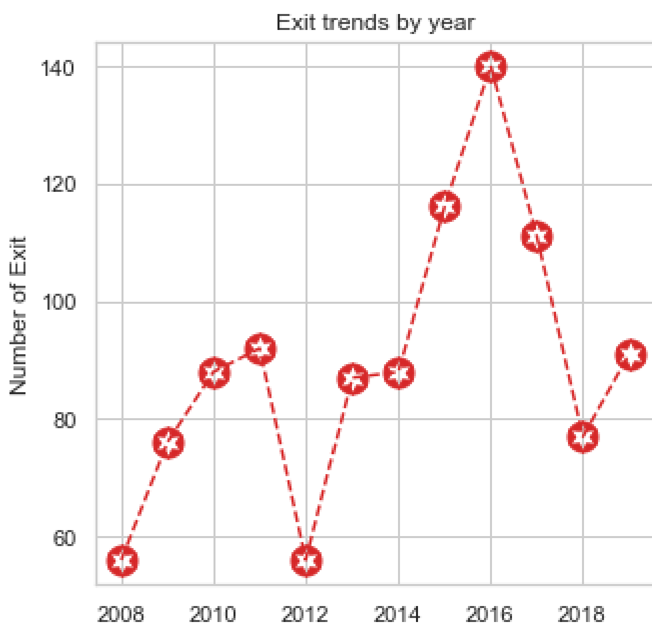
12100 rows × 12 columns

In [153]:
```
pd.crosstab(df.gender, df['Age-Group'], margins=False).plot(kind='bar')
```

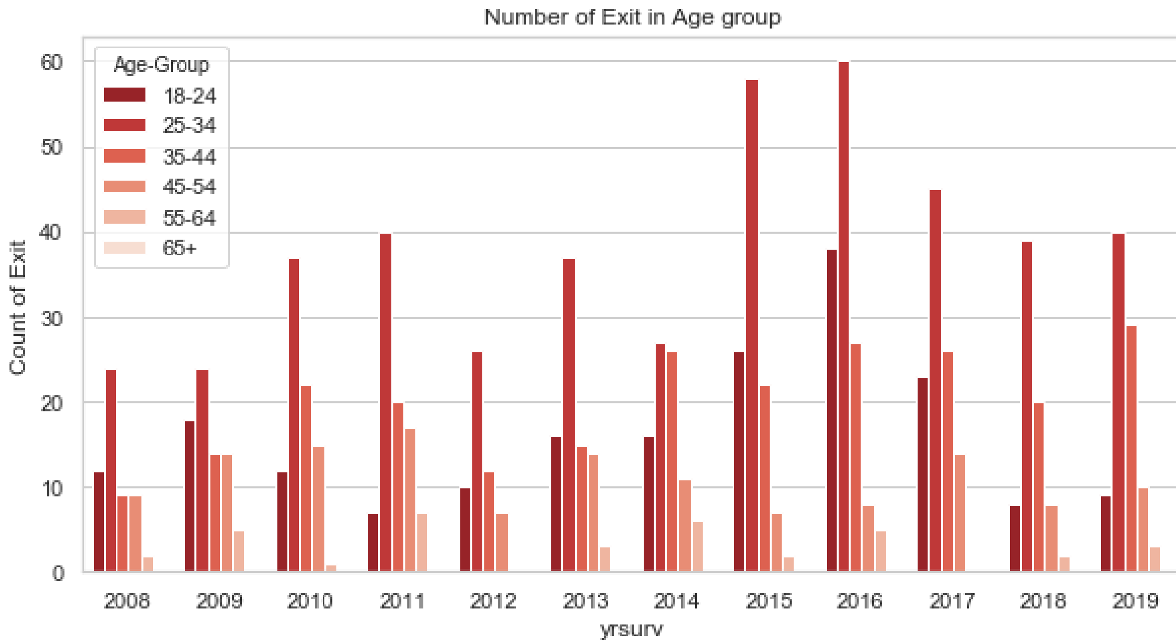
Out[153]: <matplotlib.axes._subplots.AxesSubplot at 0x14c887ad7c8>



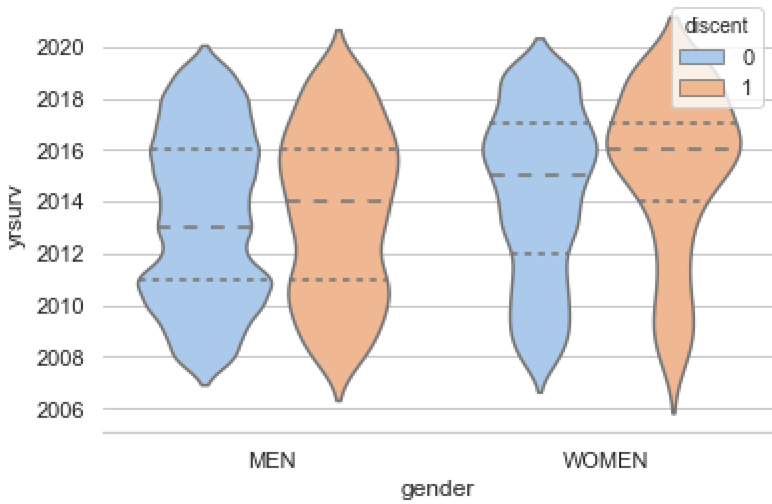
In [156]:
```
import matplotlib.path as mpath
q=df.groupby('yrsurv').agg({'discent':'sum'})

star = mpath.Path.unit_regular_star(6)
circle = mpath.Path.unit_circle()
# concatenate the circle with an internal cutout of the star
verts = np.concatenate([circle.vertices, star.vertices[::-1, ...]])
codes = np.concatenate([circle.codes, star.codes])
cut_star = mpath.Path(verts, codes)

figsize = (8,8)
plt.plot(q, '--r', marker=cut_star, markersize=15,C='#d62728')

plt.ylabel('Number of Exit')
plt.title('Exit trends by year')
plt.show()
```



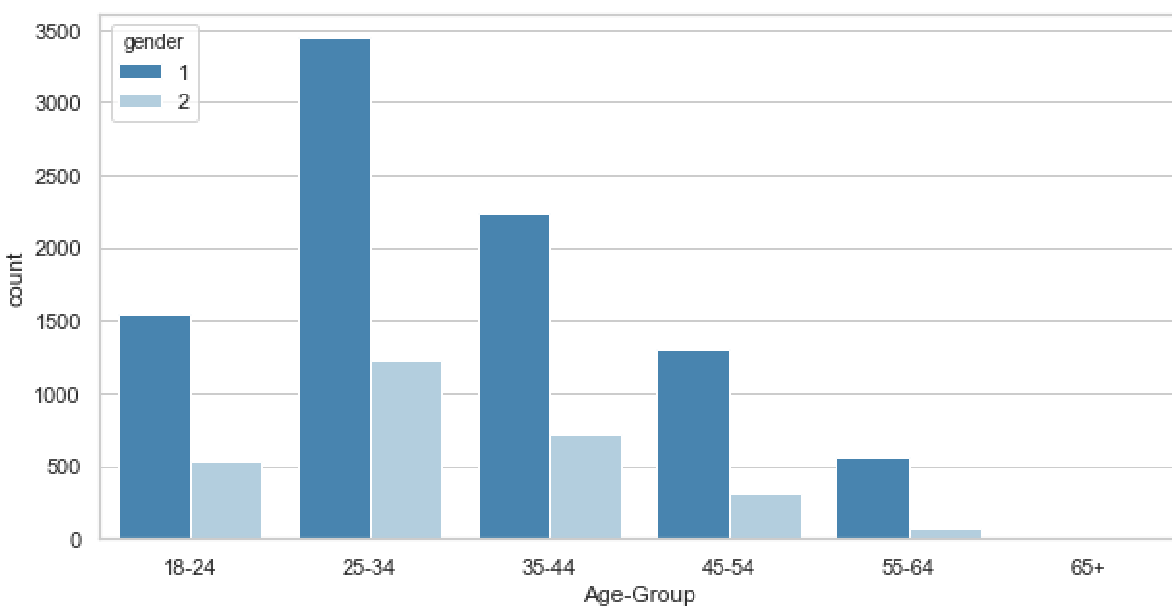
In [119]:
```
fig = plt.subplots(figsize=(10,5))


sns.countplot(df.yrsurv[df.discent==1], hue=df['Age-Group'][df.discent==1], pa
lette="Reds_r");

#sns.countplot(df1.yrsurv[df.discent==0], hue=df['Age-Group'][df1.discent==0],
palette="Blues_r");
plt.ylabel('Count of Exit')
plt.title('Number of Exit in Age group')
plt.show()
```



In [31]:
```
sns.set(style="whitegrid", palette="pastel")
ticks = list(range(0, 2, 1))
labels = "MEN WOMEN".split()


# Draw a nested violinplot and split the violins for easier comparison
sns.violinplot(x="gender", y="yrsurv",hue='discent',labels=["men", "women"],
               split=False, inner="quart", data=df)
plt.xticks( ticks ,labels)
sns.despine(left=True)
```



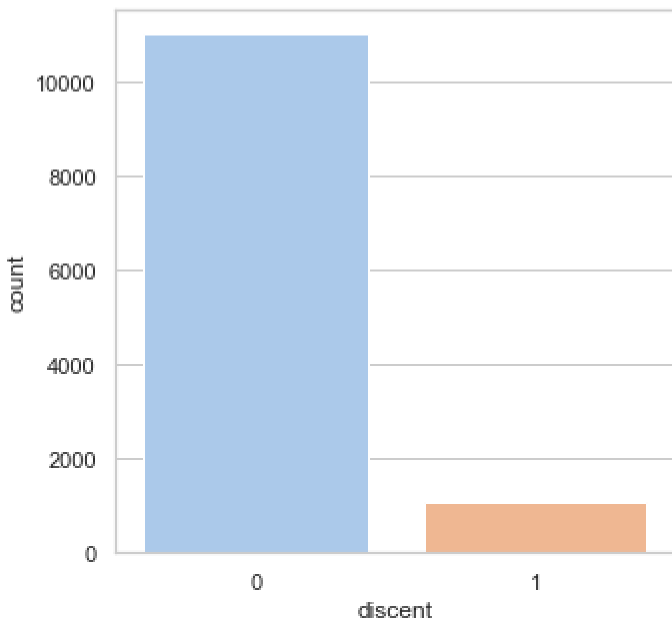
In [123]:
```
fig = plt.subplots(figsize=(10,5))


sns.countplot(df['Age-Group'], hue=df['gender'], palette="Blues_r");
#sns.countplot(df['Age-Group'], hue=df['discent'], palette="Reds_r");
```



In [157]:
```
print(df.discent.value_counts())

sns.countplot(df.discent)
```

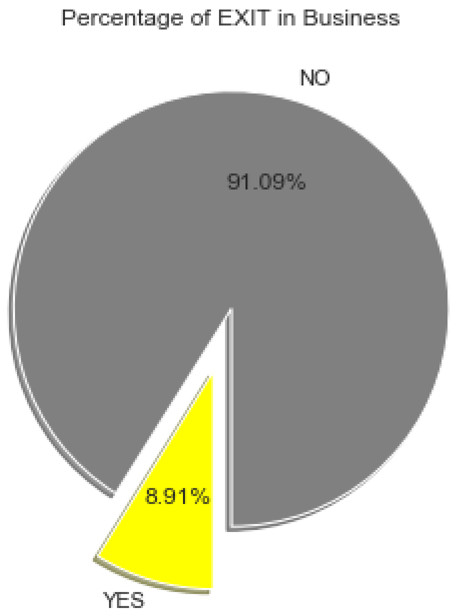
```
0    11022
1     1078
Name: discent, dtype: int64
```

Out[157]: <matplotlib.axes._subplots.AxesSubplot at 0x14c88a104c8>



In [159]:
```
from pylab import rcParams

# Data to plot
sizes = df['discent'].value_counts(sort = True)
colors = ["grey","yellow"]
rcParams['figure.figsize'] = 5,5 # Plot

plt.pie(sizes, explode = (0,0.3), labels=["NO", "YES"], colors=colors,
        autopct='%.2f%%', shadow=True, startangle=270)

plt.title('Percentage of EXIT in Business')
```

Out[159]:
```
Text(0.5, 1.0, 'Percentage of EXIT in Business')
```



In [160]:
```
df=df.drop(['Age-Group'],axis=1)
```

In [161]:
```
df
```

Out[161]:

	yrsurv	age	gender	irstrata	fearfail	suskill	opport	knowent	discent	exreason	bstar
0	2008	28	2	2	2	1	1	1	0	0	1
1	2008	38	1	2	2	1	1	1	0	0	1
2	2008	26	2	6	2	1	1	1	0	0	1
3	2008	25	1	6	2	1	1	2	0	0	2
4	2008	45	1	2	-1	2	-1	1	0	0	1
...	...	...	...	...	...	...	...	...	...	...	..
12095	2019	54	2	6	1	1	2	1	0	0	1
12096	2019	21	2	6	1	2	2	1	0	0	1
12097	2019	24	2	6	2	1	1	1	0	0	1
12098	2019	31	2	6	2	1	2	2	0	0	1
12099	2019	32	2	6	2	2	2	1	0	0	2

12100 rows × 11 columns

In [162]:
```
x=df.drop(['discent'], axis=1)
y=df.discent
```

In [163]:
```
print(x.shape , y.shape)
```

```
(12100, 10) (12100,)
```

In [164]:
```
x_train, x_test, y_train, y_test= train_test_split(x, y, test_size=0.3, random
_state=1)

x_train, x_val, y_train, y_val  = train_test_split(x_train, y_train, train_siz
e=0.7, random_state=1)
  # 0.25 x 0.8 = 0.2

print('valid', x_val.shape, y_val.shape)
print('Train', x_train.shape, y_train.shape)
print('Test', x_test.shape, y_test.shape)
```

```
valid (2541, 10) (2541,)
Train (5929, 10) (5929,)
Test (3630, 10) (3630,)
```

In [165]:
```
from imblearn import over_sampling
from imblearn.over_sampling import SMOTE
import sklearn
import imblearn
```

In [166]:
```
y_train.value_counts()
```

Out[166]:
```
0    5394
1     535
Name: discent, dtype: int64
```

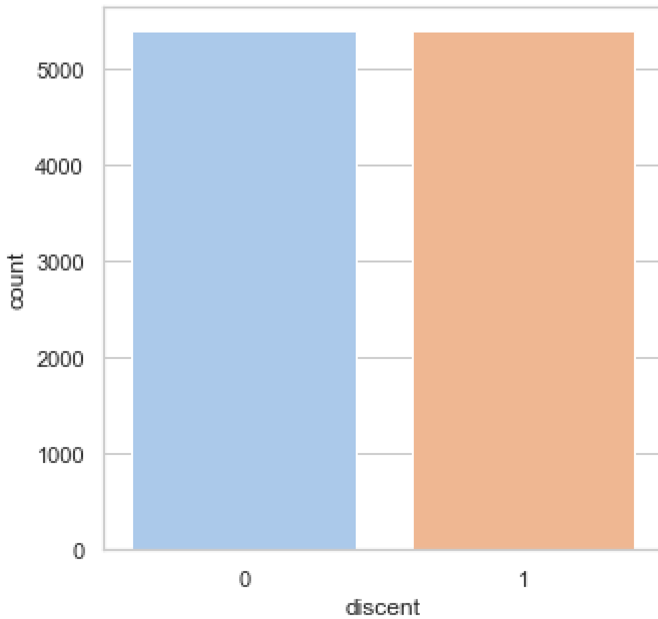
In [167]:
```
smt = SMOTE()
x_train , y_train = smt.fit_sample(x_train , y_train)
```

In [168]:
```
np.bincount(y_train)
```

Out[168]:
```
array([5394, 5394], dtype=int64)
```

In [169]:
```
sns.countplot(y_train)
```

Out[169]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x14c8886f748>
```



In [170]:
```
x_train.shape
```

Out[170]:
```
(10788, 10)
```

In [171]:
```
y_train.value_counts()
```

Out[171]:
```
1    5394
0    5394
Name: discent, dtype: int64
```

In [210]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC

from xgboost import XGBClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics import accuracy_score , average_precision_score , precisi
on_recall_curve , f1_score ,roc_curve ,auc
```

In [211]:
```
#LinearRegression
lm = LinearRegression()

lm.fit(x_train, y_train)

y_pred = lm.predict(x_test)

lm.score(x_test, y_test)
```

Out[211]: 0.5497208065285251

In [242]:
```
#LogisticRegression
lr_c=LogisticRegression(random_state=0)
lr_c.fit(x_train,y_train)
lr_pred=lr_c.predict(x_val)
lr_cm=confusion_matrix(y_val,lr_pred)
lr_ac=accuracy_score(y_val, lr_pred)
```

In [243]:
```
#RandomForest
rdf_c=RandomForestClassifier(n_estimators=10,criterion='entropy',random_state=
0)
rdf_c.fit(x_train,y_train)
rdf_pred=rdf_c.predict(x_val)
rdf_cm=confusion_matrix(y_val,rdf_pred)
rdf_ac=accuracy_score(rdf_pred,y_val)
```

In [244]:
```
# DecisionTree Classifier
dtree_c=DecisionTreeClassifier(criterion='entropy',random_state=0)
dtree_c.fit(x_train,y_train)
dtree_pred=dtree_c.predict(x_val)
dtree_cm=confusion_matrix(y_val,dtree_pred)
dtree_ac=accuracy_score(dtree_pred,y_val)
```

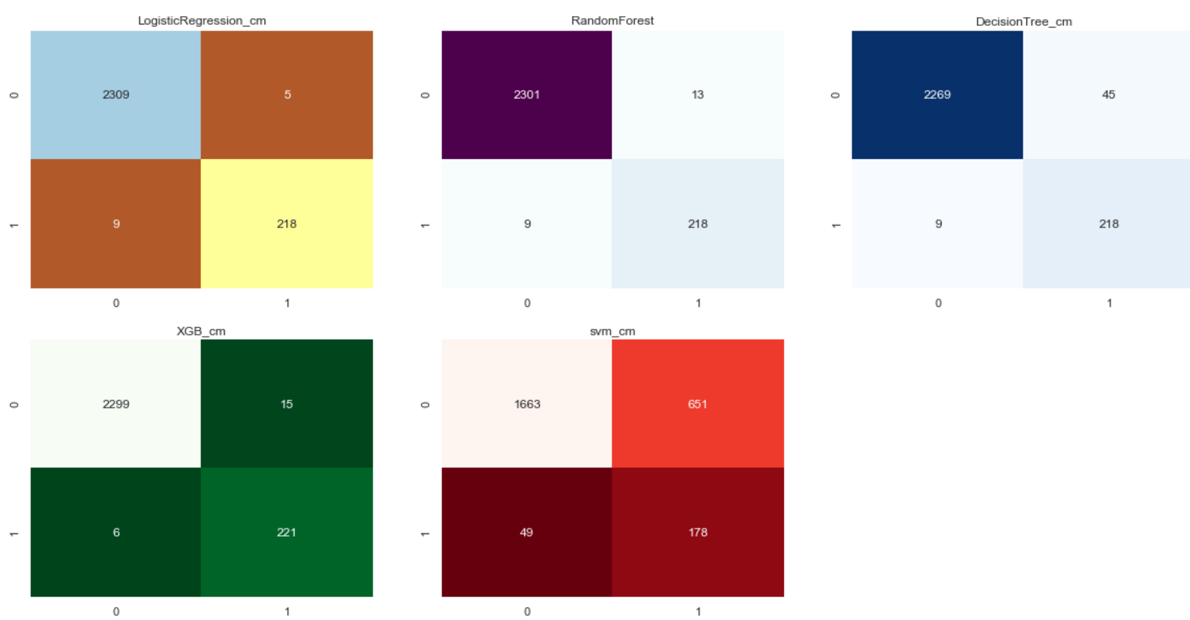
In [245]:
```
#XGBoost
XGB=XGBClassifier()
XGB.fit(x_train,y_train)
XGB_pred=XGB.predict(x_val)
XGB_cm=confusion_matrix(y_val,XGB_pred)
XGB_ac=accuracy_score(XGB_pred,y_val)
```

In [257]:
```
#SVM
svm_c=SVC( C=1.0)
svm_c.fit(x_train,y_train)
svm_pred=svm_c.predict(x_val)
svm_cm=confusion_matrix(y_val,svm_pred)
svm_ac=accuracy_score(svm_pred,y_val)
```

In [ ]:

In [258]:
```
plt.figure(figsize=(20,10))
target_names = ["continue", "exit"]

plt.subplot(2,3,1)
plt.title("LogisticRegression_cm")
sns.heatmap(lr_cm,annot=True,cmap="Paired_r",fmt="d",cbar=False)


plt.subplot(2,3,2)
plt.title("RandomForest")
sns.heatmap(rdf_cm,annot=True,cmap="BuPu",fmt="d",cbar=False)


plt.subplot(2,3,3)
plt.title("DecisionTree_cm")
sns.heatmap(dtree_cm,annot=True,cmap="Blues",fmt="d",cbar=False)


plt.subplot(2,3,4)
plt.title("XGB_cm")
sns.heatmap(XGB_cm,annot=True,cmap="Greens_r",fmt="d",cbar=False)


plt.subplot(2,3,5)
plt.title("svm_cm")
sns.heatmap(svm_cm,annot=True,cmap="Reds_r",fmt="d",cbar=False)
```

Out[258]: <matplotlib.axes._subplots.AxesSubplot at 0x14c88921b48>



In [266]:

```
print('LogisticRegression_accuracy:\t',lr_ac)
print('RandomForest_accuracy:\t\t',rdf_ac)
print('DecisionTree_accuracy:\t\t',dtree_ac)
print('XGB_accuracy:\t\t\t',XGB_ac)
print('SVM_accuracy:\t\t\t',svm_ac)
```

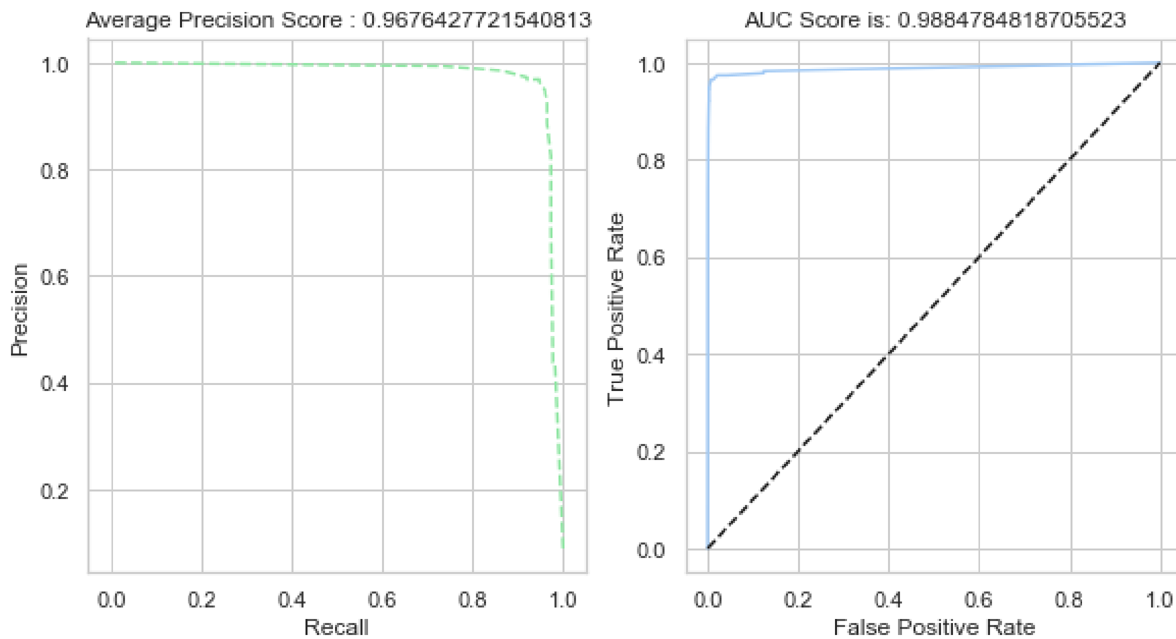
```
LogisticRegression_accuracy:     0.9944903581267218
RandomForest_accuracy:           0.9913419913419913
DecisionTree_accuracy:           0.9787485242030697
XGB_accuracy:                    0.9917355371900827
SVM_accuracy:                    0.7245179063360881
```

In [260]:

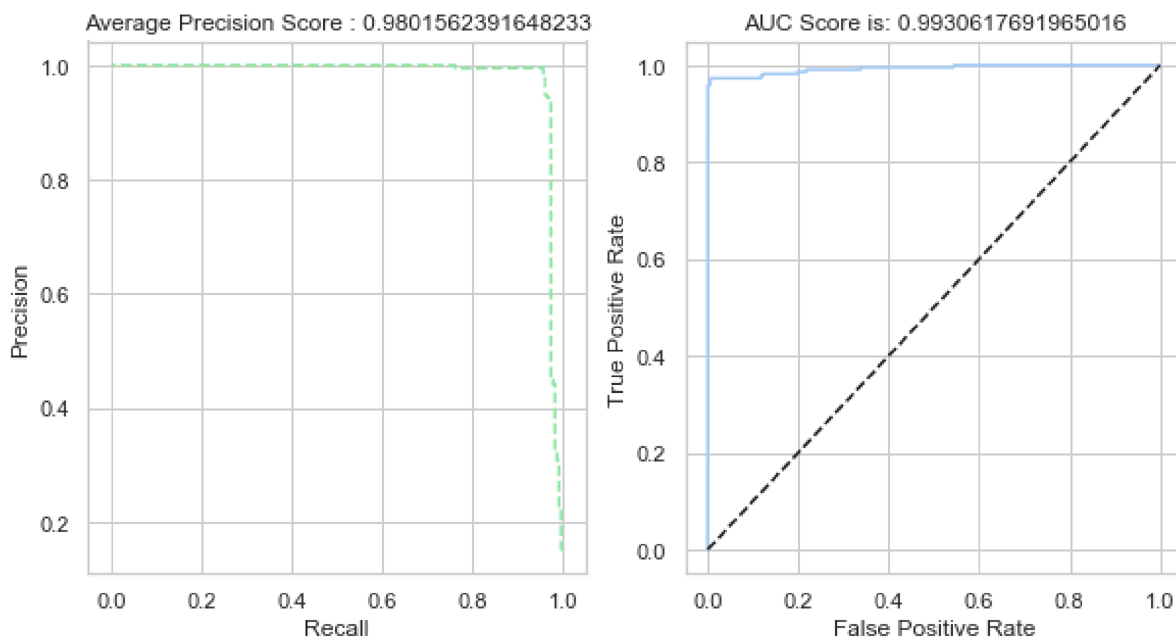
```
def plotting(true,pred):
    fig,ax=plt.subplots(1,2,figsize=(10,5))

    precision,recall,threshold = precision_recall_curve(true,pred[:,1])
    ax[0].plot(recall,precision,'g--')
    ax[0].set_xlabel('Recall')
    ax[0].set_ylabel('Precision')
    ax[0].set_title("Average Precision Score : {}".format(average_precision_sc
ore(true,pred[:,1])))


    fpr,tpr,threshold = roc_curve(true,pred[:,1])
    ax[1].plot(fpr,tpr)
    ax[1].set_title("AUC Score is: {}".format(auc(fpr,tpr)))
    ax[1].plot([0,1],[0,1],'k--')
    ax[1].set_xlabel('False Positive Rate')
    ax[1].set_ylabel('True Positive Rate')
```

In [261]:
```
plt.figure()
plotting(y_val ,rdf_c.predict_proba(x_val))


plt.figure()
plotting(y_val ,XGB.predict_proba(x_val))
```

```
<Figure size 360x360 with 0 Axes>
```




```
<Figure size 360x360 with 0 Axes>
```



In [262]:
```
from sklearn.metrics import accuracy_score, confusion_matrix, precision_score,
recall_score, precision_recall_curve


print('precision_score of LR: ',  precision_score(lr_pred, y_val))
print('precision_score of random forest : ',  precision_score(rdf_pred, y_val
))
print('precision_score of DTree: ',  precision_score(dtree_pred, y_val))
print('precision_score of XGB: ',  precision_score(XGB_pred, y_val))
print('precision_score of SVM: ',  precision_score(svm_pred, y_val))
```

```
precision_score of LR:  0.960352422907489
precision_score of random forest :  0.960352422907489
precision_score of DTree:  0.960352422907489
precision_score of XGB:  0.973568281938326
precision_score of SVM:  0.7841409691629956
```

In [263]:
```
print('recall_score of LR: ',  recall_score(lr_pred, y_val))
print('recall_score of random forest : ',  recall_score(rdf_pred, y_val))
print('recall_score of DTree: ',  recall_score(dtree_pred, y_val))
print('recall_score of XGB: ',  recall_score(XGB_pred, y_val))
print('recall_score of SVM: ',  recall_score(svm_pred, y_val))
```

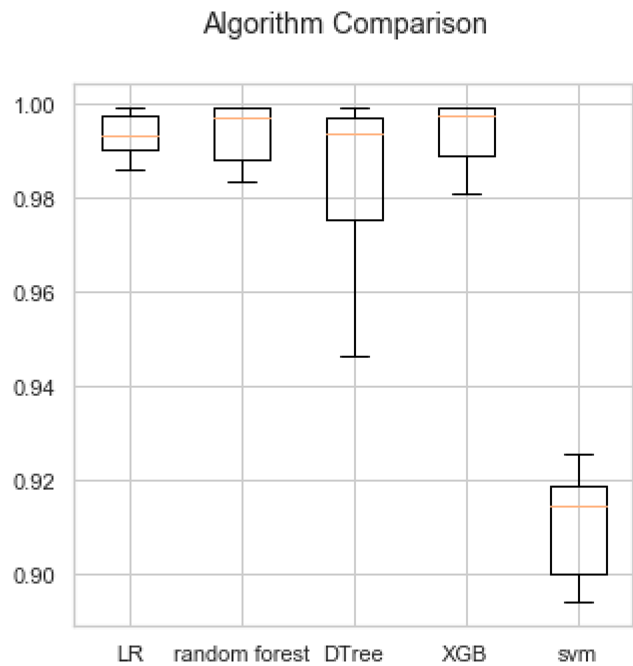
```
recall_score of LR:  0.9775784753363229
recall_score of random forest :  0.9437229437229437
recall_score of DTree:  0.8288973384030418
recall_score of XGB:  0.9364406779661016
recall_score of SVM:  0.2147165259348613
```

In [264]:
```
print('f1_score of LR: ',  f1_score(lr_pred, y_val))
print('f1_score of random forest : ',  f1_score(rdf_pred, y_val))
print('f1_score of DTree: ',  f1_score(dtree_pred, y_val))
print('f1_score of XGB: ',  f1_score(XGB_pred, y_val))
print('f1_score of SVM: ',  f1_score(svm_pred, y_val))
```

```
f1_score of LR:  0.9688888888888889
f1_score of random forest :  0.9519650655021834
f1_score of DTree:  0.889795918367347
f1_score of XGB:  0.9546436285097192
f1_score of SVM:  0.33712121212121215
```

In [265]:
```
from sklearn import model_selection
dataframe = df
array = dataframe.values

# prepare configuration for cross validation test harness
seed = 7
# prepare models
models = []
models.append(('LR', LogisticRegression()))
models.append(('random forest',RandomForestClassifier(n_estimators=10,criterio
n='entropy',random_state=0)))
models.append(('DTree', DecisionTreeClassifier(criterion='entropy',random_stat
e=0)))
models.append(('XGB', XGBClassifier()))
models.append(('svm' , SVC()))

# evaluate each model in turn
results = []
names = []
scoring = 'accuracy'
for name, model in models:
        kfold = model_selection.KFold(n_splits=10, random_state=seed)
        cv_results = model_selection.cross_val_score(model, x, y, cv=kfold, sc
oring=scoring)
        results.append(cv_results)
        names.append(name)
        msg = "%s: %f (%f)" % (name, cv_results.mean(), cv_results.std())
        print(msg)
# boxplot algorithm comparison
fig = plt.figure()
fig.suptitle('Algorithm Comparison')
ax = fig.add_subplot(111)
plt.boxplot(results)
ax.set_xticklabels(names)
plt.show()
```

```
LR: 0.993140 (0.004527)
random forest: 0.993554 (0.006270)
DTree: 0.982893 (0.018947)
XGB: 0.993802 (0.006176)
svm: 0.910909 (0.010653)
```



In [225]:
```
from sklearn.model_selection import GridSearchCV
rf = RandomForestClassifier()
n_estimators = [500,800,1000,2000]
max_depth = [3,5,8,10,11]
min_samples_split = [3,5]
min_samples_leaf = [1]

hyperF = dict (n_estimators = n_estimators, max_depth = max_depth,
              min_samples_split = min_samples_split,
             min_samples_leaf = min_samples_leaf)

gridF = GridSearchCV(rf , hyperF, cv = 3, verbose = 1)
bestF = gridF.fit(x_train, y_train)
```

```
Fitting 3 folds for each of 40 candidates, totalling 120 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent worke
rs.
[Parallel(n_jobs=1)]: Done 120 out of 120 | elapsed: 17.7min finished
```

In [226]:
```
gridF.best_params_
```

Out[226]:
```
{'max_depth': 11,
 'min_samples_leaf': 1,
 'min_samples_split': 3,
 'n_estimators': 800}
```

In [227]:
```
gridF.best_score_
```

Out[227]:
```
0.9839636633296255
```

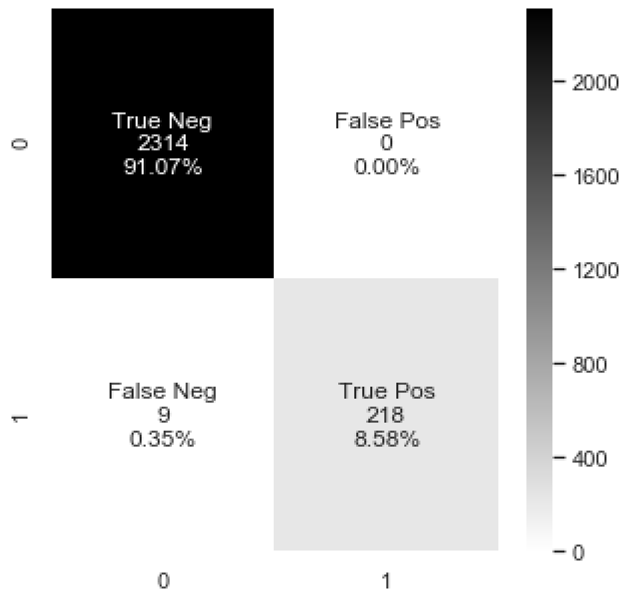
In [229]:
```
model = RandomForestClassifier(n_estimators = 800, max_depth = 11,
              min_samples_split = 3,
             min_samples_leaf = 1)
model.fit(x_val, y_val)

model_pred=model.predict(x_val)
model_cm=confusion_matrix(y_val,model_pred)
model_ac=accuracy_score(model_pred,y_val)
```

In [230]:
```
print('RandomForest_accuracy:\t\t',model_ac)

print('recall_score : ',  recall_score(model_pred, y_val))

print('precision_score : ',  precision_score(model_pred, y_val))

print('f1_score : ',  f1_score(model_pred, y_val))
```

```
RandomForest_accuracy:           0.9964580873671782
recall_score :  1.0
precision_score :  0.960352422907489
f1_score :  0.9797752808988764
```

In [231]:
```
group_names = ['True Neg','False Pos','False Neg','True Pos']
group_counts = ['{0:0.0f}'.format(value) for value in
                model_cm.flatten()]
group_percentages = ['{0:.2%}'.format(value) for value in
                     model_cm.flatten()/np.sum(model_cm)]
labels = [f"{v1}\n{v2}\n{v3}" for v1, v2, v3 in
          zip(group_names,group_counts,group_percentages)]
labels = np.asarray(labels).reshape(2,2)
sns.heatmap(model_cm, annot=labels, fmt='', cmap='binary')
```

Out[231]: <matplotlib.axes._subplots.AxesSubplot at 0x14c88e95d88>



In [232]:
```
accuracy = model.score(x_test, y_test)
print("Accuracy is %.2f %%" %(accuracy * 100))
```

Accuracy is 99.37 %

In [233]:
```
pred_classes = model.predict(x_test)

print("Predicted classes:")
print(pred_classes)
print("Actual classes:")
print(y_test)
```

```
Predicted classes:
[0 0 1 ... 0 1 0]
Actual classes:
1300     0
8033     0
5853     1
1475     0
1416     0
        ..
11861    0
3933     0
3906     1
4760     1
11628    0
Name: discent, Length: 3630, dtype: int64
```

In [234]:
```
from sklearn.metrics import roc_auc_score
```

In [235]:
```
y_pred = model.predict(x_test)
print("Roc_auc_score: ",roc_auc_score(y_test,y_pred)*100,"%")
```

```
Roc_auc_score:  96.36075949367088 %
```

In [236]:
```
model_T = RandomForestClassifier(n_estimators = 800, max_depth = 11,
              min_samples_split = 3,
             min_samples_leaf = 1)
model_T.fit(x_test, y_test)

model_pred=model_T.predict(x_test)
model_cm=confusion_matrix(y_test,model_pred)
model_ac=accuracy_score(model_pred,y_test)
```

In [237]:
```
from sklearn.metrics import accuracy_score, confusion_matrix, precision_score,
recall_score, precision_recall_curve
print('RandomForest_accuracy:\t\t',model_ac)

print('recall_score : ',  recall_score(model_pred, y_test))

print('precision_score : ',  precision_score(model_pred, y_test))

print('f1_score : ',  f1_score(model_pred, y_test))
```

```
RandomForest_accuracy:           0.9939393939393939
recall_score :  1.0
precision_score :  0.930379746835443
f1_score :  0.9639344262295081
```

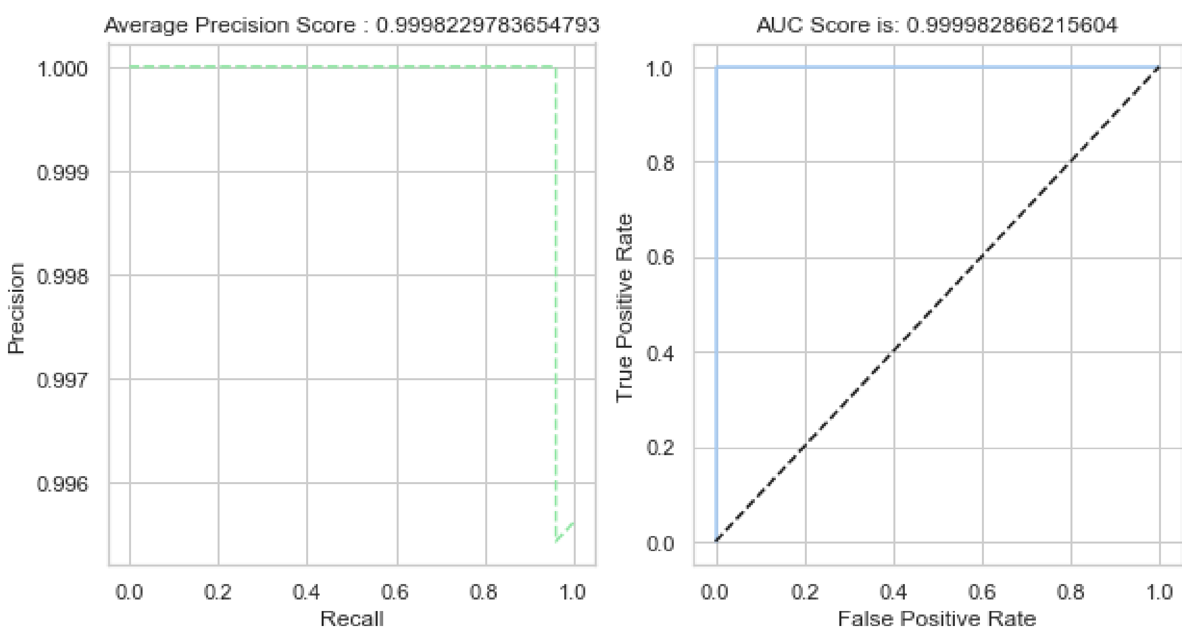
In [ ]:

In [ ]:

In [238]:
```
def plotting(true,pred):
    fig,ax=plt.subplots(1,2,figsize=(10,5))

    precision,recall,threshold = precision_recall_curve(true,pred[:,1])
    ax[0].plot(recall,precision,'g--')
    ax[0].set_xlabel('Recall')
    ax[0].set_ylabel('Precision')
    ax[0].set_title("Average Precision Score : {}".format(average_precision_sc
ore(true,pred[:,1])))


    fpr,tpr,threshold = roc_curve(true,pred[:,1])
    ax[1].plot(fpr,tpr)
    ax[1].set_title("AUC Score is: {}".format(auc(fpr,tpr)))
    ax[1].plot([0,1],[0,1],'k--')
    ax[1].set_xlabel('False Positive Rate')
    ax[1].set_ylabel('True Positive Rate')
```

In [239]:
```
plt.figure()
plotting(y_val ,model.predict_proba(x_val))
```

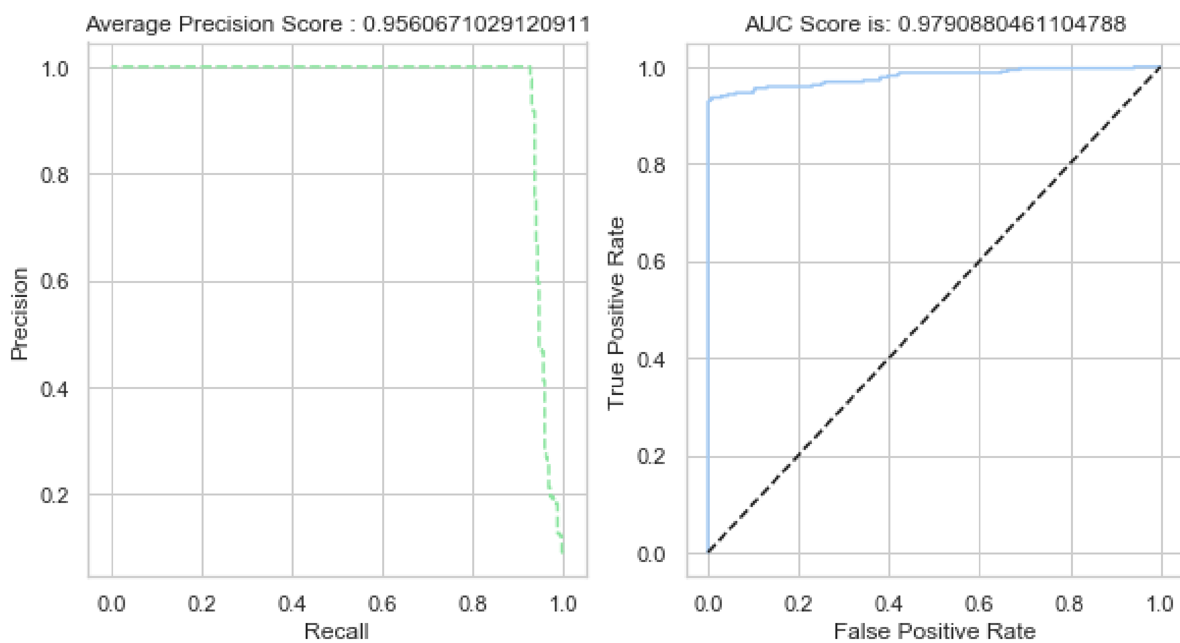
```
<Figure size 360x360 with 0 Axes>
```



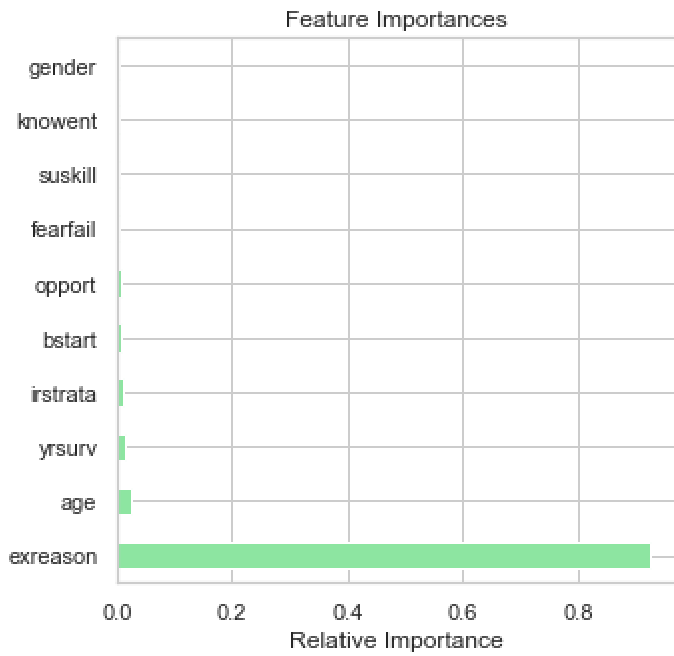
In [240]:
```
import sklearn.metrics as metrics
def plotting(true,pred):
    fig,ax=plt.subplots(1,2,figsize=(10,5))

    precision,recall,threshold = precision_recall_curve(true,pred[:,1])
    ax[0].plot(recall,precision,'g--')
    ax[0].set_xlabel('Recall')
    ax[0].set_ylabel('Precision')
    ax[0].set_title("Average Precision Score : {}".format(average_precision_sc
ore(true,pred[:,1])))


    fpr,tpr,threshold = roc_curve(true,pred[:,1])
    roc_auc = metrics.auc(fpr, tpr)
    ax[1].plot(fpr,tpr)
    ax[1].set_title("AUC Score is: {}".format(auc(fpr,tpr)))
    ax[1].plot([0,1],[0,1],'k--')
    ax[1].set_xlabel('False Positive Rate')
    ax[1].set_ylabel('True Positive Rate')
```

In [241]:
```
plt.figure()
plotting(y_test ,model.predict_proba(x_test))
```

```
<Figure size 360x360 with 0 Axes>
```

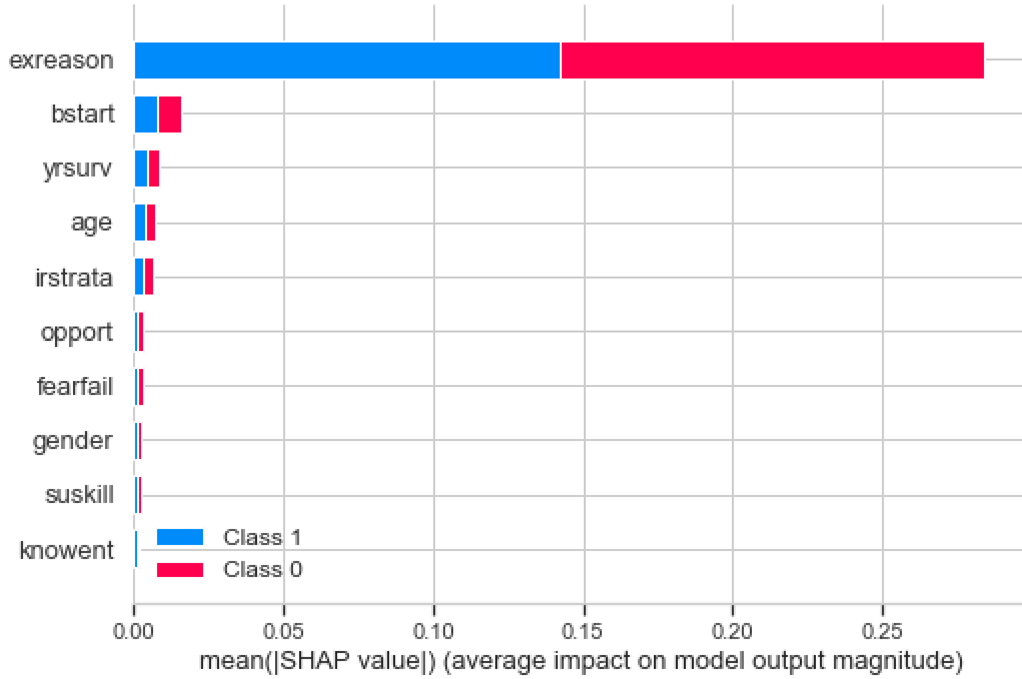


In [109]:
```
feat_importances = pd.Series(model.feature_importances_, index=x.columns)

feat_importances.nlargest(20).plot(kind='barh', color='g',)
plt.title('Feature Importances')
#plt.barh(range(len(indices)), importances[indices], color='g', align='cente
r')
#plt.yticks(range(len(indices)), [features[i] for i in indices])
plt.xlabel('Relative Importance')
plt.show()
```



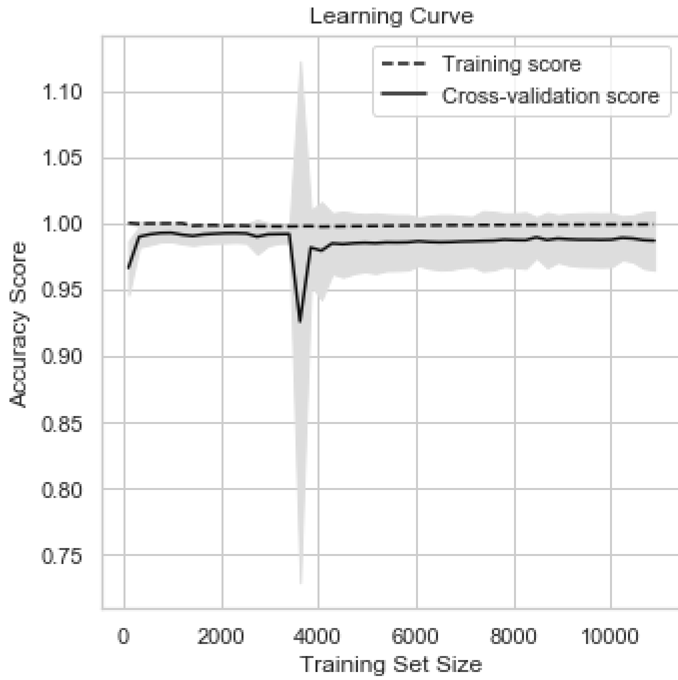
In [92]:
```
import shap
explainer = shap.TreeExplainer(model)
shap_values = explainer.shap_values(x_test)
```

In [93]:
```
shap.summary_plot(shap_values, x_test, plot_type="bar")
```



In [94]:
```
from sklearn.model_selection import learning_curve
from sklearn.model_selection import ShuffleSplit
```

In [95]:
```
train_sizes, train_scores, test_scores = learning_curve(RandomForestClassifier
(),
                                                        x,
                                                        y,
                                                        # Number of folds in c
ross-validation
                                                        cv=10,
                                                        # Evaluation metric
                                                        scoring='accuracy',
                                                        # Use all computer cor
es
                                                        n_jobs=-1,
                                                        # 50 different sizes o
f the training set
                                                        train_sizes=np.linspac
e(0.01, 1.0, 50))

# Create means and standard deviations of training set scores
train_mean = np.mean(train_scores, axis=1)
train_std = np.std(train_scores, axis=1)

# Create means and standard deviations of test set scores
test_mean = np.mean(test_scores, axis=1)
test_std = np.std(test_scores, axis=1)

# Draw lines
plt.plot(train_sizes, train_mean, '--', color="#111111",  label="Training scor
e")
plt.plot(train_sizes, test_mean, color="#111111", label="Cross-validation scor
e")


# Draw bands
plt.fill_between(train_sizes, train_mean - train_std, train_mean + train_std,
color="#DDDDDD")
plt.fill_between(train_sizes, test_mean - test_std, test_mean + test_std, colo
r="#DDDDDD")


# Create plot
plt.title("Learning Curve")
plt.xlabel("Training Set Size"), plt.ylabel("Accuracy Score"), plt.legend(loc=
"best")
plt.tight_layout()
plt.show()
```



In [96]:
```
# save the model to disk with pickle
from pickle import dump

filename = 'finalized_RandomForest_GEM_model-E.sav'
dump(model, open(filename, 'wb'))
```

In [97]:
```
# load the model from disk with pickle
from pickle import load

loaded_model = load(open(filename, 'rb'))
result = loaded_model.score(x_test, y_test)
print(result)
```

```
0.99366391184573
```

In [ ]:

In [ ]: