```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import nltk
from nltk.stem.porter import PorterStemmer
nltk.download('stopwords')
from nltk.corpus import stopwords
STOPWORDS = set(stopwords.words('english'))

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import StratifiedKFold
from sklearn.metrics import accuracy_score
from wordcloud import WordCloud
from sklearn.tree import DecisionTreeClassifier
from xgboost import XGBClassifier
import pickle
import re
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\Joy\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

```
%pip install wordcloud
```

```
Requirement already satisfied: wordcloud in c:\users\joy\appdata\
local\programs\python\python312\lib\site-packages (1.9.3)
Requirement already satisfied: numpy>=1.6.1 in c:\users\joy\appdata\
local\programs\python\python312\lib\site-packages (from wordcloud)
(1.26.4)
Requirement already satisfied: pillow in c:\users\joy\appdata\local\
programs\python\python312\lib\site-packages (from wordcloud) (10.3.0)
Requirement already satisfied: matplotlib in c:\users\joy\appdata\
local\programs\python\python312\lib\site-packages (from wordcloud)
(3.9.1)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\joy\
appdata\local\programs\python\python312\lib\site-packages (from
matplotlib->wordcloud) (1.2.1)
Requirement already satisfied: cycler>=0.10 in c:\users\joy\appdata\
local\programs\python\python312\lib\site-packages (from matplotlib-
>wordcloud) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\joy\
appdata\local\programs\python\python312\lib\site-packages (from
matplotlib->wordcloud) (4.53.1)
```

```
Requirement already satisfied: kiwisolver>=1.3.1 in c:\users\joy\
appdata\local\programs\python\python312\lib\site-packages (from
matplotlib->wordcloud) (1.4.5)
Requirement already satisfied: packaging>=20.0 in c:\users\joy\
appdata\local\programs\python\python312\lib\site-packages (from
matplotlib->wordcloud) (24.1)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\joy\
appdata\local\programs\python\python312\lib\site-packages (from
matplotlib->wordcloud) (3.1.2)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\joy\
appdata\local\programs\python\python312\lib\site-packages (from
matplotlib->wordcloud) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in c:\users\joy\appdata\local\
programs\python\python312\lib\site-packages (from python-
dateutil>=2.7->matplotlib->wordcloud) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

```
#Load the data

data = pd.read_csv(r"D:\Project Sentiment Analysis\amazon_alexa.tsv",
delimiter = '\t', quoting = 3)

print(f"Dataset shape : {data.shape}")
```

```
Dataset shape : (3150, 5)
```

```
data.head()
```

```
   rating       date         variation  \
0       5  31-Jul-18  Charcoal Fabric
1       5  31-Jul-18  Charcoal Fabric
2       4  31-Jul-18    Walnut Finish
3       5  31-Jul-18  Charcoal Fabric
4       5  31-Jul-18  Charcoal Fabric

                                     verified_reviews  feedback
0                                   Love my Echo!         1
1                                       Loved it!         1
2  "Sometimes while playing a game, you can answe...         1
3  "I have had a lot of fun with this thing. My 4...         1
4                                            Music         1
```

```
#Column names

print(f"Feature names : {data.columns.values}")
```

```
Feature names : ['rating' 'date' 'variation' 'verified_reviews'
'feedback']
```

```
#Now we will be checking for null values

data.isnull().sum()
```

```
rating               0
date                 0
variation            0
verified_reviews     1
feedback             0
dtype: int64
```

```
#Now we'll be getting the record where 'verified_reviews' is null

data[data['verified_reviews'].isna() == True]
```

```
     rating       date variation verified_reviews  feedback
473       2  29-Jun-18     White              NaN         0
```

```
#Now, we will drop the null record

data.dropna(inplace=True)

print(f"Dataset shape after dropping null values : {data.shape}")
```

```
Dataset shape after dropping null values : (3149, 5)
```

```
#Creating a new column 'length' that will contain the length of the
string in 'verified_reviews' column

data['length'] = data['verified_reviews'].apply(len)

data.head()
```

```
   rating       date         variation  \
0       5  31-Jul-18  Charcoal Fabric
1       5  31-Jul-18  Charcoal Fabric
2       4  31-Jul-18    Walnut Finish
3       5  31-Jul-18  Charcoal Fabric
4       5  31-Jul-18  Charcoal Fabric

                                    verified_reviews  feedback  length
0                                       Love my Echo!         1      13
1                                           Loved it!         1       9
2  "Sometimes while playing a game, you can answe...         1     197
3  "I have had a lot of fun with this thing. My 4...         1     174
4                                              Music         1       5
```

The 'length' column is new generated column - stores the length of 'verified_reviews' for that record. Let's check for some sample records.

```
print(f"'verified_reviews' column value: {data.iloc[10]
['verified_reviews']}") #Original value
print(f"Length of review : {len(data.iloc[10]['verified_reviews'])}")
#Length of review using len()
print(f"'length' column value : {data.iloc[10]['length']}") #Value of
the column 'length'
```

```
'verified_reviews' column value: "I sent it to my 85 year old Dad, and
he talks to it constantly."
Length of review : 65
'length' column value : 65
```

```
data.dtypes
```

```
rating                int64
date                 object
variation            object
verified_reviews     object
feedback              int64
dtype: object
```

```
#We can clearly see that rating, feedback are all integral values
#Date, Variation, Verified_reviews are all objects/string values

#NOW WE WILL START ANALYSING THE DATA

len(data)
```

```
3149
```

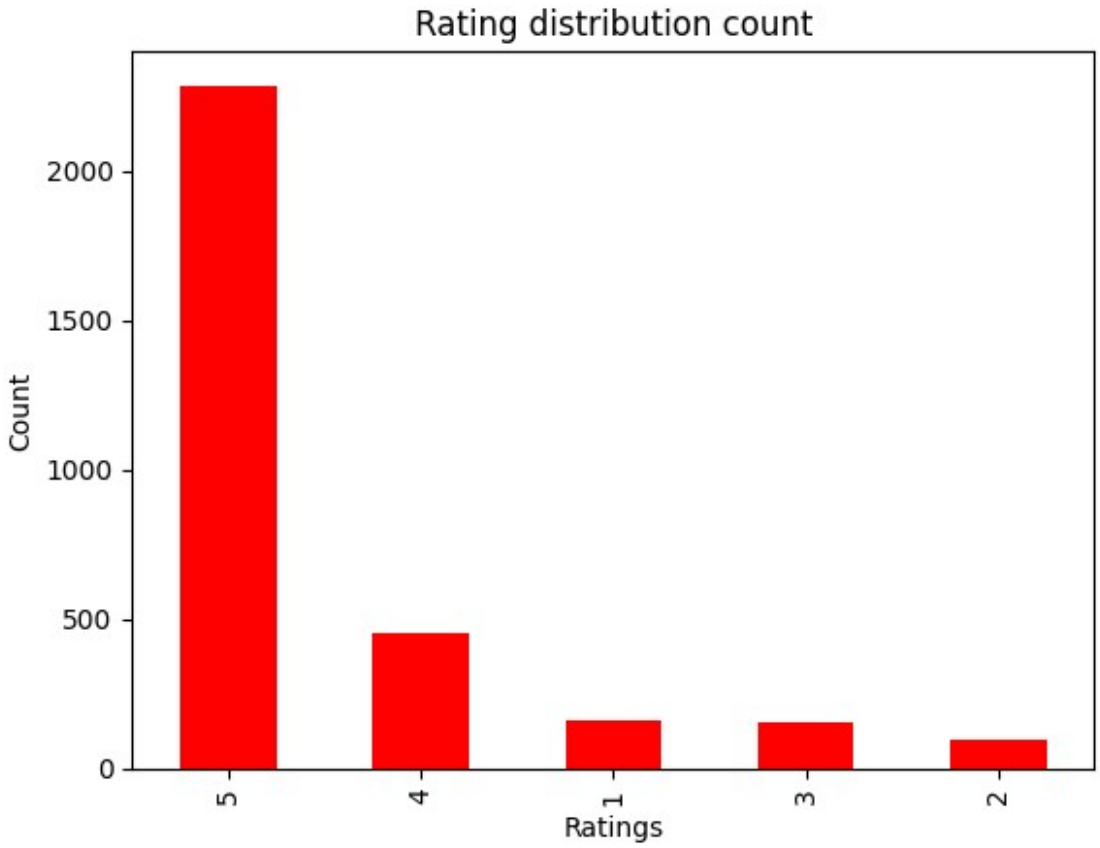
```
#Distinct values of 'rating' and its count

print(f"Rating value count: \n{data['rating'].value_counts()}")
```

```
Rating value count:
rating
5    2286
4     455
1     161
3     152
2      95
Name: count, dtype: int64
```

Now we will plot graphs for the same

```
#Bar plot to visualize the total counts of each rating

data['rating'].value_counts().plot.bar(color = 'red')
```

```
plt.title('Rating distribution count')
plt.xlabel('Ratings')
plt.ylabel('Count')
plt.show()
```

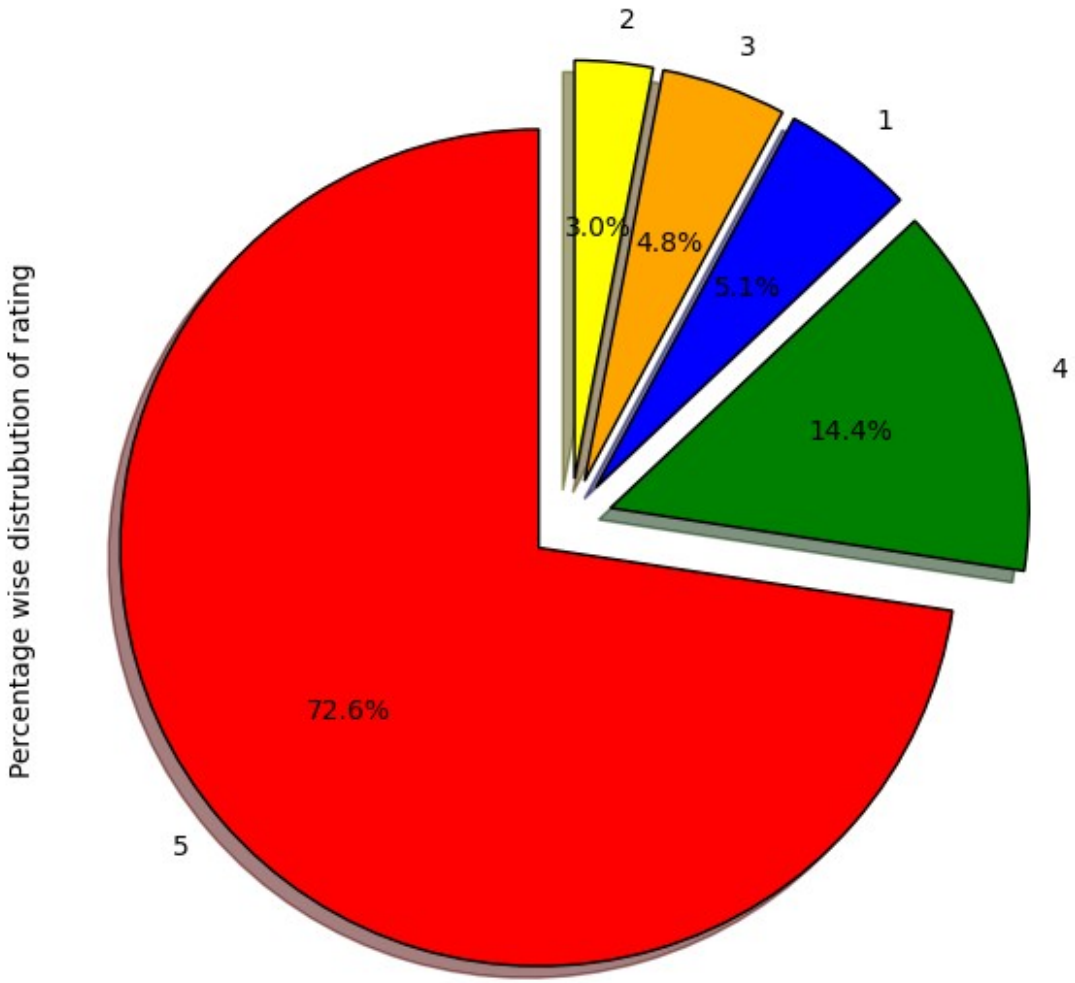



```
#Finding the percentage distribution of each rating - we'll divide the
number of records for each rating by total number of records

print(f"Rating value count - percentage distribution: \
n{round(data['rating'].value_counts()/data.shape[0]*100,2)}")
```

```
Rating value count - percentage distribution:
rating
5    72.59
4    14.45
1     5.11
3     4.83
2     3.02
Name: count, dtype: float64
```

```
#Now we will plot a pie chart for the data.

fig = plt.figure(figsize=(7,7))
```

```
colors = ('red', 'green', 'blue','orange','yellow')

wp = {'linewidth':1, "edgecolor":'black'}

tags = data['rating'].value_counts()/data.shape[0]

explode=(0.1,0.1,0.1,0.1,0.1)

tags.plot(kind='pie', autopct="%1.1f%%", shadow=True, colors=colors,
startangle=90, wedgeprops=wp, explode=explode, label='Percentage wise
distrubution of rating')

from io import  BytesIO

graph = BytesIO()

fig.savefig(graph, format="png")
```



We will now start analysing the feedback coloumn.

```
#Distinct values of 'feedback' and its count

print(f"Feedback value count: \n{data['feedback'].value_counts()}")
```

```
Feedback value count:
feedback
1    2893
0     256
Name: count, dtype: int64
```

```
#Extracting the 'verified_reviews' value for one record with feedback
= 0

review_0 = data[data['feedback'] == 0].iloc[1]['verified_reviews']
print(review_0)
```

```
Sound is terrible if u want good music too get a bose
```

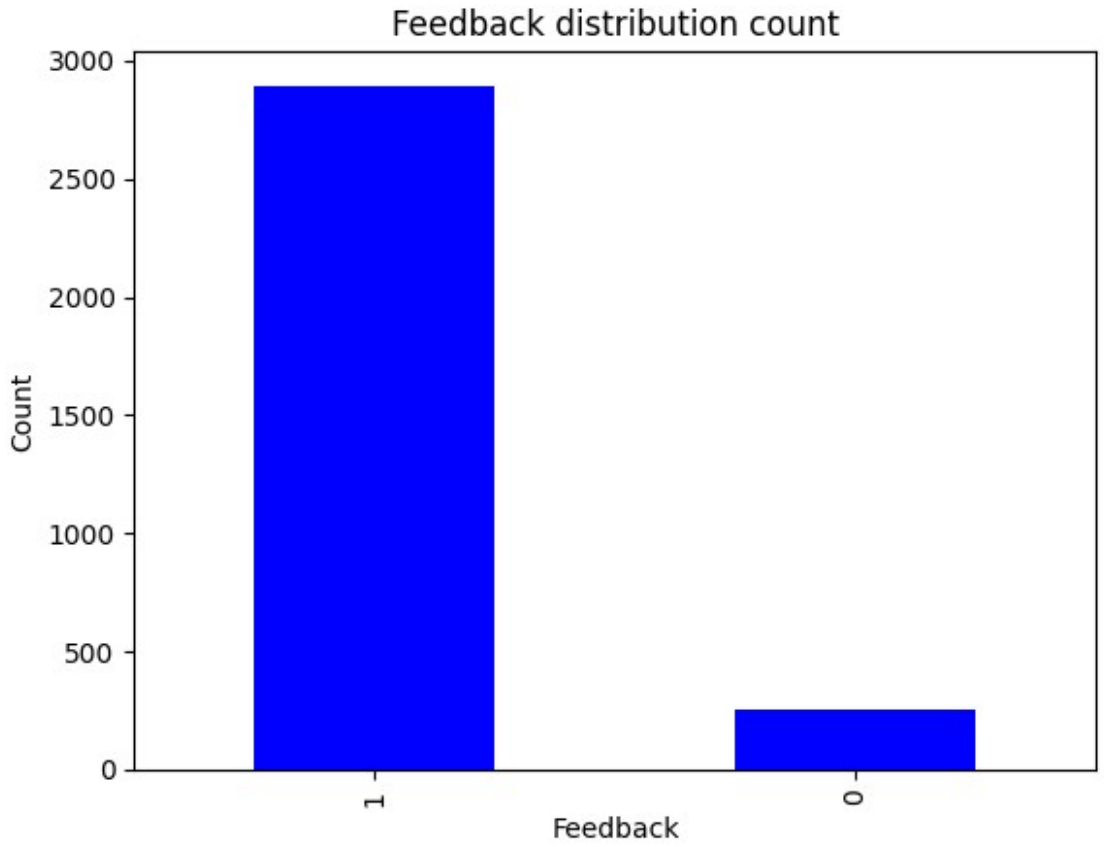
```
#Extracting the 'verified_reviews' value for one record with feedback
= 1

review_1 = data[data['feedback'] == 1].iloc[1]['verified_reviews']
print(review_1)
```

```
Loved it!
```

From the above 2 examples we can see that feedback 0 is negative review and 1 is positive review

Let's plot the feedback value count in a bar graph.

```
#Bar graph to visualize the total counts of each feedback

data['feedback'].value_counts().plot.bar(color = 'blue')
plt.title('Feedback distribution count')
plt.xlabel('Feedback')
plt.ylabel('Count')
plt.show()
```



```
#Finding the percentage distribution of each feedback - we'll divide
the number of records for each feedback by total number of records

print(f"Feedback value count - percentage distribution: \
n{round(data['feedback'].value_counts()/data.shape[0]*100,2)}")
```

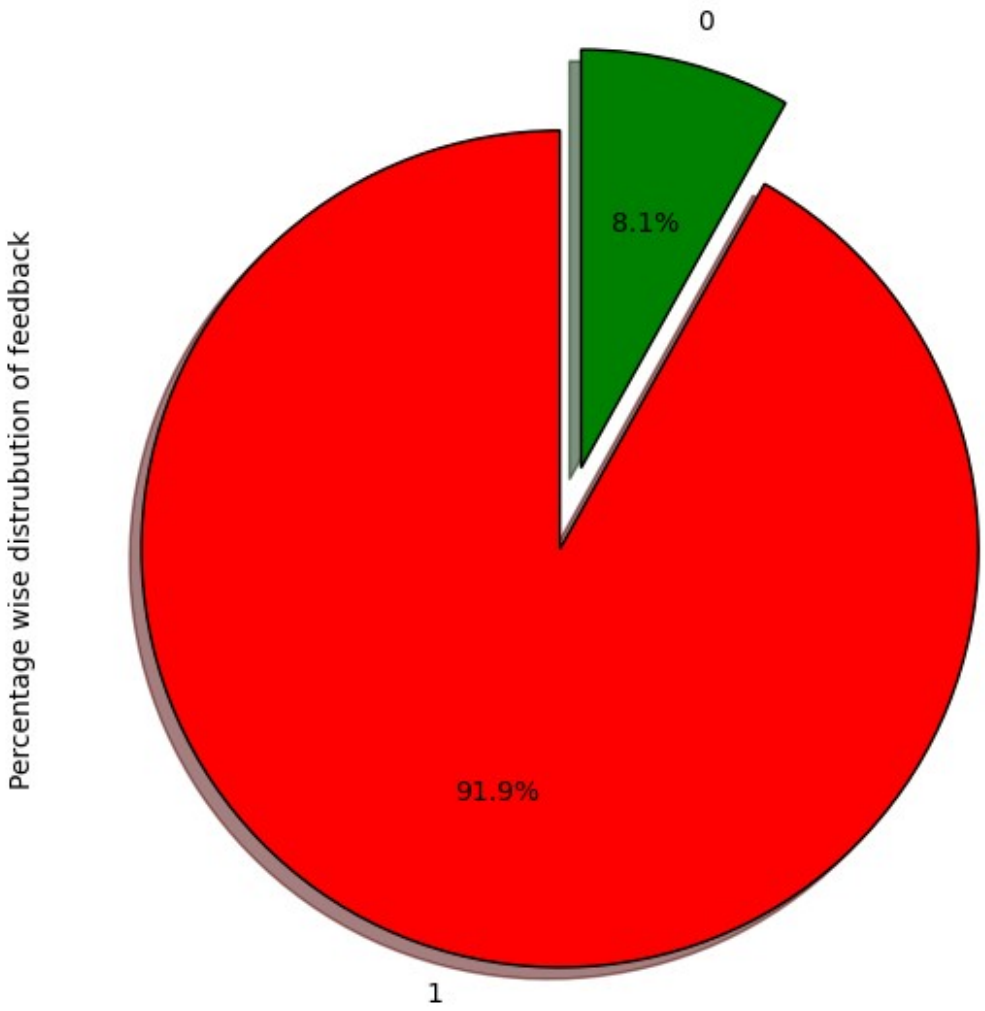
```
Feedback value count - percentage distribution:
feedback
1    91.87
0     8.13
Name: count, dtype: float64
```

Feedback distribution,

91.87% reviews are positive. 8.13% reviews are negative.

```
fig = plt.figure(figsize=(7,7))

colors = ('red', 'green')

wp = {'linewidth':1, "edgecolor":'black'}

tags = data['feedback'].value_counts()/data.shape[0]

explode=(0.1,0.1)

tags.plot(kind='pie', autopct="%1.1f%%", shadow=True, colors=colors,
startangle=90, wedgeprops=wp, explode=explode, label='Percentage wise
distrubution of feedback')
```

```
<Axes: ylabel='Percentage wise distrubution of feedback'>
```



Let's see the 'rating' values for different values of 'feedback'.

```
#Feedback = 0
data[data['feedback'] == 0]['rating'].value_counts()
```

```
rating
1    161
2     95
Name: count, dtype: int64
```

If rating of a review is 1 or 2 then the feedback is 0 (negative) and if the rating is 3, 4 or 5 then the feedback is 1 (positive).

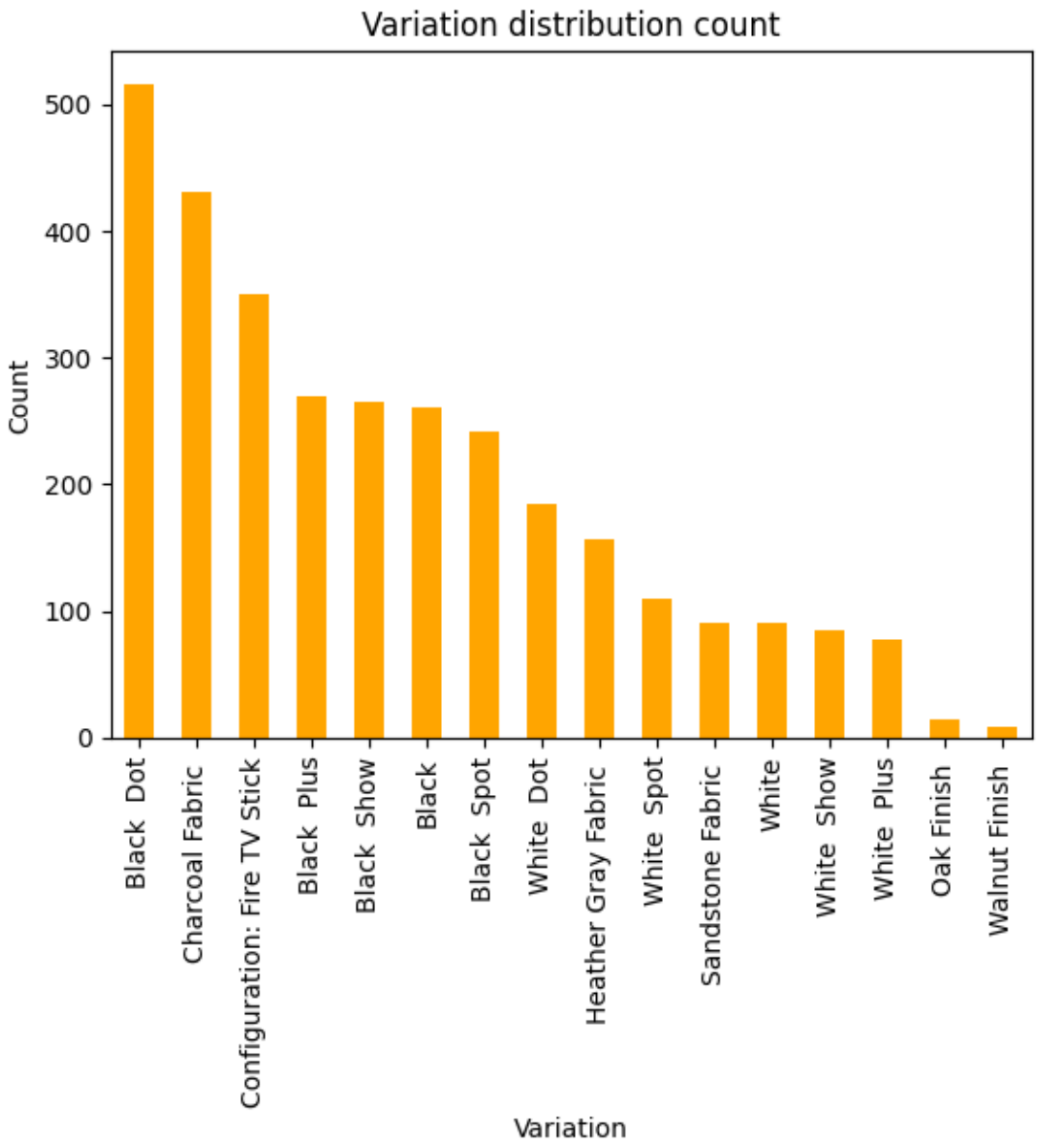
Analyzing 'variation' column

This column refers to the variation or type of Amazon Alexa product. Example - Black Dot, Charcoal Fabric etc.

```
#Distinct values of 'variation' and its count

print(f"Variation value count: \n{data['variation'].value_counts()}")
```

```
Variation value count:
variation
Black  Dot                        516
Charcoal Fabric                   430
Configuration: Fire TV Stick      350
Black  Plus                       270
Black  Show                       265
Black                             261
Black  Spot                       241
White  Dot                        184
Heather Gray Fabric               157
White  Spot                       109
Sandstone Fabric                   90
White                              90
White  Show                        85
White  Plus                        78
Oak Finish                         14
Walnut Finish                       9
Name: count, dtype: int64
```

```
#Bar graph to visualize the total counts of each variation

data['variation'].value_counts().plot.bar(color = 'orange')
plt.title('Variation distribution count')
plt.xlabel('Variation')
plt.ylabel('Count')
plt.show()
```




```
#Finding the percentage distribution of each variation - we'll divide
the number of records for each variation by total number of records

print(f"Variation value count - percentage distribution: \
n{round(data['variation'].value_counts()/data.shape[0]*100,2)}")
```

```
Variation value count - percentage distribution:
variation
Black  Dot                       16.39
Charcoal Fabric                  13.66
Configuration: Fire TV Stick     11.11
Black  Plus                       8.57
Black  Show                       8.42
```

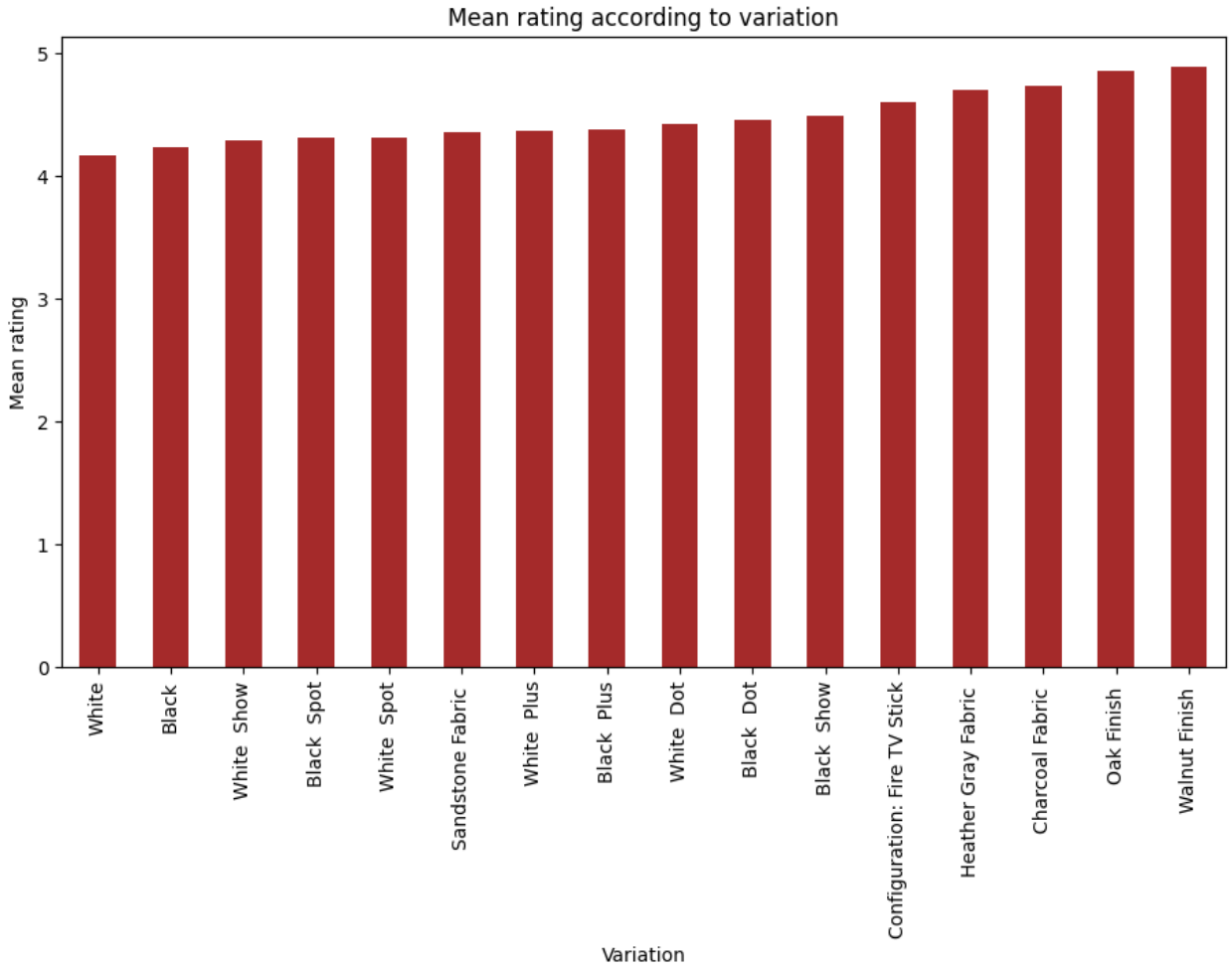
```
Black                                8.29
Black  Spot                          7.65
White  Dot                           5.84
Heather Gray Fabric                  4.99
White  Spot                          3.46
Sandstone Fabric                     2.86
White                                2.86
White  Show                          2.70
White  Plus                          2.48
Oak Finish                           0.44
Walnut Finish                        0.29
Name: count, dtype: float64
```

```
data.groupby('variation')['rating'].mean()
```

```
variation
Black                               4.233716
Black  Dot                          4.453488
Black  Plus                         4.370370
Black  Show                         4.490566
Black  Spot                         4.311203
Charcoal Fabric                     4.730233
Configuration: Fire TV Stick        4.591429
Heather Gray Fabric                 4.694268
Oak Finish                          4.857143
Sandstone Fabric                    4.355556
Walnut Finish                       4.888889
White                               4.166667
White  Dot                          4.423913
White  Plus                         4.358974
White  Show                         4.282353
White  Spot                         4.311927
Name: rating, dtype: float64
```

We will now the above ratings.

```
data.groupby('variation')
['rating'].mean().sort_values().plot.bar(color = 'brown', figsize=(11,
6))
plt.title("Mean rating according to variation")
plt.xlabel('Variation')
plt.ylabel('Mean rating')
plt.show()
```



Analyzing 'verified_reviews' column,

This column contains the textual review given by the user for a variation for the product.

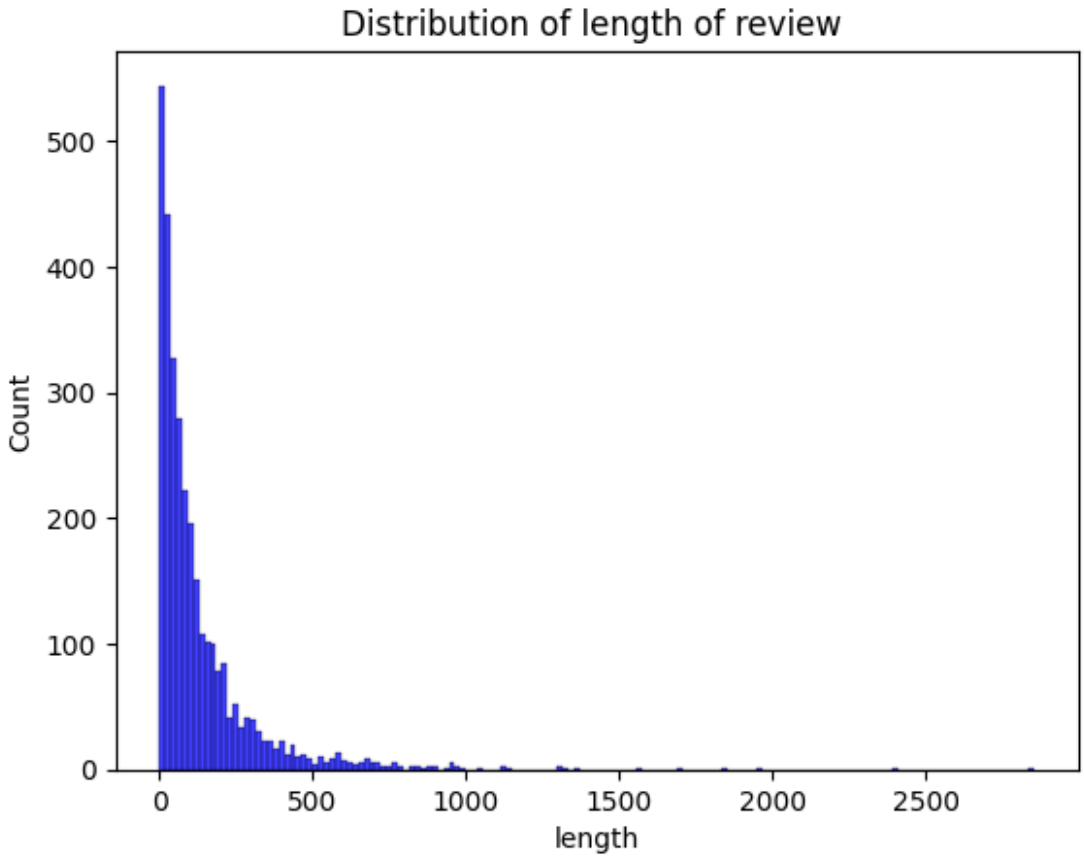
```
data['length'].describe()
```

```
count    3149.000000
mean      132.714513
std       182.541531
min         1.000000
25%        30.000000
50%        74.000000
75%       166.000000
max      2853.000000
Name: length, dtype: float64
```

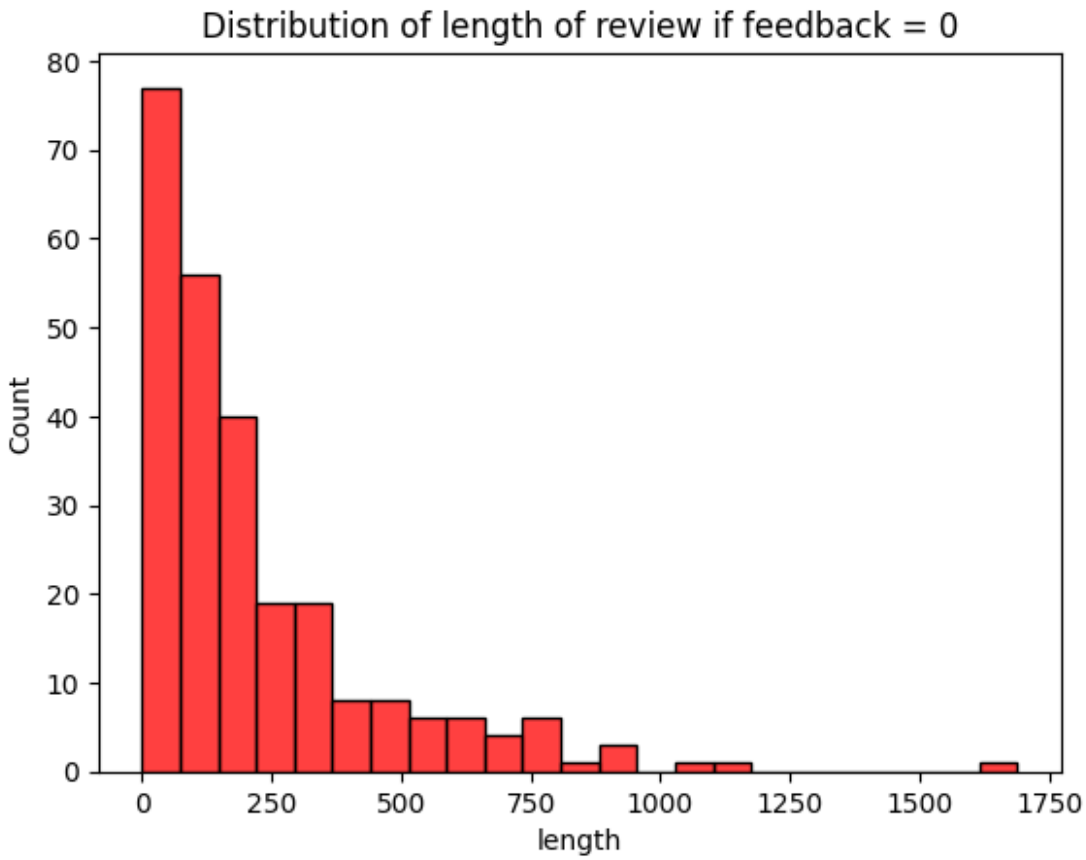
#Length analysis for full dataset.

```
sns.histplot(data['length'],color='blue').set(title='Distribution of
length of review ')
```

```
[Text(0.5, 1.0, 'Distribution of length of review ')]
```

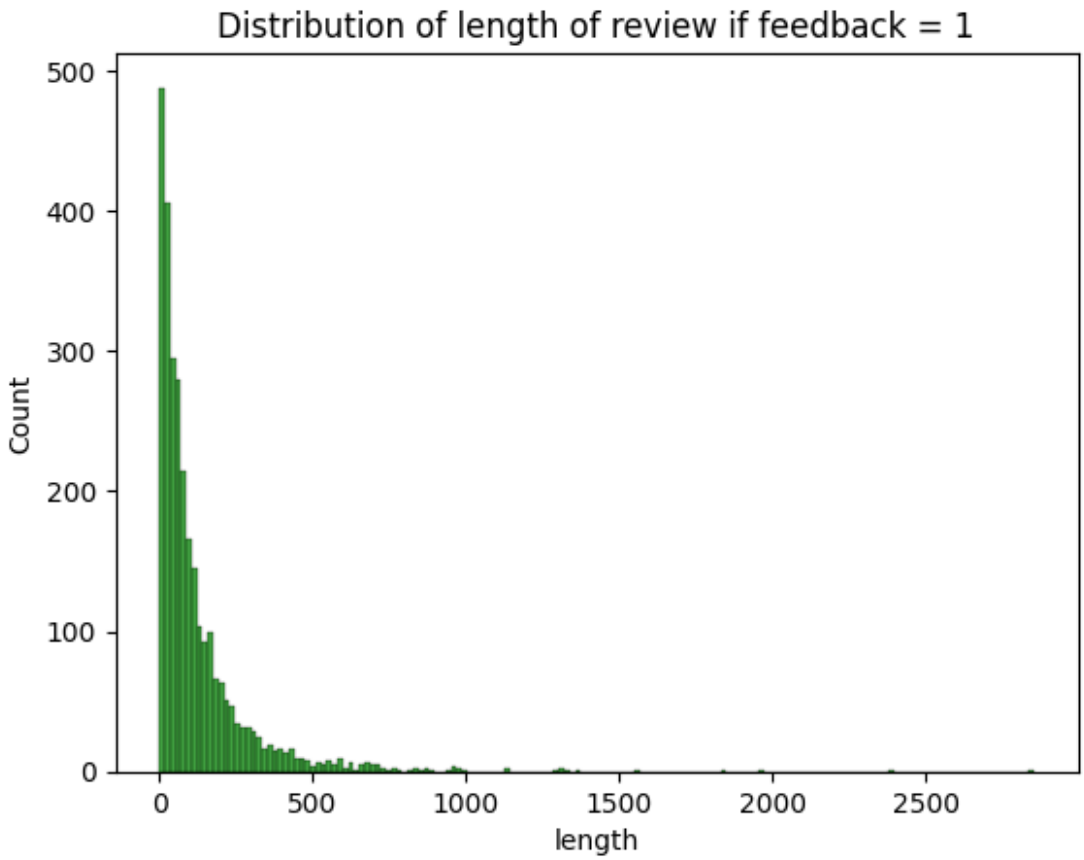



```
#Length analysis when feedback is zero(negative).

sns.histplot(data[data['feedback']==0]
['length'],color='red').set(title='Distribution of length of review if
feedback = 0')

[Text(0.5, 1.0, 'Distribution of length of review if feedback = 0')]
```

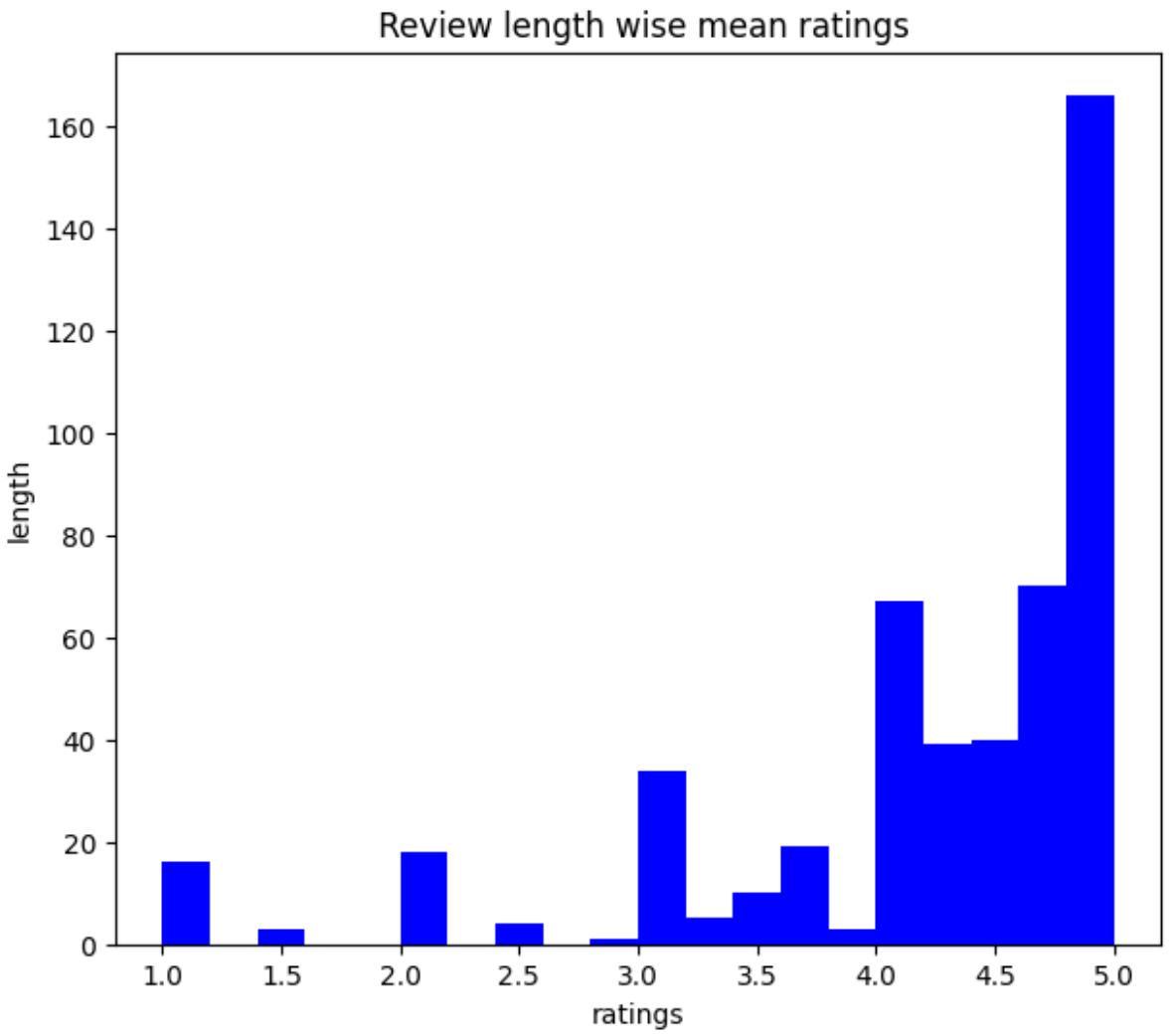



```
#Length analysis when feedback is 1(positive).

sns.histplot(data[data['feedback']==1]
['length'],color='green').set(title='Distribution of length of review
if feedback = 1')
```

```
[Text(0.5, 1.0, 'Distribution of length of review if feedback = 1')]
```




```
#Lengthwise mean rating.

data.groupby('length')['rating'].mean().plot.hist(color = 'blue',
figsize=(7, 6), bins = 20)
plt.title(" Review length wise mean ratings")
plt.xlabel('ratings')
plt.ylabel('length')
plt.show()
```



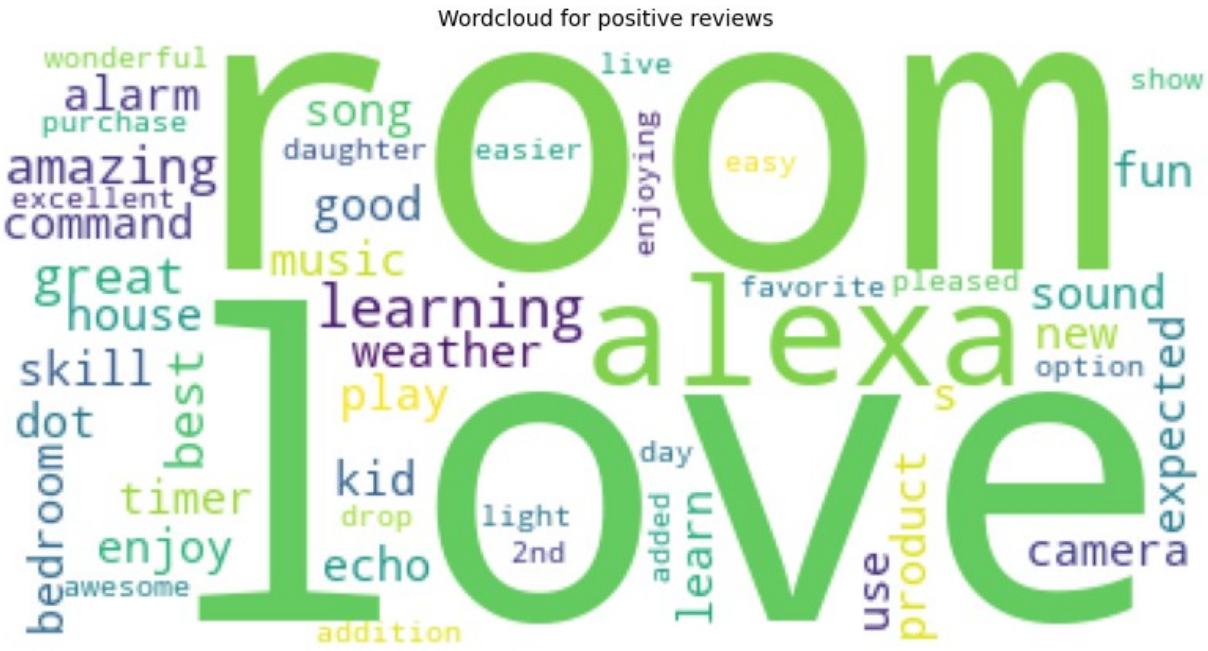

```
cv = CountVectorizer(stop_words='english')
words = cv.fit_transform(data.verified_reviews)

# Combine all reviews
reviews = " ".join([review for review in data['verified_reviews']])

# Initialize wordcloud object
wc = WordCloud(background_color='white', max_words=50)

# Generate and plot wordcloud
plt.figure(figsize=(10,10))
plt.imshow(wc.generate(reviews))
plt.title('Wordcloud for all reviews', fontsize=10)
plt.axis('off')
plt.show()
```

Now let's find the unique keyword in each feedback category.

```
# Combine all reviews for each feedback category and splitting them
into individual words
neg_reviews = " ".join([review for review in data[data['feedback'] ==
0]['verified_reviews']])
neg_reviews = neg_reviews.lower().split()

pos_reviews = " ".join([review for review in data[data['feedback'] ==
1]['verified_reviews']])
pos_reviews = pos_reviews.lower().split()

#Finding words from reviews which are present in that feedback
category only
unique_negative = [x for x in neg_reviews if x not in pos_reviews]
unique_negative = " ".join(unique_negative)

unique_positive = [x for x in pos_reviews if x not in neg_reviews]
unique_positive = " ".join(unique_positive)

wc = WordCloud(background_color='white', max_words=50)

# Generate and plot wordcloud
plt.figure(figsize=(10,10))
plt.imshow(wc.generate(unique_negative))
plt.title('Wordcloud for negative reviews', fontsize=10)
plt.axis('off')
plt.show()
```

Negative words can be seen in the above word cloud - garbage, pointless, poor, horrible, repair etc.

```
wc = WordCloud(background_color='white', max_words=50)

# Generate and plot wordcloud
plt.figure(figsize=(10,10))
plt.imshow(wc.generate(unique_positive))
plt.title('Wordcloud for positive reviews', fontsize=10)
plt.axis('off')
plt.show()
```



Positive words can be seen in the above word cloud - good, enjoying, amazing, best, great etc.

Preprocessing and Modelling To build the corpus from the 'verified_reviews' we perform the following -

1.Replace any non alphabet characters with a space 2.Covert to lower case and split into words 3.Iterate over the individual words and if it is not a stopword then add the stemmed form of the word to the corpus.

```
corpus = []
stemmer = PorterStemmer()
for i in range(0, data.shape[0]):
  review = re.sub('[^a-zA-Z]', ' ', data.iloc[i]['verified_reviews'])
  review = review.lower().split()
  review = [stemmer.stem(word) for word in review if not word in
STOPWORDS]
  review = ' '.join(review)
  corpus.append(review)

cv = CountVectorizer(max_features = 2500)

#Storing independent and dependent variables in X and y
X = cv.fit_transform(corpus).toarray()
y = data['feedback'].values

#Here cv is CountVector

pickle.dump(cv, open(r"D:\Project Sentiment Analysis\
countVectorizer.pkl", 'wb'))
```

Now Checking the shape of X and Y

```
print(f"X shape: {X.shape}")
print(f"y shape: {y.shape}")
```

```
X shape: (3149, 2500)
y shape: (3149,)
```

We are now splitting data into train and test with only 30% of data testing.

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size =
0.3, random_state = 15)

print(f"X train: {X_train.shape}")
print(f"y train: {y_train.shape}")
print(f"X test: {X_test.shape}")
print(f"y test: {y_test.shape}")
```

```
X train: (2204, 2500)
y train: (2204,)
X test: (945, 2500)
y test: (945,)
```

```
print(f"X train max value: {X_train.max()}")
print(f"X test max value: {X_test.max()}")
```

```
X train max value: 12
X test max value: 10
```

Now we'll scale X_train and X_test so that all values are between 0 and 1.

```
scaler = MinMaxScaler()

X_train_scl = scaler.fit_transform(X_train)
X_test_scl = scaler.transform(X_test)

#Saving the scaler model
pickle.dump(scaler, open(r"D:\Project Sentiment Analysis\
countVectorizer.pkl", 'wb'))
```

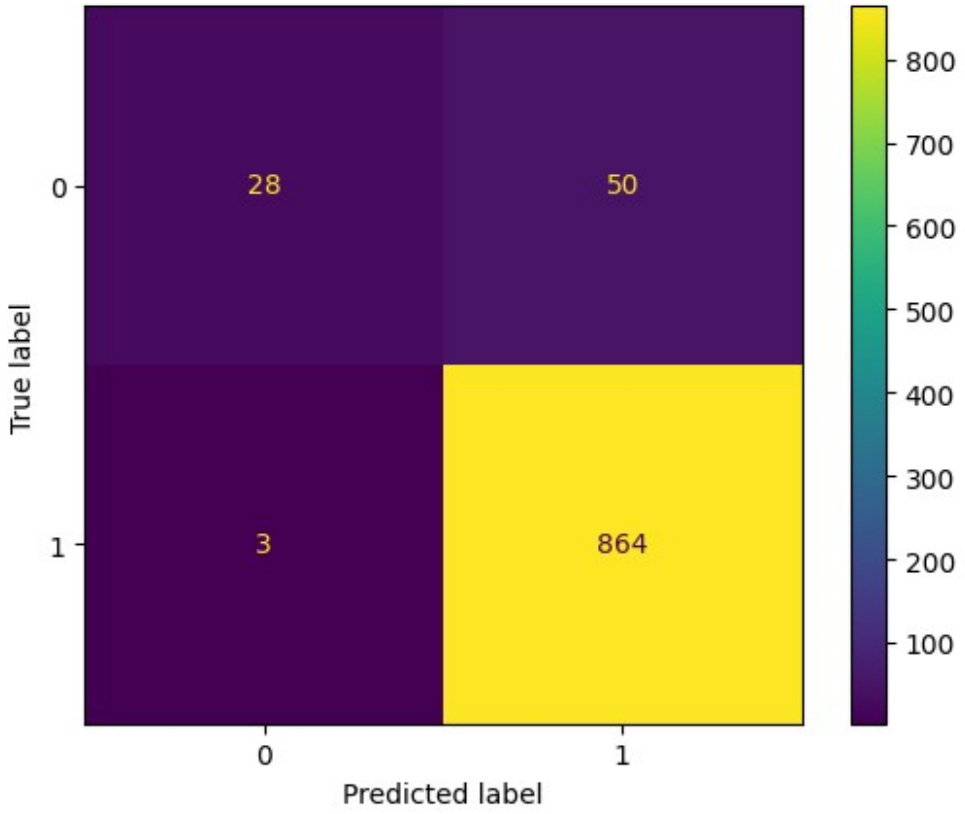
RANDOM FOREST

```
#Fitting scaled X_train and y_train on Random Forest Classifier
model_rf = RandomForestClassifier()
model_rf.fit(X_train_scl, y_train)
```

```
RandomForestClassifier()
```

```
#Accuracy of the model on training and testing data
```

```
print("Training Accuracy :", model_rf.score(X_train_scl, y_train))
print("Testing Accuracy :", model_rf.score(X_test_scl, y_test))

Training Accuracy : 0.9945553539019963
Testing Accuracy : 0.9439153439153439

#Predicting on the test set
y_preds = model_rf.predict(X_test_scl)

#Confusion Matrix
cm = confusion_matrix(y_test, y_preds)

cm_display =
ConfusionMatrixDisplay(confusion_matrix=cm,display_labels=model_rf.cla
sses_)
cm_display.plot()
plt.show()
```



K-fold cross validation.

```
accuracies = cross_val_score(estimator = model_rf, X = X_train_scl, y
= y_train, cv = 10)

print("Accuracy :", accuracies.mean())
print("Standard Variance :", accuracies.std())
```

```
Accuracy : 0.9305882352941177
Standard Variance : 0.00832094627164994
```

We will now apply grid search to attain optimal parameters on random forest.

```
params = {
    'bootstrap': [True],
    'max_depth': [80, 100],
    'min_samples_split': [8, 12],
    'n_estimators': [100, 300]
}

cv_object = StratifiedKFold(n_splits = 2)

grid_search = GridSearchCV(estimator = model_rf, param_grid = params,
cv = cv_object, verbose = 0, return_train_score = True)
grid_search.fit(X_train_scl, y_train.ravel())
```

```
GridSearchCV(cv=StratifiedKFold(n_splits=2, random_state=None,
shuffle=False),
             estimator=RandomForestClassifier(),
             param_grid={'bootstrap': [True], 'max_depth': [80, 100],
                         'min_samples_split': [8, 12],
                         'n_estimators': [100, 300]},
             return_train_score=True)
```

```
#Getting the best parameters from the grid search


print("Best Parameter Combination :
{}".format(grid_search.best_params_))
```

```
Best Parameter Combination : {'bootstrap': True, 'max_depth': 80,
'min_samples_split': 8, 'n_estimators': 300}
```

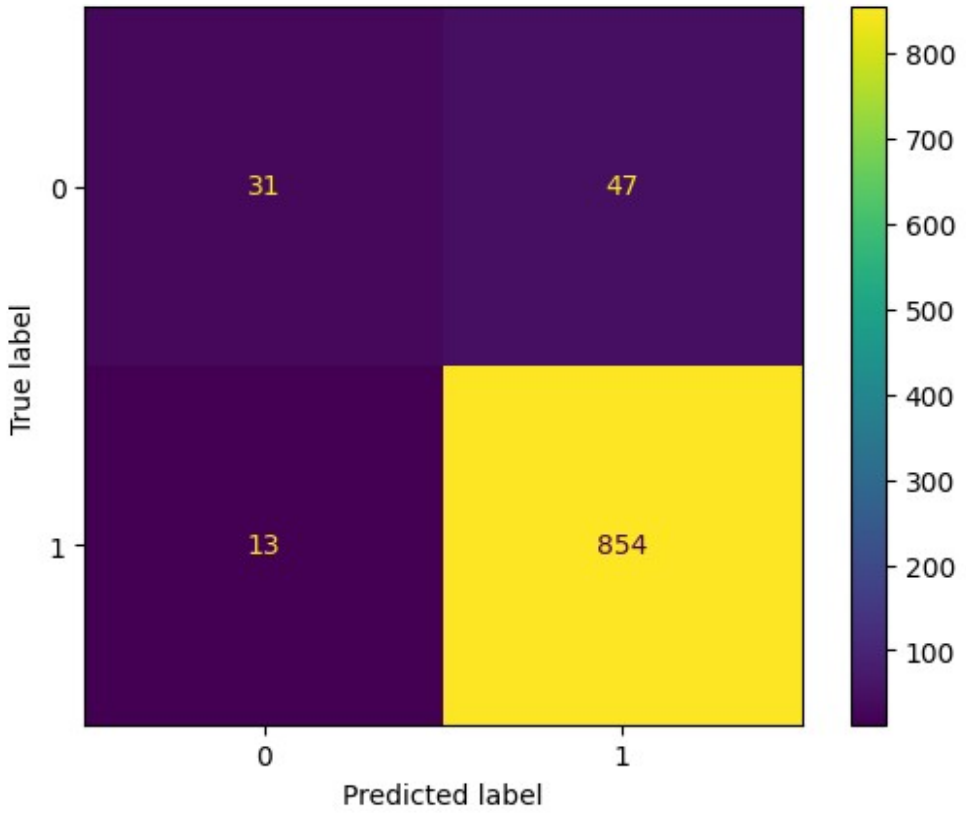
```
print("Cross validation mean accuracy on train set :
{}".format(grid_search.cv_results_['mean_train_score'].mean()*100))
print("Cross validation mean accuracy on test set :
{}".format(grid_search.cv_results_['mean_test_score'].mean()*100))
print("Accuracy score for test set :", accuracy_score(y_test,
y_preds))
```

```
Cross validation mean accuracy on train set : 96.79559891107078
Cross validation mean accuracy on test set : 92.13362068965516
Accuracy score for test set : 0.9439153439153439
```

Now using XgBoost.

```
model_xgb = XGBClassifier()
model_xgb.fit(X_train_scl, y_train)
```

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None,
early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None,
feature_types=None,
              gamma=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None,
max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan,
monotone_constraints=None,
              multi_strategy=None, n_estimators=None, n_jobs=None,
              num_parallel_tree=None, random_state=None, ...)

#Accuracy of the model on training and testing data

print("Training Accuracy :", model_xgb.score(X_train_scl, y_train))
print("Testing Accuracy :", model_xgb.score(X_test_scl, y_test))

Training Accuracy : 0.971415607985481
Testing Accuracy : 0.9417989417989417

y_preds = model_xgb.predict(X_test)

#Confusion Matrix
cm = confusion_matrix(y_test, y_preds)
print(cm)

[[ 31  47]
 [ 13 854]]

cm_display =
ConfusionMatrixDisplay(confusion_matrix=cm,display_labels=model_xgb.cl
asses_)
cm_display.plot()
plt.show()
```




```
#Saving the XGBoost classifier
pickle.dump(model_xgb, open(r"D:\Project Sentiment Analysis\
model_xgb.pkl", 'wb'))
```

Decision Tree Classfier.

```
model_dt = DecisionTreeClassifier()
model_dt.fit(X_train_scl, y_train)
```

```
DecisionTreeClassifier()
```

```
#Accuracy of the model on training and testing data

print("Training Accuracy :", model_dt.score(X_train_scl, y_train))
print("Testing Accuracy :", model_dt.score(X_test_scl, y_test))
```

```
Training Accuracy : 0.9945553539019963
Testing Accuracy : 0.9227513227513228
```

```
y_preds = model_dt.predict(X_test)

#Confusion Matrix
cm = confusion_matrix(y_test, y_preds)
print(cm)
```

```
[[ 41  37]
 [ 98 769]]

cm_display =
ConfusionMatrixDisplay(confusion_matrix=cm,display_labels=model_dt.cla
sses_)
cm_display.plot()
plt.show()
```