Gmail Classification Models

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Import Libraries

In [57]:

```
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns
sns.set_style('whitegrid')

import nltk
from nltk.tokenize import word_tokenize
from nltk.tokenize import RegexpTokenizer
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix
from sklearn.linear_model import LogisticRegression

import warnings
warnings.filterwarnings("ignore")
```

Read Excel file

In [2]:

```
df = pd.read_excel("All_Emails.xlsx")

df.drop('Unnamed: 0', axis=1, inplace = True)
df.columns = ['Label', 'Text', 'Label_Number']
df.head()
```

Out[2]:

	Label	Text	Label_Number
0	spam	Why United Kingdom is best study destination_x...	1
1	non_spam	Homeowners are looking for a tenant like you z...	0
2	non_spam	Shop Assigned Mi Home VM JanakpuriHigh Street...	0
3	non_spam	Profile picture pending approval_x000D_\nHi Ru...	0
4	non_spam	Mahimagoyal JEE Main New Exam Dates Out_x000D_\n	0

In [3]:

```
df.shape
```

Out[3]:

```
(980, 3)
```

In [4]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 980 entries, 0 to 979
Data columns (total 3 columns):
```

```
Data columns (total 3 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Label         980 non-null    object
 1   Text          980 non-null    object
 2   Label_Number  980 non-null    int64
dtypes: int64(1), object(2)
memory usage: 23.1+ KB
```

In [5]:

```
df.isna().sum()
```

Out[5]:

```
Label           0
Text            0
Label_Number    0
dtype: int64
```

In [6]:

```
df['Label_Number'].value_counts()
```

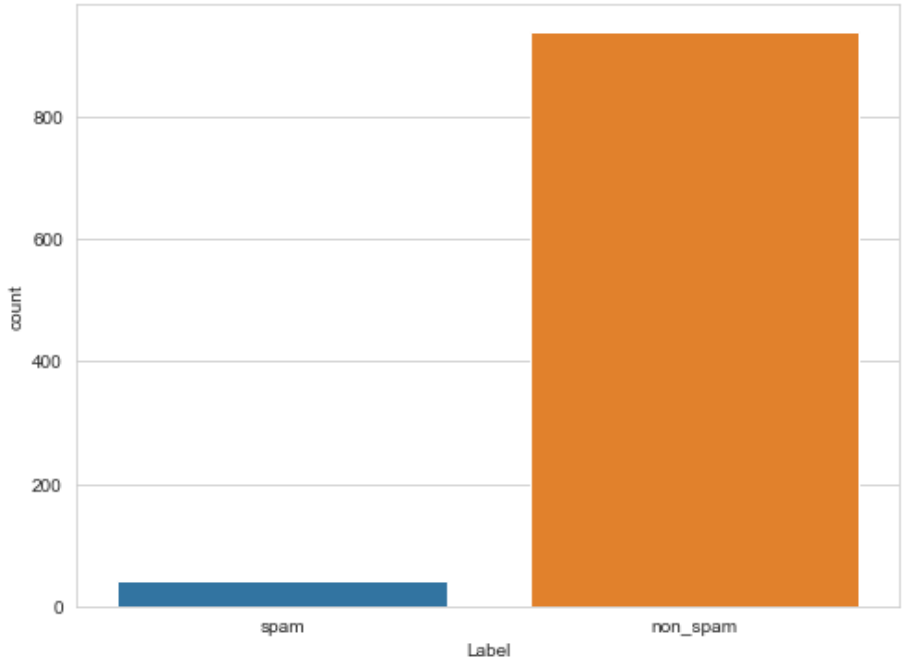
Out[6]:

```
0    938
1     42
Name: Label_Number, dtype: int64
```

Count Plot

In [7]:

```
plt.figure(figsize = (8, 6))
sns.countplot(data = df, x = 'Label');
```



Count no. of each word

In [8]:

```
import nltk
  nltk.download('punkt')
```

```
[nltk_data] Error loading punkt: <urlopen error [WinError 10061] No
[nltk_data]     connection could be made because the target machine
[nltk_data]     actively refused it>
```

Out[8]:

```
False
```

In [9]:

```
def count_words(text):
    words = word_tokenize(text)
    return len(words)
df['count']=df['Text'].apply(count_words)
df['count']
```

Out[9]:

```
0      713
1      114
2      687
3      107
4        7
      ...
975     27
976     28
977    277
978     15
979      3
Name: count, Length: 980, dtype: int64
```

In [10]:

```
df.groupby('Label_Number')['count'].mean()
```

Out[10]:

```
Label_Number
0    199.382729
1    423.642857
Name: count, dtype: float64
```

Tokenization

In [11]:

```
%%time
def clean_str(string, reg = RegexpTokenizer(r'[a-z]+')):
    # Clean a string with RegexpTokenizer
    string = string.lower()
    tokens = reg.tokenize(string)
    return " ".join(tokens)

print('Before cleaning:')
df.head()
```

```
Before cleaning:
Wall time: 0 ns
```

Out[11]:

	Label	Text	Label_Number	count
0	spam	Why United Kingdom is best study destination_x...	1	713
1	non_spam	Homeowners are looking for a tenant like you z...	0	114
2	non_spam	Shop Assigned Mi Home VM JanakpuriHigh Street...	0	687
3	non_spam	Profile picture pending approval_x000D_\nHi Ru...	0	107
4	non_spam	Mahimagoyal JEE Main New Exam Dates Out_x000D_\n	0	7

In [12]:

```
print('After cleaning:')
```

```
print('After cleaning:')
df['Text'] = df['Text'].apply(lambda string: clean_str(string))
df.head()
```

After cleaning:

Out[12]:

	Label	Text	Label_Number	count
0	spam	why united kingdom is best study destination x...	1	713
1	non_spam	homeowners are looking for a tenant like you z...	0	114
2	non_spam	shop assigned mi home vm janakpurihigh street ...	0	687
3	non_spam	profile picture pending approval x d hi rupal ...	0	107
4	non_spam	mahimagoyal jee main new exam dates out x d	0	7

Stemming words

In [13]:

```
from nltk.stem import PorterStemmer
stemmer = PorterStemmer()
def stemming (text):
    return ''.join([stemmer.stem(word) for word in text])
df['Text']=df['Text'].apply(stemming)
df.head()
```

Out[13]:

	Label	Text	Label_Number	count
0	spam	why united kingdom is best study destination x...	1	713
1	non_spam	homeowners are looking for a tenant like you z...	0	114
2	non_spam	shop assigned mi home vm janakpurihigh street ...	0	687
3	non_spam	profile picture pending approval x d hi rupal ...	0	107
4	non_spam	mahimagoyal jee main new exam dates out x d	0	7

In [14]:

```
X = df.loc[:, 'Text']
y = df.loc[:, 'Label_Number']

print(f"Shape of X: {X.shape}\nshape of y: {y.shape}")
```

```
Shape of X: (980,)
shape of y: (980,)
```

Split into Training data and Test data

In [15]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20, random_stat
e=11)
```

In [16]:

```
print(f"Training Data Shape: {X_train.shape}\nTest Data Shape: {X_test.shape}")
```

```
Training Data Shape: (784,)
Test Data Shape: (196,)
```

Count Vectorization to Extract Features from Text

In [17]:

```
from sklearn.feature_extraction.text import CountVectorizer
cv=CountVectorizer()
cv.fit(X_train)
```

Out[17]:

▾ CountVectorizer
CountVectorizer()

In [18]:

```
print('No.of Tokens: ',len(cv.vocabulary_.keys()))
```

```
No.of Tokens:  9246
```

In [19]:

```
dtv = cv.transform(X_train)
type(dtv)
```

Out[19]:

```
scipy.sparse.csr.csr_matrix
```

In [20]:

```
dtv = dtv.toarray()
```

In [21]:

```
print(f"Number of Observations: {dtv.shape[0]}\nTokens/Features: {dtv.shape[1]}")
```

```
Number of Observations: 784
Tokens/Features: 9246
```

In [22]:

```
dtv[1]
```

Out[22]:

```
array([0, 0, 0, ..., 0, 0, 0], dtype=int64)
```

Apply different models

In [23]:

```
%%time
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import LinearSVC, SVC
from time import perf_counter
import warnings
warnings.filterwarnings(action='ignore')
models = {
    "Random Forest": {"model":RandomForestClassifier(), "perf":0},
    "MultinomialNB": {"model":MultinomialNB(), "perf":0},
    "Logistic Regr.": {"model":LogisticRegression(solver='liblinear', penalty ='l2' ,
C = 1.0), "perf":0},
    "KNN": {"model":KNeighborsClassifier(), "perf":0},
    "Decision Tree": {"model":DecisionTreeClassifier(), "perf":0},
    "SVM (Linear)": {"model":LinearSVC(), "perf":0},
```

```
    "SVM (RBF)": {"model":SVC(), "perf":0}
}

for name, model in models.items():
    start = perf_counter()
    model['model'].fit(dtv, y_train)
    duration = perf_counter() - start
    duration = round(duration,2)
    model["perf"] = duration
    print(f"{name:20} trained in {duration} sec")
```

```
Random Forest        trained in 2.39 sec
MultinomialNB        trained in 0.12 sec
Logistic Regr.       trained in 0.23 sec
KNN                  trained in 0.0 sec
Decision Tree        trained in 1.65 sec
SVM (Linear)         trained in 0.22 sec
SVM (RBF)            trained in 1.03 sec
Wall time: 5.86 s
```

In [24]:

```
test_dtv = cv.transform(X_test)
test_dtv = test_dtv.toarray()
print(f"Number of Observations: {test_dtv.shape[0]}\nTokens: {test_dtv.shape[1]}")
```

```
Number of Observations: 196
Tokens: 9246
```

Test Accuracy and Training Time

In [25]:

```
models_accuracy = []
for name, model in models.items():
    models_accuracy.append([name, model["model"].score(test_dtv, y_test),model["perf"
]])
```

In [26]:

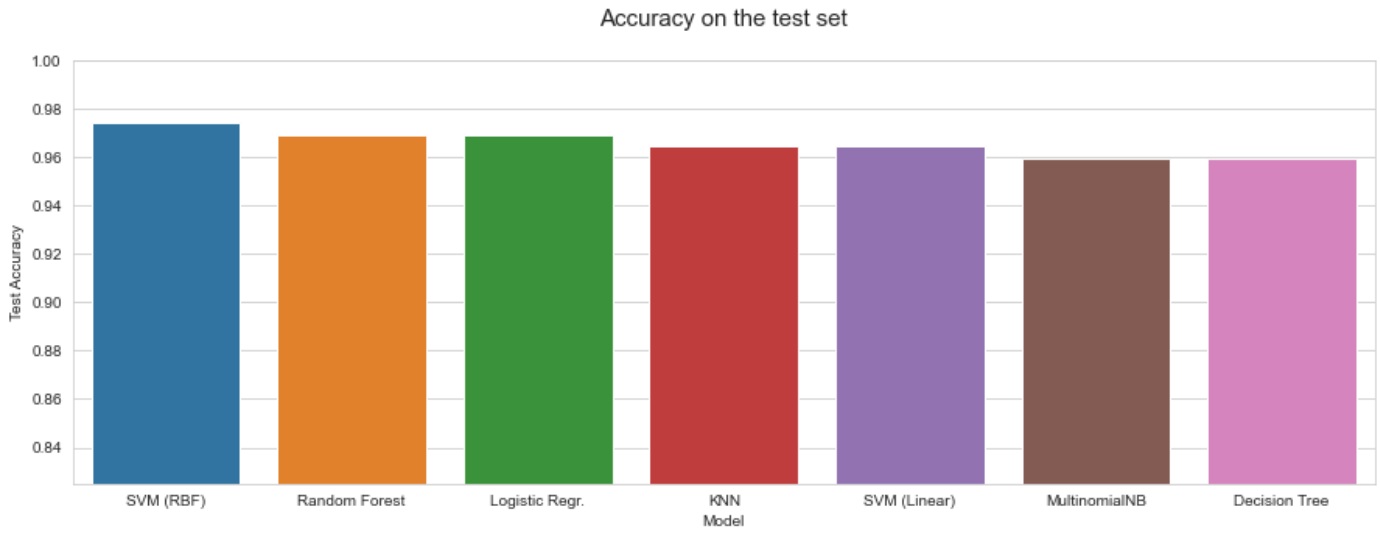
```
df_accuracy = pd.DataFrame(models_accuracy)
df_accuracy.columns = ['Model', 'Test Accuracy', 'Training time (sec)']
df_accuracy.sort_values(by = 'Test Accuracy', ascending = False, inplace=True)
df_accuracy.reset_index(drop = True, inplace=True)
df_accuracy
```

Out[26]:

	Model	Test Accuracy	Training time (sec)
0	SVM (RBF)	0.974490	1.03
1	Random Forest	0.969388	2.39
2	Logistic Regr.	0.969388	0.23
3	KNN	0.964286	0.00
4	SVM (Linear)	0.964286	0.22
5	MultinomialNB	0.959184	0.12
6	Decision Tree	0.959184	1.65

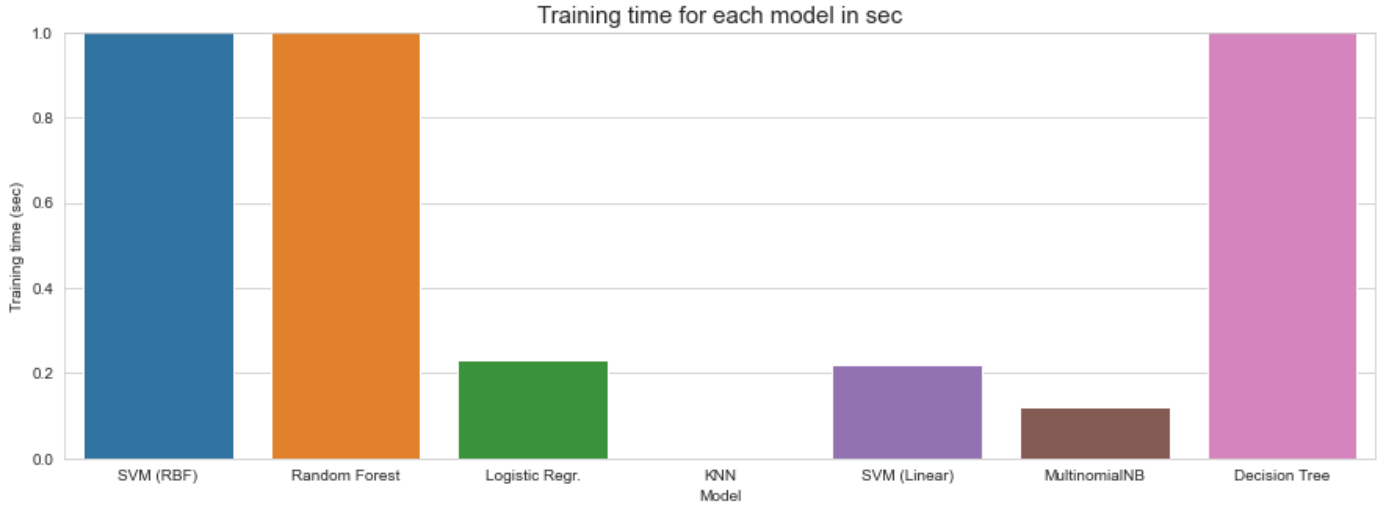
In [27]:

```
plt.figure(figsize = (15,5))
sns.barplot(x = 'Model', y ='Test Accuracy', data = df_accuracy)
plt.title('Accuracy on the test set\n', fontsize = 15)
plt.ylim(0.825,1)
plt.show()
```



In [28]:

```
plt.figure(figsize = (15,5))
sns.barplot(x = 'Model', y = 'Training time (sec)', data = df_accuracy)
plt.title('Training time for each model in sec', fontsize = 15)
plt.ylim(0,1)
plt.show()
```



Logistic Regression

In [29]:

```
%%time
lr = LogisticRegression(solver='liblinear', penalty ='l2' , C = 1.0)
lr.fit(dtv, y_train)
pred = lr.predict(test_dtv)
```

```
Wall time: 229 ms
```

In [30]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  96.93877551020408
```

Classification Report

In [31]:

```
print(classification_report(y_test, pred))
```

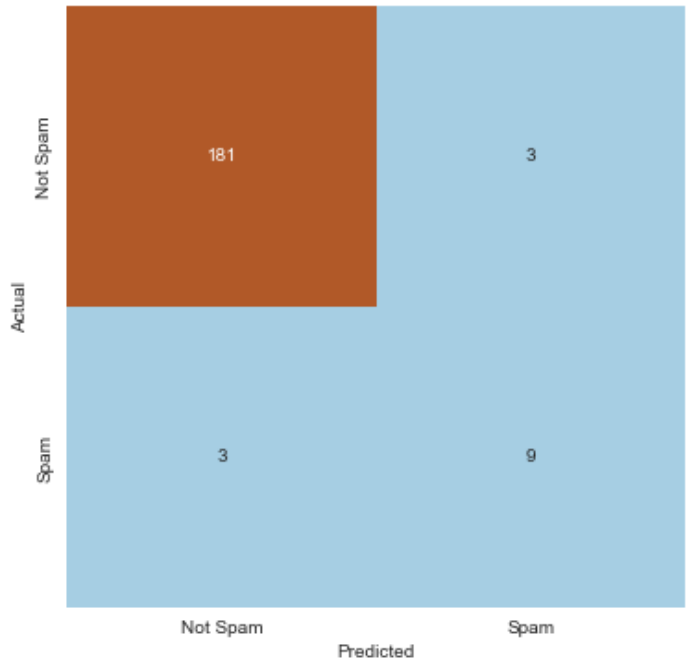
```
              precision    recall  f1-score   support
```

```
              0       0.98      0.98      0.98       184
              1       0.75      0.75      0.75        12

    accuracy                            0.97       196
   macro avg        0.87      0.87      0.87       196
weighted avg        0.97      0.97      0.97       196
```

Confusion Matrix

In [32]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```



Support Vector Machine (RBF)

In [33]:

```
%%time
svc = SVC()
svc.fit(dtv, y_train)
pred = svc.predict(test_dtv)
```

```
Wall time: 2.37 s
```

In [34]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  97.44897959183673
```

Classification Report

In [35]:

```
print(classification_report(y_test, pred))
```

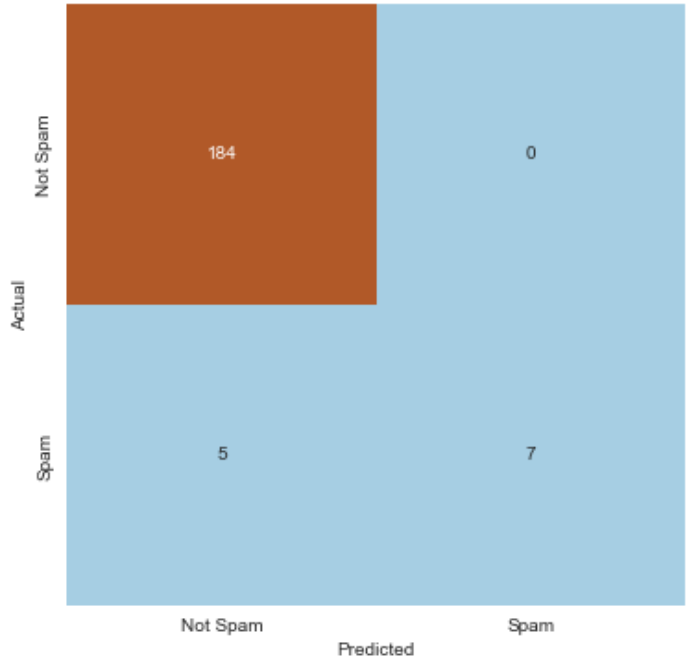
```
              precision    recall  f1-score   support

           0       0.97      1.00      0.99       184
```

```
           0       0.97      1.00      0.99       184
           1       1.00      0.58      0.74        12

    accuracy                           0.97       196
   macro avg       0.99      0.79      0.86       196
weighted avg       0.98      0.97      0.97       196
```

Confusion Matrix

In [36]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```



Random Forest Classifier

In [37]:

```
%%time
rfc = RandomForestClassifier()
rfc.fit(dtv, y_train)
pred = rfc.predict(test_dtv)
```

```
Wall time: 2.28 s
```

In [38]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  95.91836734693877
```

Classification Report

In [39]:

```
print(classification_report(y_test, pred))
```

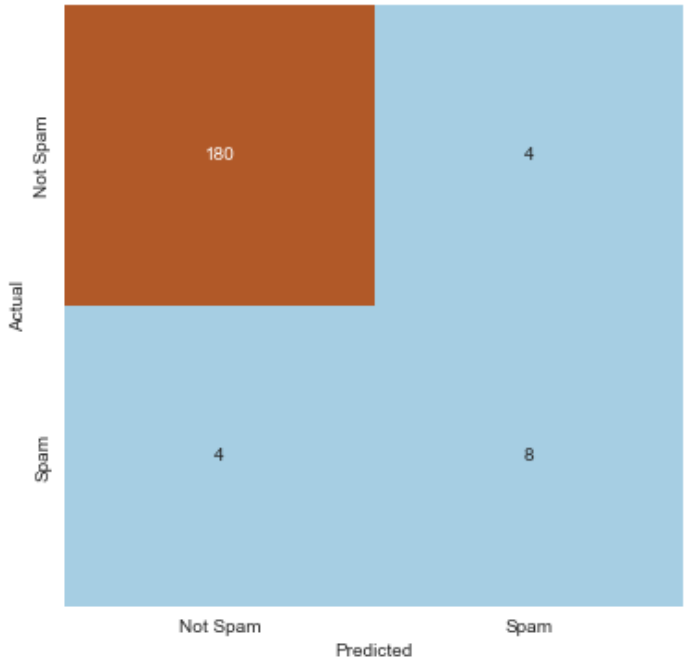
```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98       184
           1       0.67      0.67      0.67        12
```

```
    accuracy                           0.96       196
   macro avg       0.82      0.82      0.82       196
weighted avg       0.96      0.96      0.96       196
```

Confusion Matrix

In [40]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```



Multinomial Naive Bayes

In [41]:

```
%%time
mnb = MultinomialNB()
mnb.fit(dtv, y_train)
pred = mnb.predict(test_dtv)
```

```
Wall time: 120 ms
```

In [42]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  95.91836734693877
```

Classification Report

In [43]:

```
print(classification_report(y_test, pred))
```

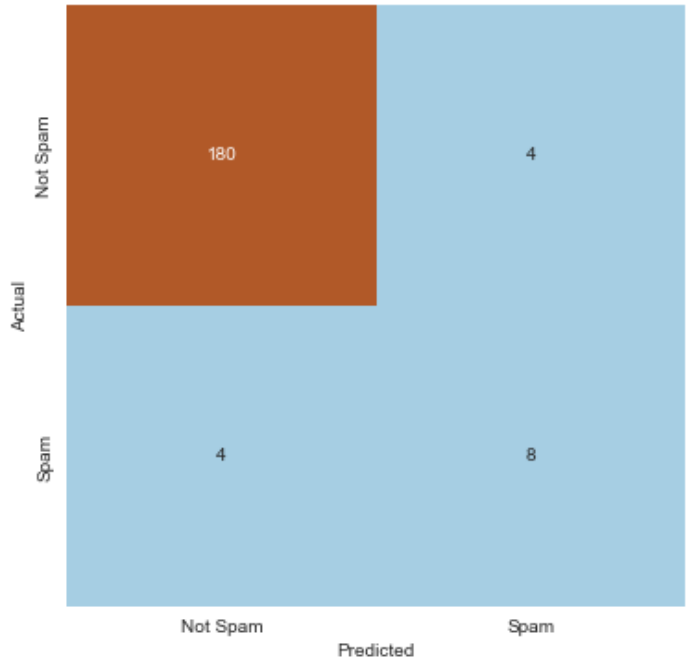
```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98       184
           1       0.67      0.67      0.67        12

    accuracy                           0.96       196
```

```
   macro avg       0.82      0.82      0.82       196
weighted avg       0.96      0.96      0.96       196
```

Confusion Matrix

In [44]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```



Support Vector Machine (Linear)

In [45]:

```
%%time
lsvc = LinearSVC()
lsvc.fit(dtv, y_train)
pred = lsvc.predict(test_dtv)
```

```
Wall time: 148 ms
```

In [46]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  96.42857142857143
```

Classification Report

In [47]:

```
print(classification_report(y_test, pred))
```

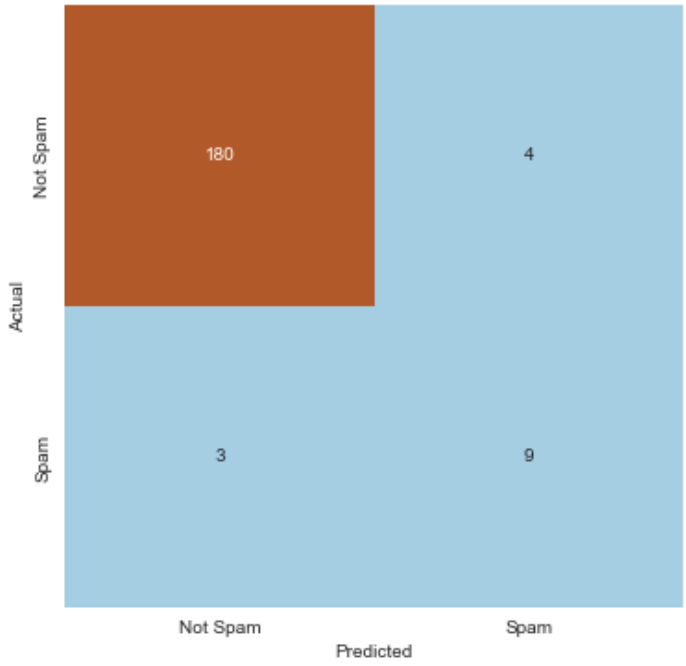
```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98       184
           1       0.69      0.75      0.72        12

    accuracy                           0.96       196
   macro avg       0.84      0.86      0.85       196
```

```
weighted avg       0.97      0.96      0.96       196
```

Confusion Matrix

In [48]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```



Decision Tree Classifier

In [49]:

```
%%time
dtc = DecisionTreeClassifier()
dtc.fit(dtv, y_train)
pred = dtc.predict(test_dtv)
```

```
Wall time: 1.57 s
```

In [50]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  96.93877551020408
```

Classification Report

In [51]:

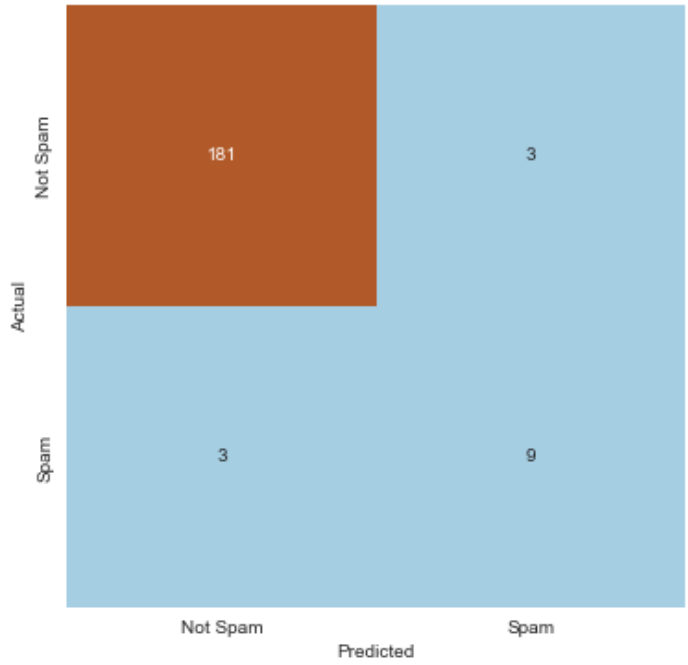
```
print(classification_report(y_test, pred))
```

```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98       184
           1       0.75      0.75      0.75        12

    accuracy                           0.97       196
   macro avg       0.87      0.87      0.87       196
weighted avg       0.97      0.97      0.97       196
```

Confusion Matrix

In [52]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```



K Nearest Neighbours

In [53]:

```
%%time
knn = KNeighborsClassifier()
knn.fit(dtv, y_train)
pred = knn.predict(test_dtv)
```

```
Wall time: 161 ms
```

In [54]:

```
print('Accuracy: ', accuracy_score(y_test, pred) * 100)
```

```
Accuracy:  96.42857142857143
```

Classification Report

In [55]:

```
print(classification_report(y_test, pred))
```

```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98       184
           1       0.73      0.67      0.70        12

    accuracy                           0.96       196
   macro avg       0.85      0.83      0.84       196
weighted avg       0.96      0.96      0.96       196
```

Confusion Matrix

In [56]:

```
confusion_matrix = pd.crosstab(y_test, pred, rownames=['Actual'], colnames=['Predicted
'])
plt.figure(figsize = (6, 6))
sns.heatmap(confusion_matrix, annot = True, cmap = 'Paired', cbar = False, fmt="d", xt
icklabels=['Not Spam', 'Spam'], yticklabels=['Not Spam', 'Spam']);
```