CSCI - 6409 - Process of Data Science - Summer 2022

</center>

Assignment 3

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Benny Daniel Tharigopala - B00899629

Karthik Kannan Nanthakumar - B00891387

Import Files to Google Colab

In [2]:

```
from google.colab import files
# uploaded = files.upload()
# https://www.kaggle.com/datasets/parvezmrobin/amazon-book-review-1m-sample
# https://medium.com/@qempsil0914/machine-learning-nlp-text-classification-with-amazon-review-data-using-python3-step-by-step-3fb
0cc0cecc1
# https://t-lanigan.github.io/amazon-review-classifier/

# https://www.dataquest.io/blog/python-json-tutorial/
```

Imports

In [3]:

```
import pandas as pd
import io
```

In [4]:

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

In [5]:

```
source_dataset = pd.read_json('/content/drive/MyDrive/Colab Notebooks/sample.jsonl', lines=True)
source_dataset = pd.read_json('/content/drive/MyDrive/Colab Notebooks/sample.json', lines=True)
```

Shape of the dataframe

In [6]:

```
print(source_dataset.shape)
```

```
(1000000, 12)
```

In [7]:

```
source_dataset.head(10)
```

Out[7]:

	overall	vote	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText	summary	unixReviewTime	image
0	3	2	False	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	{'Format:': ' School & Library Binding'}	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	NaN
1	5	NaN	True	12 11, 2014	A12Q7B7NT716RV	0001712799	{'Format:': ' Hardcover'}	True Value Girl	Love it	Five Stars	1418256000	NaN
2	4	3	False	01 6, 2006	A1DK5AZMXS1QA3	0002006448	{'Format:': ' Hardcover'}	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	NaN
3	4	NaN	False	12 8, 2014	A1JMSX54DO3LOP	0002005263	{'Format:': ' Kindle Edition'}	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	NaN
4	2	2	True	03 3, 2014	A2IP27AZB3D1SM	0002005263	{'Format:': ' Kindle Edition'}	J. A. Drummond	I have read many of the Hillerman books and en...	Tony missed the mark	1393804800	NaN
5	4	4	False	06 22, 2004	A2KSU7OOJ5C479	0002005263	{'Format:': ' Hardcover'}	Loren D. Morrison	I, like many of the other reviewers here, am a...	A COMPLEX , SUSPENSEFUL PLOT, BUT	1087862400	NaN
6	5	2	True	01 21, 2004	A3FT7WR9YGU4RK	0002005263	{'Format:': ' Audio CD'}	Anne Melvin	I had the CD read by George\nGuidall who does ...	A good mystery.	1074643200	NaN
7	1	9	True	06 10, 2003	AMFB2GBB2O84X	0002005263	{'Format:': ' Hardcover'}	Brakaian	I am a huge Tony Hillerman fan -- I've read ea...	Easily Hillerman's worst -- very disappointing	1055203200	NaN
8	5	NaN	True	12 18, 2017	A243JAEFC50KWI	0001384198	{'Format:': ' Hardcover'}	dorothy	We all love the classics.	Classics never die.	1513555200	NaN
9	5	NaN	True	09 6, 2017	A25B7XXSTTN1IY	0001384198	{'Format:': ' Hardcover'}	Snake	I love it	Five Stars	1504656000	NaN

1.A. Data quality report:

The data quality report consists of:

1. **A tabular report describing the various statistics of the SUMMARY & REVIEW_TEXT**
2. **Data visualizations of values in each feature**

Reference - Brightspace Tutorial

In [8]:

```
import warnings

pd.set_option("display.max_rows", None)
pd.set_option("display.max_columns", None)
pd.set_option('display.float_format', '{:.2f}'.format)
#Referred from Tutorial 2 of CSCI 6409 - [https://dal.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=fe8e7287-82c2-42bc-85ac-ae9
40127b726]
```

What are the features in the Amazon Review Dataset ?

How many null instances do each columns have ?

In [9]:

```
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 12 columns):
 #   Column          Non-Null Count    Dtype 
---  ------          --------------    ----- 
 0   overall         1000000 non-null  int64 
 1   vote            195489 non-null   object
 2   verified        1000000 non-null  bool  
 3   reviewTime      1000000 non-null  object
 4   reviewerID      1000000 non-null  object
 5   asin            1000000 non-null  object
 6   style           982181 non-null   object
 7   reviewerName    999966 non-null   object
 8   reviewText      999876 non-null   object
 9   summary         999693 non-null   object
 10  unixReviewTime  1000000 non-null  int64 
 11  image           2233 non-null     object
dtypes: bool(1), int64(2), object(9)
memory usage: 84.9+ MB
```

We can observe that 6 out of 12 columns of the dataset do not have any Null-records within them, since the total number of rows is 1000000 and the number of non-null records in each column is also 1000000.

#

Now let's peek at the first few rows of our data frame

In [10]:

```
source_dataset.loc[0]
```

Out[10]:

```
overall                                                          3
vote                                                             2
verified                                                     False
reviewTime                                             05 18, 2002
reviewerID                                           AJ8AQG2X9JJ2Y
asin                                                    0001712799
style                    {'Format:': ' School & Library Binding'}
reviewerName                                        Donald Gillies
reviewText        Dr. Seuss has some really brilliant books.  Th...
summary                                  A below-average Dr. Seuss Book
unixReviewTime                                          1021680000
image                                                          NaN
Name: 0, dtype: object
```

Fit the best possible datatypes for columns of type object.

In [11]:

```
source_dataset = source_dataset.convert_dtypes()
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 12 columns):
 #   Column          Non-Null Count    Dtype  
---  ------          --------------    -----  
 0   overall         1000000 non-null  Int64  
 1   vote            195489 non-null   string 
 2   verified        1000000 non-null  boolean
 3   reviewTime      1000000 non-null  string 
 4   reviewerID      1000000 non-null  string
 5   asin            1000000 non-null  string
 6   style           982181 non-null   object
 7   reviewerName    999966 non-null   string
 8   reviewText      999876 non-null   string
 9   summary         999693 non-null   string
 10  unixReviewTime  1000000 non-null  Int64
 11  image           2233 non-null     object
dtypes: Int64(2), boolean(1), object(2), string(7)
memory usage: 87.7+ MB
```

Notice that the column 'style' requires transformation since it's in the form of a "dictionary. We need to extract the value corresponding to 'Format' in each instance.

In [12]:

```
dic = {'Format:': ' No Format'}
print(type(dic))

dic2 = dict({'Format:': ' No Format'})
print(type(dic2))
print(dic2)
```

```
<class 'dict'>
<class 'dict'>
{'Format:': ' No Format'}
```

In [13]:

```
source_dataset['style'].isna().sum()
```

Out[13]:

```
17819
```

Extracting the format of the book for each review and setting format as ' No Format' for those reviews where the format is not specified.

In [14]:

```
source_dataset['format'] = [d.get("Format:") if isinstance(d,dict) else 'No Format' for d in source_dataset['style']]
```

In [15]:

```
source_dataset.head(25)
```

Out[15]:

	overall	vote	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText	summary	unixReviewTime	image	f
0	3	2	False	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	{'Format:': ' School & Library Binding'}	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	NaN	Sc L B
1	5	<NA>	True	12 11, 2014	A12Q7B7NT716RV	0001712799	{'Format:': ' Hardcover'}	True Value Girl	Love it	Five Stars	1418256000	NaN	Harc
2	4	3	False	01 6, 2006	A1DK5AZMXS1QA3	0002006448	{'Format:': ' Hardcover'}	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	NaN	Harc
3	4	<NA>	False	12 8, 2014	A1JMSX54DO3LOP	0002005263	{'Format:': ' Kindle Edition'}	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	NaN	E
4	2	2	True	03 3, 2014	A2IP27AZB3D1SM	0002005263	{'Format:': ' Kindle Edition'}	J. A. Drummond	I have read many of the Hillerman books and en...	Tony missed the mark	1393804800	NaN	E
5	4	4	False	06 22, 2004	A2KSU7OOJ5C479	0002005263	{'Format:': ' Hardcover'}	Loren D. Morrison	I, like many of the other reviewers here, am a...	A COMPLEX , SUSPENSEFUL PLOT, BUT	1087862400	NaN	Harc
6	5	2	True	01 21, 2004	A3FT7WR9YGU4RK	0002005263	{'Format:': ' Audio CD'}	Anne Melvin	I had the CD read by George Guidall who does a...	A good mystery.	1074643200	NaN	Au
7	1	9	True	06 10, 2003	AMFB2GBB2O84X	0002005263	{'Format:': ' Hardcover'}	Brakaian	I am a huge Tony Hillerman fan -- I've read ea...	Easily Hillerman's worst -- very disappointing	1055203200	NaN	Harc
8	5	<NA>	True	12 18, 2017	A243JAEFC50KWI	0001384198	{'Format:': ' Hardcover'}	dorothy	We all love the classics.	Classics never die.	1513555200	NaN	Harc
9	5	<NA>	True	09 6, 2017	A25B7XXSTTN1IY	0001384198	{'Format:': ' Hardcover'}	Snake	I love it	Five Stars	1504656000	NaN	Harc
10	5	<NA>	True	07 21, 2017	A1ZH1498KCF0II	0001384198	{'Format:': ' Hardcover'}	Pinkie	after all these years it is still a favorite	Five Stars	1500595200	NaN	Harc
11	5	<NA>	True	12 7, 2014	A2SZQ4RIBGH4S0	0001384198	{'Format:': ' Hardcover'}	tessaame	A great classic, my grandchildren love the story.	great	1417910400	NaN	Harc

	overall	vote	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText	summary	unixReviewTime	image	f
12	1	4	False	11 18, 2014	A1G2NIQIC7V94N	0001384198	{'Format:': ' Paperback'}	MGran	Not pleased with this purchase at all. I expec...	Tiny book that looks like a postcard, poor qua...	1416268800	NaN	Pape
13	4	<NA>	True	10 11, 2014	A3GURTXTBN6P1H	0001384198	{'Format:': ' Kindle Edition'}	Neen James Inc.	A friend suggested I read this leading to my f...	a good reminder we can do anything we put our ...	1412985600	NaN	E
14	5	<NA>	True	12 12, 2013	AELB7NAA4TPJA	0001384198	{'Format:': ' Paperback'}	Living in the desert	This book was purchased for a book a day adven...	Books are cool	1386806400	NaN	Pape
15	3	<NA>	True	07 9, 2013	AW19JUIQFF9UC	0001384198	{'Format:': ' Paperback'}	Millie Rhodes	It was designed to be sent in the mail which i...	I did not realize it was going to be so small	1373328000	NaN	Pape
16	5	<NA>	True	12 20, 2012	A3PQZ1F2DKRH7	0001384198	{'Format:': ' Hardcover'}	Robert M. Esch	My favorite book as a child in the 1940's. It...	I think I can, I knew I could	1355961600	NaN	Harc
17	5	<NA>	True	12 5, 2012	A3B7KA98ABG1FL	0001384198	{'Format:': ' Hardcover'}	genevieve012	I bought this book to teach my 2 1/2 year old ...	It's a Classic!	1354665600	NaN	Harc
18	5	<NA>	True	11 24, 2012	A2U9ETDO4GMT77	0001384198	{'Format:': ' Hardcover'}	Deborah	One of my granddaughters favorite book. I lov...	The story that lasts through generations	1353715200	NaN	Harc
19	5	2	True	06 2, 2010	A29CHKRGDMESA9	0001384198	{'Format:': ' Hardcover'}	Nancy E. Gordon	Can't wait to read this wonderful book to my g...	AAAAAAAAAAAA+++++++++++=	1275436800	NaN	Harc
20	5	5	True	09 4, 2007	A1TMAVN4CEM8U8	0001384198	{'Format:': ' Paperback'}	the gunner	The` Little Engine that Could Storybook Treasu...	LEARN TO READ	1188864000	NaN	Pape
21	1	3	True	09 9, 2016	A3UMD61W29D5BF	0001381733	{'Format:': ' Kindle Edition'}	Anon in Texas	The Kindle version of the Everyman's Library C...	1 star for the Everyman's Library Children's C...	1473379200	NaN	E
22	5	<NA>	True	07 5, 2016	A2UHQ1S4U0VFW	0001381733	NaN	Word Woman	The perfect gift from adults who follow throug...	Five Stars	1467676800	NaN	No F
									My children				

	overall	vote	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText	summary	unixReviewTime	image	
23	5	<NA>	True	06 26, 2015	A2FMY6FBBL3675	0001381733	{'Format:': ' Hardcover'}	3Homeschooled	My children enjoyed these poems. They now fee...	Robert Louis Stevenson	1435276800	NaN	Har
24	5	<NA>	True	05 15, 2015	A21DC7OWHXQGF2	0001381733	{'Format:': ' Kindle Edition'}	Sidney Burton	Exactly what was described.	Five Stars	1431648000	NaN	E

As visible from the information panel below, the Dataframe contains 3 objects of type 'object'

1. style
2. image and
3. format

We have extract the value from the column 'style' and stored it in the column 'format'. Also, the column 'image' does not hold any significance as it contains only 2233 Non-null values. Therefore we will remove the columns 'style' and 'image' in subsequent steps.

In [16]:

```
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 13 columns):
 #   Column          Non-Null Count    Dtype  
---  ------          --------------    -----  
 0   overall         1000000 non-null  Int64  
 1   vote            195489 non-null   string 
 2   verified        1000000 non-null  boolean
 3   reviewTime      1000000 non-null  string 
 4   reviewerID      1000000 non-null  string 
 5   asin            1000000 non-null  string 
 6   style           982181 non-null   object 
 7   reviewerName    999966 non-null   string 
 8   reviewText      999876 non-null   string 
 9   summary         999693 non-null   string 
 10  unixReviewTime  1000000 non-null  Int64  
 11  image           2233 non-null     object 
 12  format          999940 non-null   object 
dtypes: Int64(2), boolean(1), object(3), string(7)
memory usage: 95.4+ MB
```

Fitting the best possible datatype for the column 'format'

In [17]:

```
source_dataset = source_dataset.convert_dtypes()
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 13 columns):
 #   Column          Non-Null Count    Dtype  
---  ------          --------------    -----  
 0   overall         1000000 non-null  Int64  
 1   vote            195489 non-null   string 
 2   verified        1000000 non-null  boolean
 3   reviewTime      1000000 non-null  string 
 4   reviewerID      1000000 non-null  string 
 5   asin            1000000 non-null  string 
 6   style           982181 non-null   object 
 7   reviewerName    999966 non-null   string 
 8   reviewText      999876 non-null   string 
 9   summary         999693 non-null   string 
 10  unixReviewTime  1000000 non-null  Int64  
 11  image           2233 non-null     object 
 12  format          999940 non-null   string 
dtypes: Int64(2), boolean(1), object(2), string(8)
memory usage: 95.4+ MB
```

In [18]:

```
source_dataset.drop(columns=["style","image"],axis=1,inplace=True)
```

In [19]:

```
source_dataset.drop(columns=["vote"],axis=1,inplace=True)
```

In [20]:

```
source_dataset.columns
```

Out[20]:

```
Index(['overall', 'verified', 'reviewTime', 'reviewerID', 'asin',
       'reviewerName', 'reviewText', 'summary', 'unixReviewTime', 'format'],
      dtype='object')
```

Let us now add some more properties to the dataframe.

First we will add the following properties for the reviewText:

- **Number of characters.**
- **The number of words.**

- **Boolean Value to indicate the presence of non-alphanumeric characters.**

In [21]:

```
source_dataset.head(5)
```

Out[21]:

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format
0	3	False	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	School & Library Binding
1	5	True	12 11, 2014	A12Q7B7NT716RV	0001712799	True Value Girl	Love it	Five Stars	1418256000	Hardcover
2	4	False	01 6, 2006	A1DK5AZMXS1QA3	0002006448	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	Hardcover
3	4	False	12 8, 2014	A1JMSX54DO3LOP	0002005263	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	Kindle Edition
4	2	True	03 3, 2014	A2IP27AZB3D1SM	0002005263	J. A. Drummond	I have read many of the Hillerman books and en...	Tony missed the mark	1393804800	Kindle Edition

In [22]:

```
import nltk
from nltk.tokenize import sent_tokenize
from nltk.tokenize import word_tokenize
from nltk.probability import FreqDist
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
```

Out[22]:

```
True
```

Creating a column for the total number of characters in each Review Text Instance

In [23]:

```
source_dataset['reviewText_num_characters'] = [len(d) if isinstance(d,str) else 0 for d in source_dataset['reviewText']]
# source_dataset['format'] = [d.get("Format:") if isinstance(d,dict) else 'No Format' for d in source_dataset['style']]
```

Creating a column for the total number of words in each Review Text Instance

In [24]:

```
source_dataset['reviewText_num_words'] = [len(d.split()) if isinstance(d,str) else 0 for d in source_dataset['reviewText']]
```

Creating a column for verifying if the reviewText containes Non-AlphaNumeric characters

In [25]:

```
source_dataset['contains_Non_AlphaNumeric'] = ["False" if isinstance(d,str) and d.replace(" ","").isalnum()  else "True" for d i
n source_dataset['reviewText']]
```

In [26]:

```
# # source_dataset[source_dataset['reviewText_num_words'] == 1.0])
# # type(source_dataset['reviewText'][5847])
# for d in source_dataset['reviewText']:
#   if isinstance(d,str) and d.replace(" ","").isalnum():
#     print("True - No SPl")
#   else:
#     print("No Review Text")
```

In [27]:

```
source_dataset.head(5)
```

Out[27]:

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format	reviewText_num_characters	reviewText_num_w
0	3	False	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	School & Library Binding	617	
1	5	True	12 11, 2014	A12Q7B7NT716RV	0001712799	True Value Girl	Love it	Five Stars	1418256000	Hardcover	7	
2	4	False	01 6, 2006	A1DK5AZMXS1QA3	0002006448	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	Hardcover	1419	
3	4	False	12 8, 2014	A1JMSX54DO3LOP	0002005263	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	Kindle Edition	314	

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format	reviewText_num_characters	reviewText_num_w
4	2	True	03 3, 2014	A2IP27AZB3D1SM	0002005263	J. A. Drummond	many of the Hillerman books and en...	Tony missed the mark	1393804800	Kindle Edition	235	

Split the Datatypes into Numerical and Categorical attributes

Let's Segregate the columns with numerical values

In [28]:

```
source_dataset.describe(include=['number'])
```

Out[28]:

	overall	verified	unixReviewTime	reviewText_num_characters	reviewText_num_words
count	1000000.00	1000000	1000000.00	1000000.00	1000000.00
unique	NaN	2	NaN	NaN	NaN
top	NaN	True	NaN	NaN	NaN
freq	NaN	674237	NaN	NaN	NaN
mean	4.37	NaN	1406255022.37	541.05	96.48
std	1.00	NaN	101010911.58	867.98	150.61
min	1.00	NaN	849657600.00	0.00	0.00
25%	4.00	NaN	1376265600.00	114.00	21.00
50%	5.00	NaN	1425686400.00	227.00	42.00
75%	5.00	NaN	1472601600.00	599.00	108.00
max	5.00	NaN	1537920000.00	31759.00	5359.00

Let's Segregate the columns with categorical values

In [29]:

```
source_dataset.describe(exclude=['number'])
```

Out[29]:

	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	format	contains_Non_AlphaNumeric

	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	format	contains_Non_AlphaNumeric
count	1000000	1000000	1000000	999966	999876	999603	999940	1000000
unique	7514	610262	323635	435945	952186	629717	90	2
top	02 20, 2015	A2F6N60Z96CAJI	038568231X	Amazon Customer	Great	Five Stars	Kindle Edition	True
freq	1537	317	1013	46661	1105	93655	561493	943365

1.B.Data Quality Report for Continuous Features:

Code refererred from [CSCI 6409 - Tutorial 2]()

In [30]:

```
def build_continuous_features_report(data_df):

    """Build tabular report for continuous features"""

    stats = {
        "Count": len,
        "Miss %": lambda df: df.isna().sum() / len(df) * 100,
        "Card.": lambda df: df.nunique(),
        "Min": lambda df: df.min(),
        "1st Qrt.": lambda df: df.quantile(0.25),
        "Mean": lambda df: df.mean(),
        "Median": lambda df: df.median(),
        "3rd Qrt": lambda df: df.quantile(0.75),
        "Max": lambda df: df.max(),
        "Std. Dev.": lambda df: df.std(),
    }

    contin_feat_names = data_df.select_dtypes("number").columns
    continuous_data_df = data_df[contin_feat_names]

    report_df = pd.DataFrame(index=contin_feat_names, columns=stats.keys())

    for stat_name, fn in stats.items():
        # NOTE: ignore warnings for empty features
        with warnings.catch_warnings():
            warnings.simplefilter("ignore", category=RuntimeWarning)
            report_df[stat_name] = fn(continuous_data_df)

    return report_df
build_continuous_features_report(source_dataset)
```

Out[30]:

	Count	Miss %	Card.	Min	1st Qrt.	Mean	Median	3rd Qrt	Max	Std. Dev.

	Count	Miss %	Card.	Min	1st Qrt.	Mean	Median	3rd Qrt.	Max	Std. Dev.
overall	1000000	0.00	5	1	4.00	4.37	5.00	5.00	5	1.00
verified	1000000	0.00	2	False	0.00	0.67	1.00	1.00	True	0.47
unixReviewTime	1000000	0.00	7514	849657600	1376265600.00	1406255022.37	1425686400.00	1472601600.00	1537920000	101010911.58
reviewText_num_characters	1000000	0.00	7917	0	114.00	541.05	227.00	599.00	31759	867.98
reviewText_num_words	1000000	0.00	2000	0	21.00	96.48	42.00	108.00	5359	150.61

Data Quality Report for Categorical Features:

Code refererred from CSCI 6409 - Tutorial 2

In [31]:

```python
def build_categorical_features_report(data_df):

    """Build tabular report for categorical features"""

    def _mode(df):
        return df.apply(lambda ft: ft.mode().to_list()).T

    def _mode_freq(df):
        return df.apply(lambda ft: ft.value_counts()[ft.mode()].sum())

    def _second_mode(df):
        return df.apply(lambda ft: ft[~ft.isin(ft.mode())].mode().to_list()).T

    def _second_mode_freq(df):
        return df.apply(
            lambda ft: ft[~ft.isin(ft.mode())]
            .value_counts()[ft[~ft.isin(ft.mode())].mode()]
            .sum()
        )

    stats = {
        "Count": len,
        "Miss %": lambda df: df.isna().sum() / len(df) * 100,
        "Card.": lambda df: df.nunique(),
        "Mode": _mode,
        "Mode Freq": _mode_freq,
        "Mode %": lambda df: _mode_freq(df) / len(df) * 100,
        "2nd Mode": _second_mode,
        "2nd Mode Freq": _second_mode_freq,
        "2nd Mode %": lambda df: _second_mode_freq(df) / len(df) * 100,
    }

    cat_feat_names = data_df.select_dtypes(exclude="number").columns
    continuous_data_df = data_df[cat_feat_names]

    report_df = pd.DataFrame(index=cat_feat_names, columns=stats.keys())

    for stat_name, fn in stats.items():
        # NOTE: ignore warnings for empty features
        with warnings.catch_warnings():
            warnings.simplefilter("ignore", category=RuntimeWarning)
            report_df[stat_name] = fn(continuous_data_df)

    return report_df
```

In [32]:

```
# test_dataset = source_dataset[["reviewText","format"]].copy()
build_categorical_features_report(source_dataset)
```

Out[32]:

	Count	Miss %	Card.	Mode	Mode Freq	Mode %	2nd Mode	2nd Mode Freq	2nd Mode %
reviewTime	1000000	0.00	7514	02 20, 2015	1537	0.15	03 29, 2016	1243	0.12
reviewerID	1000000	0.00	610262	A2F6N60Z96CAJI	317	0.03	A2OJW07GQRNJUT	240	0.02
asin	1000000	0.00	323635	038568231X	1013	0.10	0297859382	828	0.08
reviewerName	1000000	0.00	435945	Amazon Customer	46661	4.67	Kindle Customer	32034	3.20
reviewText	1000000	0.01	952186	Great	1105	0.11	good	1071	0.11
summary	1000000	0.03	629717	Five Stars	93655	9.37	Four Stars	23557	2.36
format	1000000	0.01	90	Kindle Edition	561493	56.15	Paperback	229310	22.93
contains_Non_AlphaNumeric	1000000	0.00	2	True	943365	94.34	False	56635	5.66

In [33]:

```
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 13 columns):
 #   Column                     Non-Null Count    Dtype
---  ------                     --------------    -----
 0   overall                    1000000 non-null  Int64
 1   verified                   1000000 non-null  boolean
 2   reviewTime                 1000000 non-null  string
 3   reviewerID                 1000000 non-null  string
 4   asin                       1000000 non-null  string
 5   reviewerName               999966 non-null   string
 6   reviewText                 999876 non-null   string
 7   summary                     999693 non-null   string
 8   unixReviewTime              1000000 non-null  Int64
 9   format                      999940 non-null   string
 10  reviewText_num_characters   1000000 non-null  int64
 11  reviewText_num_words        1000000 non-null  int64
 12  contains_Non_AlphaNumeric   1000000 non-null  object
dtypes: Int64(2), boolean(1), int64(2), object(1), string(7)
memory usage: 95.4+ MB
```

Visualization of Continuous Features

Configuring Plot properties

In [34]:

```
from matplotlib import pyplot as plt
%matplotlib inline
plt.rcParams["figure.figsize"] = [12, 8]
plt.rcParams["font.size"] = 15
```

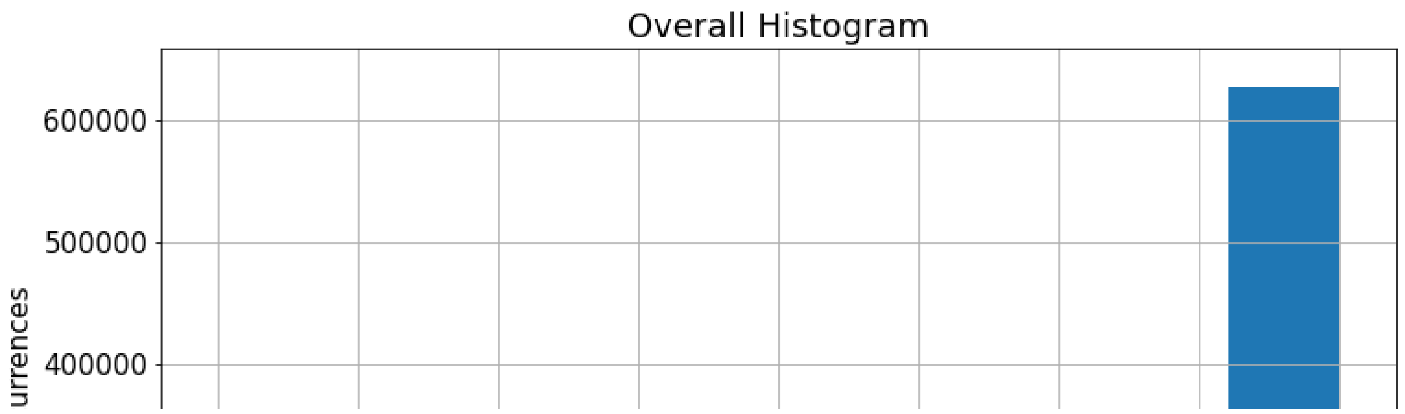
Histogram for the column - overall

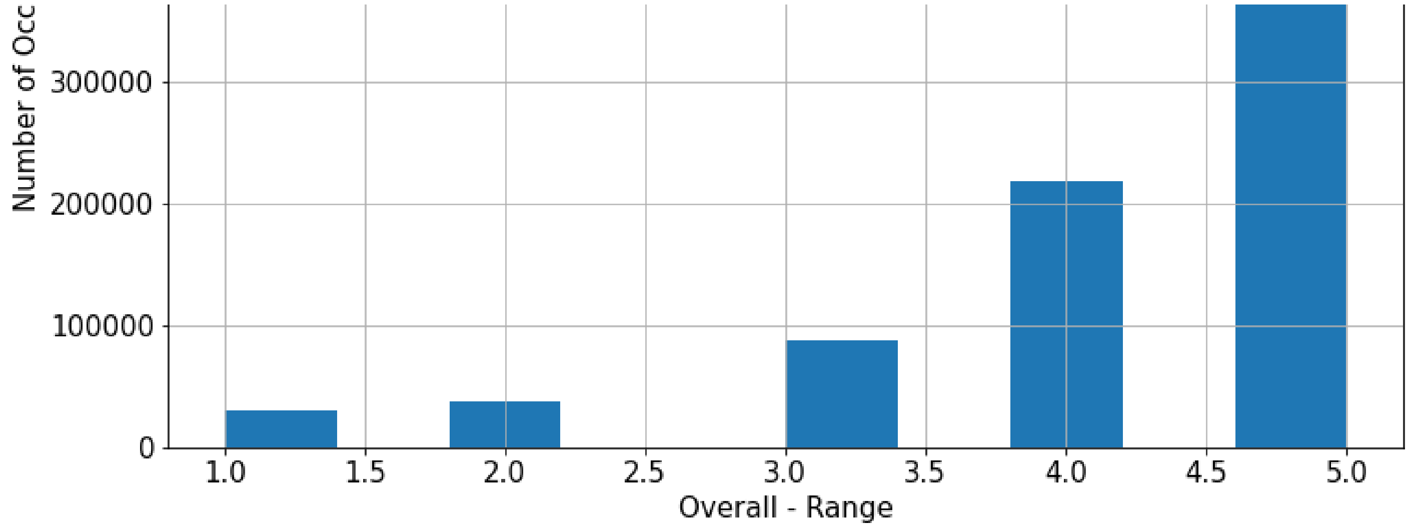
In [35]:

```
source_dataset.hist(column=['overall'])
plt.xlabel('Overall - Range')
plt.ylabel('Number of Occurrences')
plt.title('Overall Histogram')
```

Out[35]:

```
Text(0.5, 1.0, 'Overall Histogram')
```





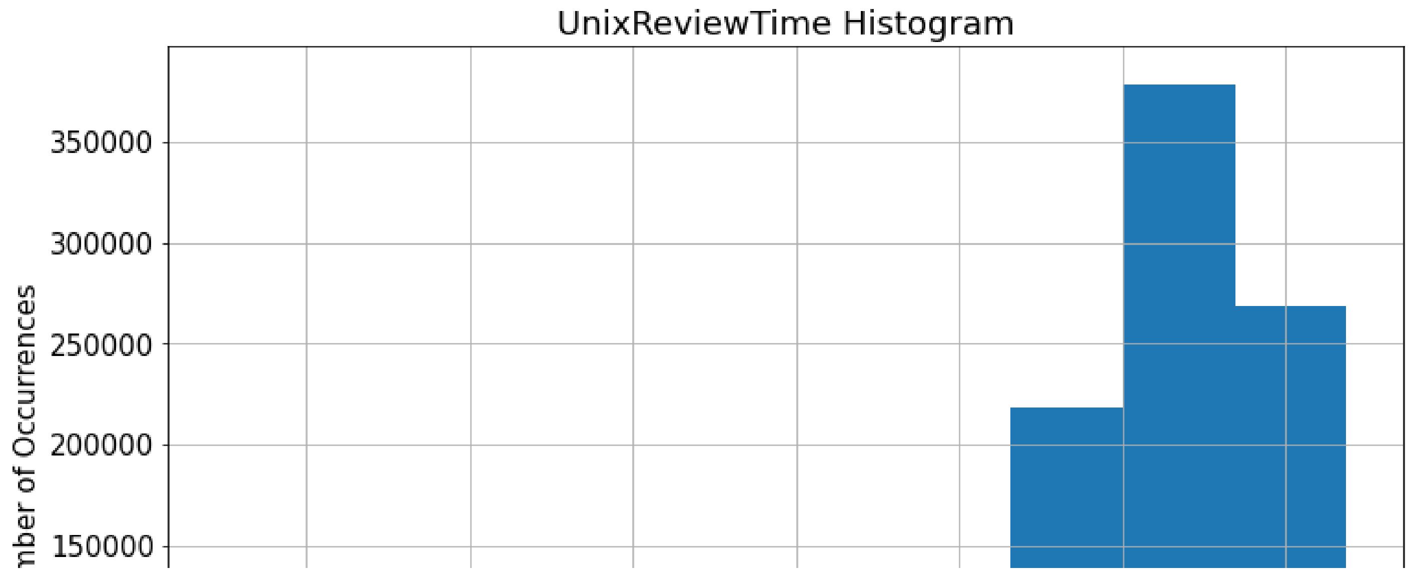
Histogram for the column - UnixReviewTime

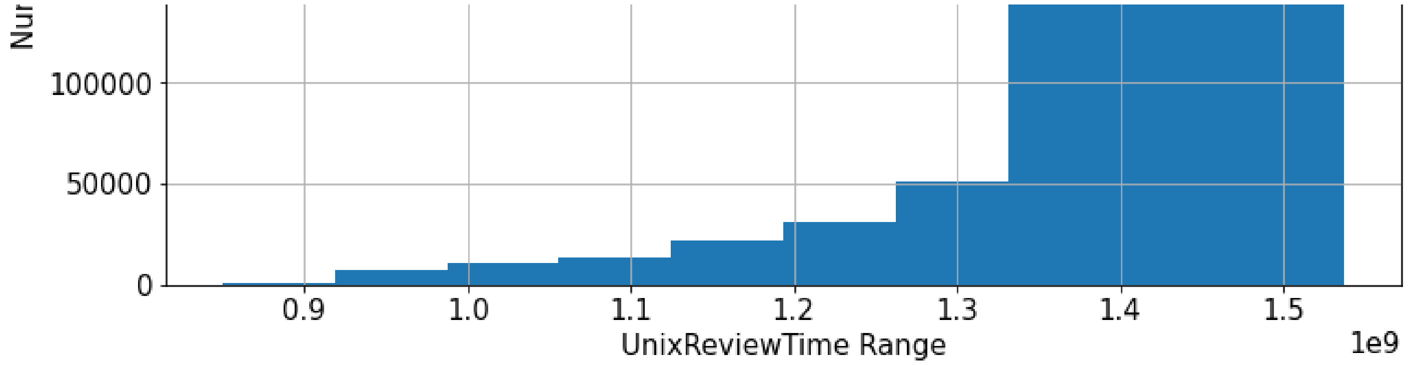
In [36]:

```
source_dataset.hist(column=['unixReviewTime'])
plt.xlabel('UnixReviewTime Range')
plt.ylabel('Number of Occurrences')
plt.title('UnixReviewTime Histogram')
```

Out[36]:

```
Text(0.5, 1.0, 'UnixReviewTime Histogram')
```





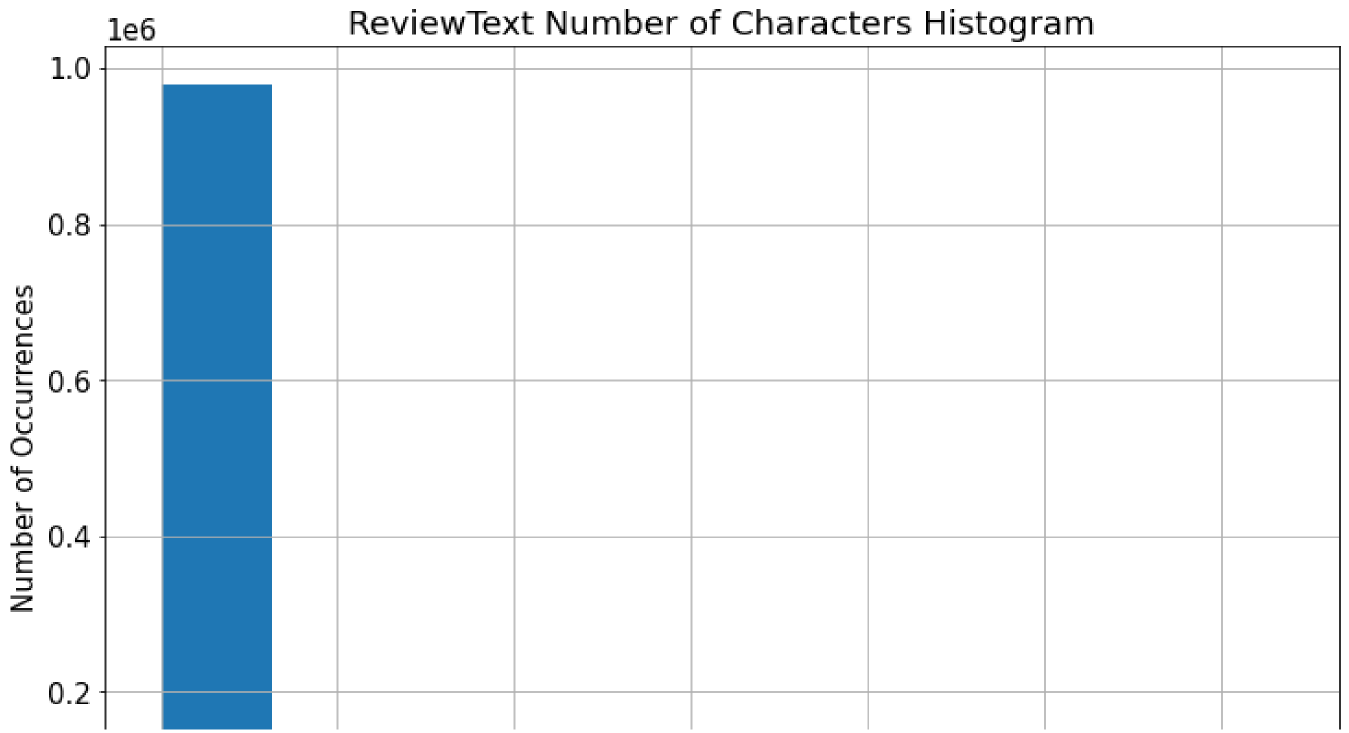
Histogram for the column - reviewText_num_characters

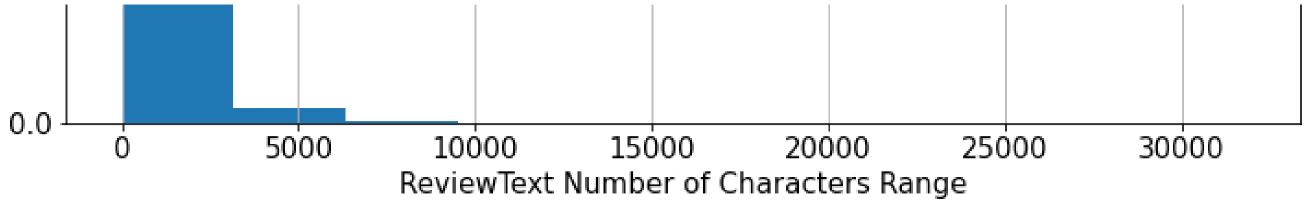
In [37]:

```
source_dataset.hist(column=['reviewText_num_characters'])
plt.xlabel('ReviewText Number of Characters Range')
plt.ylabel('Number of Occurrences')
plt.title('ReviewText Number of Characters Histogram')
```

Out[37]:

```
Text(0.5, 1.0, 'ReviewText Number of Characters Histogram')
```





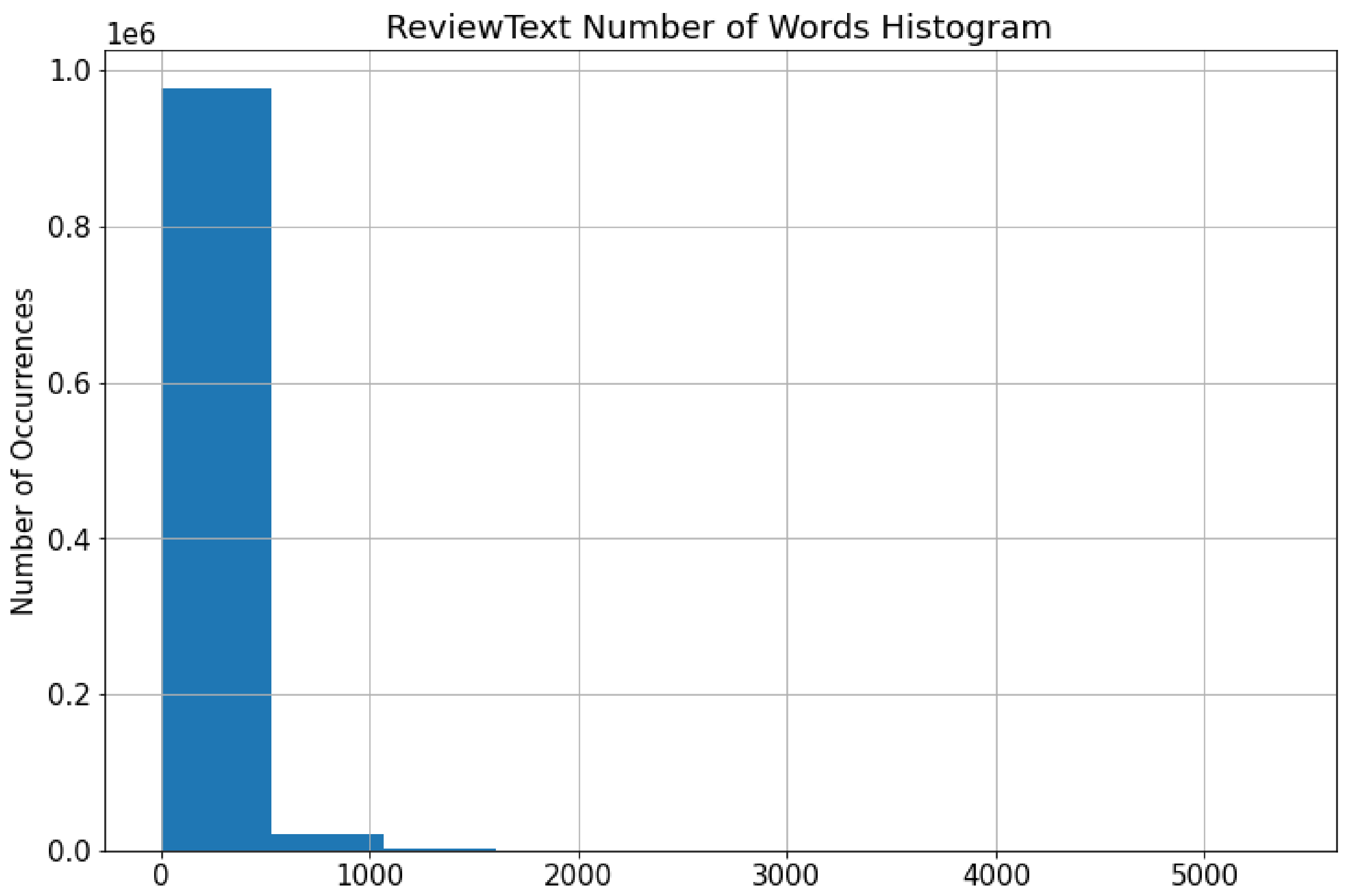
Histogram for the column - reviewText_num_words

In [38]:

```
source_dataset.hist(column=['reviewText_num_words'])
plt.xlabel('ReviewText Number of Words Range')
plt.ylabel('Number of Occurrences')
plt.title('ReviewText Number of Words Histogram')
```

Out[38]:

```
Text(0.5, 1.0, 'ReviewText Number of Words Histogram')
```



ReviewText Number of Words Range

Visualization of Categorical Features

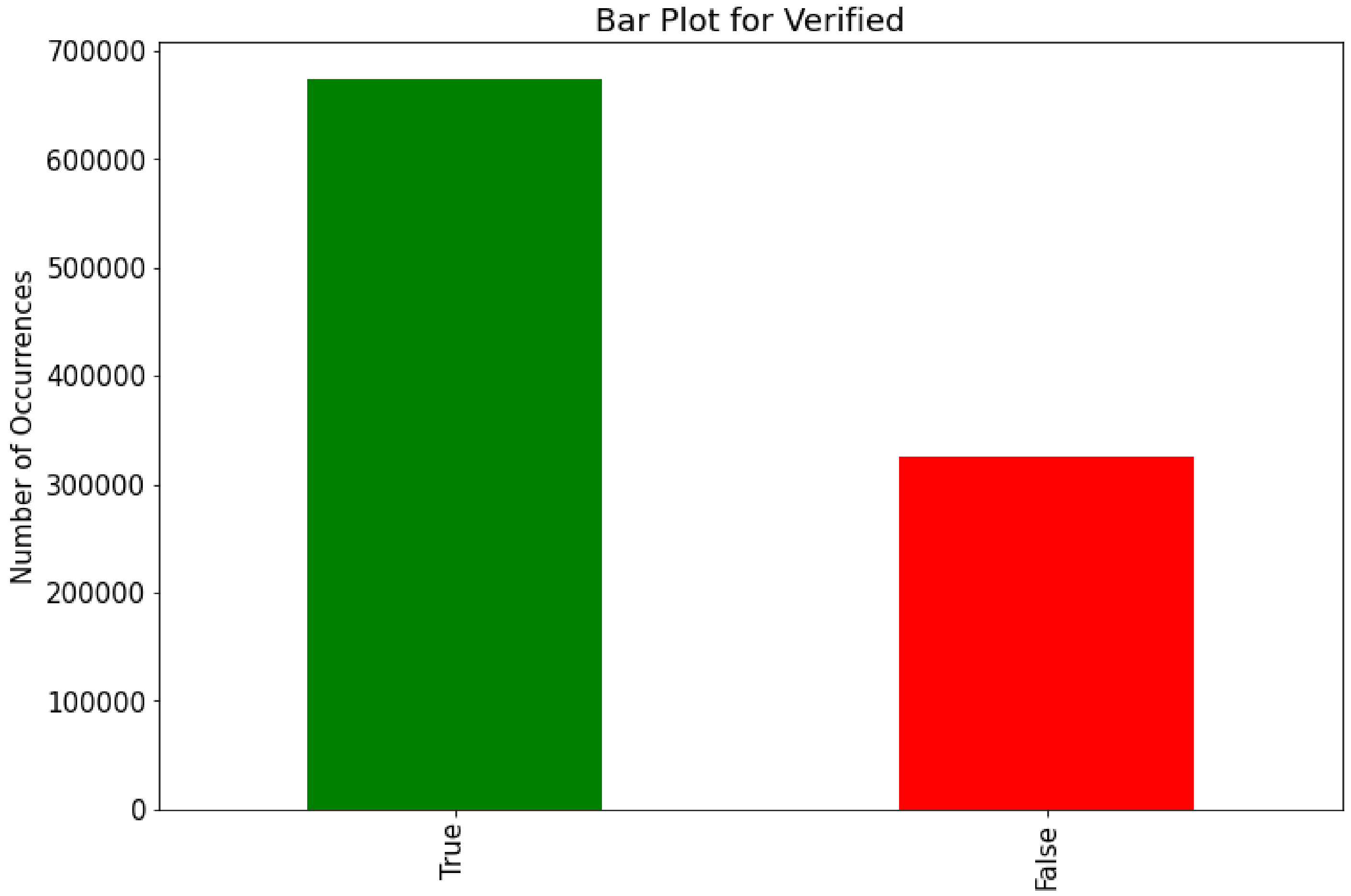
Frequencies of True / False for the Column - "verified"

In [39]:

```
p1 = source_dataset['verified'].value_counts().plot.bar(color=['green', 'red']);
plt.xlabel('Verified Categories')
plt.ylabel('Number of Occurrences')
plt.title('Bar Plot for Verified')
```

Out[39]:

```
Text(0.5, 1.0, 'Bar Plot for Verified')
```



Verified Categories

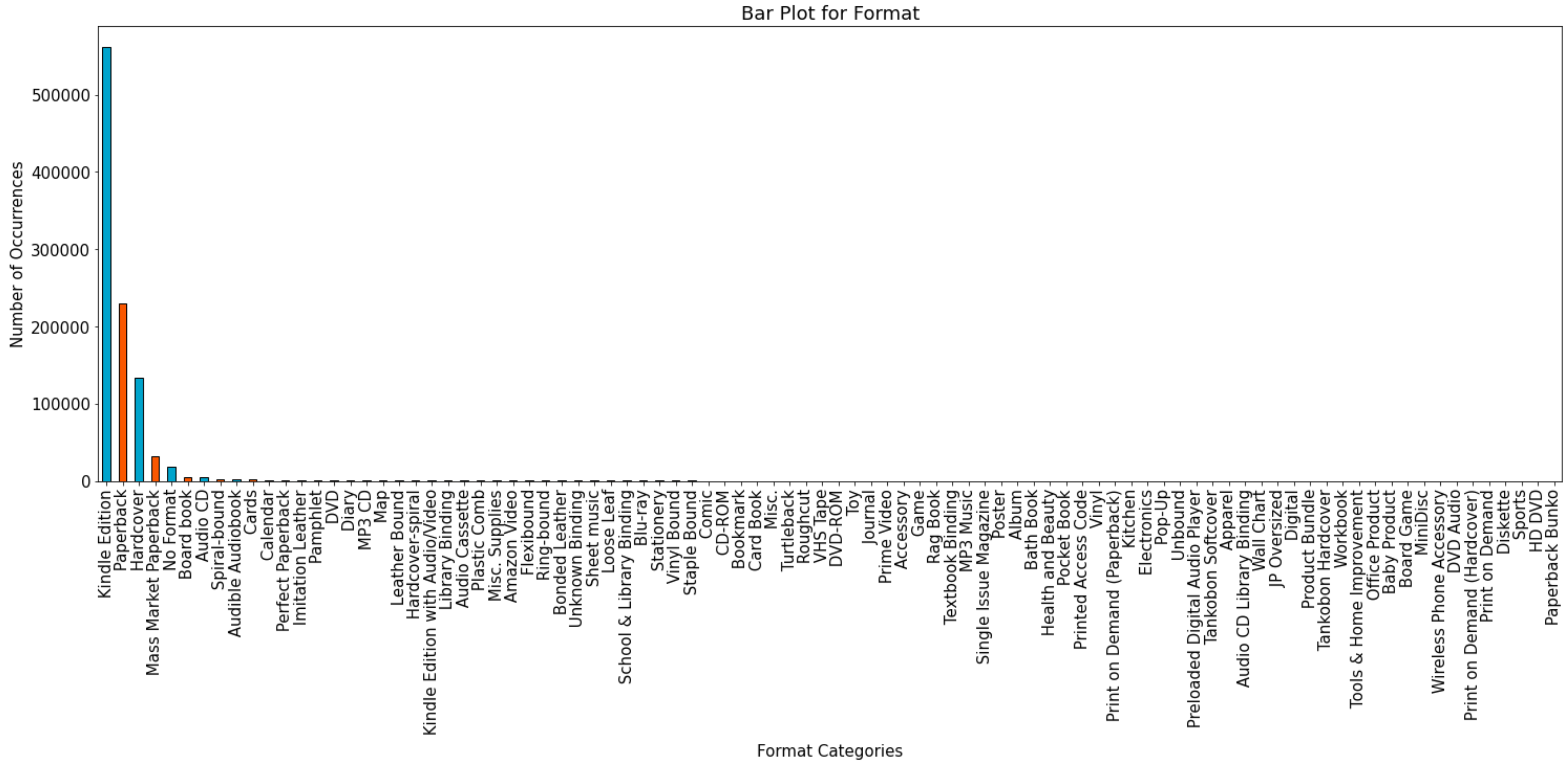
Frequency Distribution for the Column - "format"

In [40]:

```
plt.figure(figsize=(25,8))
p1 = source_dataset['format'].value_counts().plot.bar(color=['#00A4CCFF', '#F95700FF'],edgecolor='black');
plt.xlabel('Format Categories')
plt.ylabel('Number of Occurrences')
plt.title('Bar Plot for Format')
```

Out[40]:

```
Text(0.5, 1.0, 'Bar Plot for Format')
```



We have not performed Frequency distribution for the other categorical columns as they are insignificant for exploratory analysis.

1.C.Data Quality Issues, Plan and Preprocessing

Missing values:

In [41]:

```
source_dataset.isna().sum().sum()
```

Out[41]:

```
525
```

In [42]:

```
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 13 columns):
 #   Column                     Non-Null Count    Dtype  
---  ------                     --------------    -----  
 0   overall                    1000000 non-null  Int64  
 1   verified                   1000000 non-null  boolean
 2   reviewTime                 1000000 non-null  string 
 3   reviewerID                 1000000 non-null  string 
 4   asin                       1000000 non-null  string 
 5   reviewerName               999966 non-null   string 
 6   reviewText                 999876 non-null   string 
 7   summary                    999693 non-null   string 
 8   unixReviewTime             1000000 non-null  Int64  
 9   format                     999940 non-null   string 
 10  reviewText_num_characters  1000000 non-null  int64  
 11  reviewText_num_words       1000000 non-null  int64  
 12  contains_Non_AlphaNumeric  1000000 non-null  object 
dtypes: Int64(2), boolean(1), int64(2), object(1), string(7)
memory usage: 95.4+ MB
```

In [43]:

```
source_dataset.reviewerName = source_dataset.reviewerName.fillna("No Reviewer Name")
```

In [44]:

```
source_dataset.reviewText = source_dataset.reviewText.fillna("No Review Text")
```

In [45]:

```
source_dataset.summary = source_dataset.summary.fillna("No Summary")
```

In [46]:

```
source_dataset.format = source_dataset.format.fillna("No Format")
```

In [47]:

```
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 13 columns):
 #   Column                     Non-Null Count    Dtype  
---  ------                     --------------    -----  
 0   overall                    1000000 non-null  Int64  
 1   verified                   1000000 non-null  boolean
 2   reviewTime                 1000000 non-null  string 
 3   reviewerID                 1000000 non-null  string 
 4   asin                       1000000 non-null  string 
 5   reviewerName               1000000 non-null  string 
 6   reviewText                 1000000 non-null  string 
 7   summary                    1000000 non-null  string 
 8   unixReviewTime             1000000 non-null  Int64  
 9   format                     1000000 non-null  string 
 10  reviewText_num_characters  1000000 non-null  int64  
 11  reviewText_num_words       1000000 non-null  int64  
 12  contains_Non_AlphaNumeric  1000000 non-null  object 
dtypes: Int64(2), boolean(1), int64(2), object(1), string(7)
memory usage: 95.4+ MB
```

Irregular Cardinality

The column 'verified' has a cardinality of 2, which is odd for a continuous feature, therefore we will be treating this column as a categorical feature and we will also convert it into "0"s and "1"s.

"Verfied"

Let's convert the feature 'verified' into numeric values

In [48]:

```
source_dataset['verified'].replace(to_replace=True, value=1, inplace=True)
```

```
source_dataset['verified'].replace(to_replace=False,  value=0, inplace=True)
source_dataset['verified'] = source_dataset['verified'].astype(int)
source_dataset.dtypes
```

Out[48]:

```
overall                      Int64
verified                     int64
reviewTime                  string
reviewerID                  string
asin                        string
reviewerName                string
reviewText                  string
summary                     string
unixReviewTime               Int64
format                      string
reviewText_num_characters    int64
reviewText_num_words         int64
contains_Non_AlphaNumeric   object
dtype: object
```

In [49]:

```
source_dataset.head(10)
```

Out[49]:

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format	reviewText_num_characters	reviewText_num
0	3	0	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	School & Library Binding	617	
1	5	1	12 11, 2014	A12Q7B7NT716RV	0001712799	True Value Girl	Love it	Five Stars	1418256000	Hardcover	7	
2	4	0	01 6, 2006	A1DK5AZMXS1QA3	0002006448	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	Hardcover	1419	
3	4	0	12 8, 2014	A1JMSX54DO3LOP	0002005263	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	Kindle Edition	314	
4	2	1	03 3, 2014	A2IP27AZB3D1SM	0002005263	J. A.	I have read many of the Hillerman	Tony missed	1393804800	Kindle	235	

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format	reviewText_num_characters	reviewText_num
						Drummond	books and en...	the mark		Edition		
5	4	0	06 22, 2004	A2KSU7OOJ5C479	0002005263	Loren D. Morrison	I, like many of the other reviewers here, am a...	A COMPLEX , SUSPENSEFUL PLOT, BUT	1087862400	Hardcover	2244	
6	5	1	01 21, 2004	A3FT7WR9YGU4RK	0002005263	Anne Melvin	I had the CD read by George Guidall who does a...	A good mystery.	1074643200	Audio CD	462	
7	1	1	06 10, 2003	AMFB2GBB2O84X	0002005263	Brakaian	I am a huge Tony Hillerman fan -- I've read ea...	Easily Hillerman's worst -- very disappointing	1055203200	Hardcover	1781	
8	5	1	12 18, 2017	A243JAEFC50KWI	0001384198	dorothy	We all love the classics.	Classics never die.	1513555200	Hardcover	25	
9	5	1	09 6, 2017	A25B7XXSTTN1IY	0001384198	Snake	I love it	Five Stars	1504656000	Hardcover	9	

Let's perform 'one-hot encoding' to determine the correlation between features and subsequently build models to predict customer churn.

In [50]:

```
# #import pandas as pd
# transformed_df = pd.get_dummies(source_dataset, columns = ['format'])
# transformed_df.head(5)
```

What is the distribution of the top 50 most frequent words (excluding the stop words) for each of the textual features?

Answer: We will be considering the textual features reviewText and summary for this question

Let us first remove the stop words and create corresponding columns for each of these features

In [51]:

```
# source_dataset.drop(["reviewText_num_characters","reviewText_num_words","contains_Non_AlphaNumeric"],axis=1])
# source_dataset.drop(columns=["reviewText_num_characters","reviewText_num_words","contains_Non_AlphaNumeric"],axis=1,inplace=Tru
e)
```

In [52]:

```
from nltk.corpus import stopwords
nltk.download('stopwords')
stop_words = set(stopwords.words('english'))
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

In [53]:

```
# a = [ ] while(1): a.append('1')
```

In [54]:

```
source_dataset['reviewText'][0]
```

Out[54]:

```
'Dr. Seuss has some really brilliant books.  This book is just a so-so Dr. Seuss.  As a parent who is familiar with about 15 Dr. S
euss books, this is one of my least favorite books.\nThe book attempts to teach the child what "Up" means.  There is a terrific am
ount of repetition, and the cleverness in the rhyming and pictures is not "Up!" to par with other Dr. Seuss books.\nMy 6-month old
children are too young to understand this book, but I think that Mommy and Daddy will tire of the book long before they have gotte
n the very simple and trivial message in this book : what is the difference between Up and Down ...'
```

In [55]:

```
# words = [word for w in source_dataset['reviewText_tokenized'] for word in w  if word.lower() not in stop_words]

source_dataset['reviewText_filtered'] = source_dataset['reviewText'].apply(lambda x: ' '.join(word for word in x.split() if word.
lower() not in stop_words))
source_dataset['summary_filtered'] = source_dataset['summary'].apply(lambda x: ' '.join(word for word in x.split() if word.lower(
) not in stop_words))


# [[w for w in text.split() if w.lower() not in stopwords_set]
#             for text in texts]
```

In [56]:

```
source_dataset['reviewText_filtered'][0]
```

Out[56]:

```
'Dr. Seuss really brilliant books. book so-so Dr. Seuss. parent familiar 15 Dr. Seuss books, one least favorite books. book attem
pts teach child "Up" means. terrific amount repetition, cleverness rhyming pictures "Up!" par Dr. Seuss books. 6-month old childre
n young understand book, think Mommy Daddy tire book long gotten simple trivial message book : difference ...'
```

In [57]:

In [57]:

```
# from nltk.probability import FreqDist

# # Count frequency of each token in the list
# FreqDist(words)
# words=pd.series
source_dataset['reviewText_filtered'].value_counts(ascending=False)[0:50]
```

Out[57]:

```
good           1737
great          1117
Great          1109
Great book      964
Good            898
good book       863
Good read       724
ok              723
Excellent       687
good read       683
Good book       682
great book      642
Great book!     539
Great read      506
love            487
Loved           441
Love            437
Great!          412
Great book.     408
excellent       364
loved           337
Good read.      321
Loved it!       298
great read      296
Good book.      288
Great read!     280
Ok              254
good read.      253
Awesome         231
                230
OK              230
Excellent!      226
nice            224
Thanks          214
Great read.     209
Love it!        207
gift            196
good.           190
Thank           189
expected        178
thanks          177
```

```
interesting      175
Loved it.        166
good book.       158
thank            155
helpful          146
A+               144
Perfect          144
Interesting      143
informative      142
Name: reviewText_filtered, dtype: int64
```

In [58]:

```
import gc
gc.collect()
```

Out[58]:

```
267
```

In [59]:

```
source_dataset['summary_filtered'].value_counts(ascending=False)[0:50]
```

Out[59]:

```
Five Stars        93657
Four Stars        23557
Three Stars        9118
Great book         3501
Good read          3310
Great read         3042
Two Stars          2949
One Star           2752
Loved              2357
Excellent          2327
Loved it!          2235
Great              2089
good read          1929
Good               1857
Good book          1847
good               1802
Great Read         1779
Great Book         1716
Great book!        1607
Good Read          1593
Awesome            1520
Love               1473
Great read!        1461
Amazing            1412
                   1328
Wow                1171
```

```
great read         1153
great book         1150
good book          1075
Wonderful          1072
Interesting        1070
Great story         985
Disappointing       917
Great!              867
Enjoyable           829
great               814
Excellent!          807
Good Book           796
love                773
Great Book!         764
ok                  759
Fantastic           729
Disappointed        715
Love it!            715
Great Read!         712
Wow!                691
Good story          678
Awesome!            671
loved               659
must read           650
Name: summary_filtered, dtype: int64
```

In [60]:

```
source_dataset["format"].value_counts(ascending=False)
```

Out[60]:

```
 Kindle Edition                     561493
 Paperback                          229310
 Hardcover                          133260
 Mass Market Paperback               32080
No Format                            17879
 Board book                           4847
 Audio CD                             4275
 Spiral-bound                         2434
 Audible Audiobook                    2008
 Cards                                1643
 Calendar                              905
 Perfect Paperback                     854
 Imitation Leather                     813
 Pamphlet                              659
 DVD                                   559
 Diary                                 519
 MP3 CD                                514
 Map                                   472
 Leather Bound                         462
```

```
Hardcover-spiral                      427
Kindle Edition with Audio/Video       423
Library Binding                       408
Audio Cassette                        391
Plastic Comb                          382
Misc. Supplies                        361
Amazon Video                          326
Flexibound                            322
Ring-bound                            157
Bonded Leather                        155
Unknown Binding                       135
Sheet music                           105
Loose Leaf                            102
School & Library Binding              101
Blu-ray                                98
Stationery                             88
Vinyl Bound                            82
Staple Bound                           75
Comic                                  67
CD-ROM                                 57
Bookmark                               54
Card Book                              49
Misc.                                  48
Turtleback                             47
Roughcut                               41
VHS Tape                               38
DVD-ROM                                37
Toy                                    35
Journal                                34
Prime Video                            33
Accessory                              29
Game                                   27
Rag Book                               24
Textbook Binding                       23
MP3 Music                              23
Single Issue Magazine                  22
Poster                                 20
Album                                  19
Bath Book                              18
Health and Beauty                      14
Pocket Book                            13
Printed Access Code                    10
Vinyl                                   8
Print on Demand (Paperback)             8
Kitchen                                 8
Electronics                             8
Pop-Up                                  7
Unbound                                 6
Preloaded Digital Audio Player          6
Tankobon Softcover                      4
Apparel                                 4
```

```
 Apparel                              1
 Audio CD Library Binding             4
 Wall Chart                           4
 JP Oversized                         3
 Digital                              3
 Product Bundle                       2
 Tankobon Hardcover                   2
 Workbook                             2
 Tools & Home Improvement             2
 Office Product                       2
 Baby Product                         1
 Board Game                           1
 MiniDisc                             1
 Wireless Phone Accessory             1
 DVD Audio                            1
 Print on Demand (Hardcover)          1
 Print on Demand                      1
 Diskette                             1
 Sports                               1
 HD DVD                               1
 Paperback Bunko                      1
Name: format, dtype: Int64
```

As visible from the proportion information, the following are the least common formats of books:

Baby Product

Board Game

MiniDisc

Wireless Phone Accessory

DVD Audio

Print on Demand (Hardcover)

Diskette

Sports

HD DVD

Paperback Bunko

In [61]:

```
source_dataset["format"].value_counts(ascending=False)
```

Out[61]:

```
 Kindle Edition                     561493
 Paperback                          229310
 Hardcover                          133260
 Mass Market Paperback               32080
No Format                            17879
 Board book                           4847
 Audio CD                             4275
 Spiral-bound                         2434
 Audible Audiobook                    2008
 Cards                                1643
 Calendar                              905
 Perfect Paperback                     854
 Imitation Leather                     813
 Pamphlet                              659
 DVD                                   559
 Diary                                 519
 MP3 CD                                514
 Map                                   472
 Leather Bound                         462
 Hardcover-spiral                      427
 Kindle Edition with Audio/Video       423
 Library Binding                       408
 Audio Cassette                        391
 Plastic Comb                          382
 Misc. Supplies                        361
 Amazon Video                          326
 Flexibound                            322
 Ring-bound                            157
 Bonded Leather                        155
 Unknown Binding                       135
 Sheet music                           105
 Loose Leaf                            102
 School & Library Binding              101
 Blu-ray                                98
 Stationery                             88
 Vinyl Bound                            82
 Staple Bound                           75
 Comic                                  67
 CD-ROM                                 57
 Bookmark                               54
 Card Book                              49
 Misc.                                  48
 Turtleback                             47
 Roughcut                               41
 VHS Tape                               38
 DVD-ROM                                37
 Toy                                    35
 Journal                                34
 Prime Video                            33
 Accessory                              29
 Game                              27
 Rag Book                          24
 Textbook Binding                  23
 MP3 Music                         23
 Single Issue Magazine             22
 Poster                            20
 Album                             19
 Bath Book                         18
 Health and Beauty                 14
 Pocket Book                       13
 Printed Access Code               10
 Vinyl                              8
 Print on Demand (Paperback)        8
 Kitchen                            8
 Electronics                        8
 Pop-Up                             7
 Unbound                            6
 Preloaded Digital Audio Player     6
 Tankobon Softcover                 4
 Apparel                            4
 Audio CD Library Binding           4
 Wall Chart                         4
 JP Oversized                       3
 Digital                            3
 Product Bundle                     2
 Tankobon Hardcover                 2
 Workbook                           2
 Tools & Home Improvement           2
 Office Product                     2
 Baby Product                       1
 Board Game                         1
 MiniDisc                           1
 Wireless Phone Accessory           1
 DVD Audio                          1
 Print on Demand (Hardcover)        1
 Print on Demand                    1
 Diskette                           1
 Sports                             1
 HD DVD                             1
 Paperback Bunko                    1
Name: format, dtype: Int64
```

Finding Patterns in the Dataset

Kindle Edition, Paperbacks and Hardcovers are the three most popular formats of Books, within the scope of the dataset.

Again Kindle Edition, Paperbacks and Hardcovers are the three most popular formats of Books which have an overall score of 5

In [62]:

```
source_dataset[source_dataset.overall==5]["format"].value_counts()
```

Out[62]:

```
 Kindle Edition                     344655
 Paperback                          149846
 Hardcover                           84124
 Mass Market Paperback               17897
No Format                            12160
 Board book                           3819
 Audio CD                             2838
 Spiral-bound                         1755
 Cards                                1224
 Audible Audiobook                    1087
 Calendar                              779
 Perfect Paperback                     625
 Imitation Leather                     623
 Pamphlet                              460
 Diary                                 386
 DVD                                   382
 Leather Bound                         369
 MP3 CD                                332
 Hardcover-spiral                      312
 Map                                   311
 Library Binding                       292
 Plastic Comb                          283
 Misc. Supplies                        261
 Flexibound                            244
 Kindle Edition with Audio/Video       241
 Audio Cassette                        227
 Amazon Video                          198
 Ring-bound                            128
 Bonded Leather                        125
 Unknown Binding                        81
 Sheet music                            79
 Blu-ray                                69
 School & Library Binding               69
 Stationery                             65
 Loose Leaf                             64
 Vinyl Bound                            59
 Staple Bound                           51
 Bookmark                               45
 Comic                                  42
 Turtleback                             40
 CD-ROM                             34
 Card Book                          34
 Roughcut                           31
 VHS Tape                           29
 Misc.                              29
 Journal                            28
 DVD-ROM                            24
 Toy                                24
 Game                               21
 Rag Book                           21
 Accessory                          20
 MP3 Music                          19
 Bath Book                          15
 Album                              14
 Poster                             14
 Single Issue Magazine              13
 Pocket Book                        12
 Prime Video                        12
 Textbook Binding                   11
 Health and Beauty                  10
 Electronics                         7
 Kitchen                             7
 Pop-Up                              6
 Print on Demand (Paperback)         6
 Printed Access Code                 6
 Vinyl                               6
 Tankobon Softcover                  4
 Wall Chart                          3
 JP Oversized                        3
 Apparel                             3
 Preloaded Digital Audio Player      3
 Tools & Home Improvement            2
 Office Product                      2
 Digital                             2
 Baby Product                        1
 Print on Demand                     1
 Unbound                             1
 Wireless Phone Accessory            1
 DVD Audio                           1
 Diskette                            1
 Board Game                          1
 HD DVD                              1
 Audio CD Library Binding            1
 Product Bundle                      1
 Tankobon Hardcover                  1
Name: format, dtype: Int64
```

A total of 12160 books where the format wasn't specified had an overall score of 5.

In [63]:

```
source_dataset[source_dataset.format=="No Format"]["overall"].value_counts(ascending=True)
```

Out[63]:

```
2      576
1      651
3     1326
4     3166
5    12160
Name: overall, dtype: Int64
```

2. Text normalization and feature engineering

Create a new column merging review summary and text.

In [64]:

```
source_dataset['merged_review_summary'] = source_dataset['reviewText'] + source_dataset['summary']
```

Remove stop words.

Reference: Stackoverflow

In [65]:

```
source_dataset['merged_review_summary'] = source_dataset['merged_review_summary'].apply(lambda x: ' '.join(word.lower() for word
in x.split() if word.lower() not in stop_words))
```

In [66]:

```
source_dataset['merged_review_summary'][5]
```

Out[66]:

```
'i, like many reviewers here, long standing fan tony hillerman\'s mysteries featuring joe "the legendary lieutenant" leaphorn jim
chee. i, also like many reviewers, found __the sinister pig__ compelling mystery. carries many themes earlier hillerman mysteries:
sgt. jim chee navajo tribal police, love bernadette "bernie" manuelito, formerly tribal police, border patrol. chee afraid tell fe
elings fear rejection. aforementioned bernadette manuuelito love jim chee, also afraid express love due fear. retired "legendary l
ieutenant" ever-present maps analytical mind. always pleasure meet three again. powerful businessman/criminal money, political co
nnections, evil intentions let anything anyone stand way. couple ex-c.i.a. agents, one operating incognito murdered almost book op
ens, working amoral rich man. throw characters pot mix search 40 billion dollars missing royalties never paid various indigenous t
ribes, c.i.a. man\'s murder, drug smuggling plot, mystery (or perhaps mysteries) requires best leaphorn\'s analytical abilities ch
ee\'s intuition begin get bottom things. well, that\'s plot nutshell, make story well worth reading, but, something missing come a
nticipate hillerman\'s novels. majority previous novels, included, integral part plots, information widely known navajo, occasiona
```

```
lly hopi, customs, mythological history, religious rites. always felt getting cultural education well reading good mystery. unique
aspect previous books missing here, i, one, missed aspect knowledge usually shares us. even unique aspect writing missing, __the s
inister pig__ novel worth reading.a complex , suspenseful plot, . . . . .'
```

Remove numbers and other non-letter characters.

In [67]:

```
source_dataset['merged_review_summary'] = source_dataset['merged_review_summary'].str.replace('[^a-zA-Z]', ' ')
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:1: FutureWarning: The default value of regex will change from True to
False in a future version.
  """Entry point for launching an IPython kernel.
```

In [68]:

```
source_dataset['merged_review_summary'][5]
```

Out[68]:

```
'i  like many reviewers here  long standing fan tony hillerman s mysteries featuring joe  the legendary lieutenant  leaphorn jim c
hee  i  also like many reviewers  found   the sinister pig   compelling mystery  carries many themes earlier hillerman mysteries
sgt  jim chee navajo tribal police  love bernadette  bernie  manuelito  formerly tribal police  border patrol  chee afraid tell f
eelings fear rejection  aforementioned bernadette manuuelito love jim chee  also afraid express love due fear  retired  legendary
lieutenant  ever present maps analytical mind  always pleasure meet three again  powerful businessman criminal money  political co
nnections  evil intentions let anything anyone stand way  couple ex c i a  agents  one operating incognito murdered almost book o
pens  working amoral rich man  throw characters pot mix search    billion dollars missing royalties never paid various indigenous
tribes  c i a  man s murder  drug smuggling plot  mystery  or perhaps mysteries  requires best leaphorn s analytical abilities ch
ee s intuition begin get bottom things  well  that s plot nutshell  make story well worth reading  but  something missing come an
ticipate hillerman s novels  majority previous novels  included  integral part plots  information widely known navajo  occasional
ly hopi  customs  mythological history  religious rites  always felt getting cultural education well reading good mystery  unique
aspect previous books missing here  i  one  missed aspect knowledge usually shares us  even unique aspect writing missing    the
sinister pig   novel worth reading a complex   suspenseful plot           '
```

Perform either lemmatization or stemming. Motivate your choice.

We have perfromed lemmatization. This is due to the fact that lemmatization reveals the root word corresponding to each word whereas stemming removes the inflections such as "ish" and "ing" from words. We desired to find the root word to perform analysis on the nature of the review. Stemming might have had adverse impact on this analysis since it does not always return complete words.

Please note that we have taken only 100,000 rows, as stated in the assignment handout, in the interest if time and simplicity.

In [69]:

```
# w_tokenizer = nltk.tokenize.WhitespaceTokenizer()
# lemmatizer = nltk.stem.WordNetLemmatizer()
# def lemmatize_text(text):
#     return [lemmatizer.lemmatize(w) for w in w_tokenizer.tokenize(text)]

# source_dataset['text_lemmatized'] = df.text.apply(lemmatize_text)

from nltk.stem.wordnet import WordNetLemmatizer

# instantiate lemmatizer
lem = WordNetLemmatizer()

# word = "flies"
# # lemmatize "flies" as a verb (flies => (to) fly)
# print("Lemmatized Word:",lem.lemmatize(word,"v"))

min_dataset = source_dataset.iloc[0:100000]

min_dataset['text_lemmatized'] = min_dataset.merged_review_summary.apply(lambda x: ' '.join(lem.lemmatize(word,"v") for word in x
.split()))
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:20: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versu
s-a-copy
```

In [70]:

```
source_dataset['merged_review_summary'][5]
```

Out[70]:

```
'i  like many reviewers here  long standing fan tony hillerman s mysteries featuring joe  the legendary lieutenant  leaphorn jim c
hee  i  also like many reviewers  found   the sinister pig   compelling mystery  carries many themes earlier hillerman mysteries
sgt  jim chee navajo tribal police  love bernadette  bernie  manuelito  formerly tribal police  border patrol  chee afraid tell f
eelings fear rejection  aforementioned bernadette manuuelito love jim chee  also afraid express love due fear  retired  legendary
lieutenant  ever present maps analytical mind  always pleasure meet three again  powerful businessman criminal money  political co
nnections  evil intentions let anything anyone stand way  couple ex c i a  agents  one operating incognito murdered almost book o
pens  working amoral rich man  throw characters pot mix search    billion dollars missing royalties never paid various indigenous
tribes  c i a  man s murder  drug smuggling plot  mystery  or perhaps mysteries  requires best leaphorn s analytical abilities ch
ee s intuition begin get bottom things  well  that s plot nutshell  make story well worth reading  but  something missing come an
ticipate hillerman s novels  majority previous novels  included  integral part plots  information widely known navajo  occasional
ly hopi  customs  mythological history  religious rites  always felt getting cultural education well reading good mystery  unique
aspect previous books missing here  i  one  missed aspect knowledge usually shares us  even unique aspect writing missing    the
sinister pig   novel worth reading a complex   suspenseful plot           '
```

In [71]:

```
min_dataset['text_lemmatized'][5]
```

```
'i like many reviewers here long stand fan tony hillerman s mysteries feature joe the legendary lieutenant leaphorn jim chee i als
o like many reviewers find the sinister pig compel mystery carry many theme earlier hillerman mysteries sgt jim chee navajo tribal
police love bernadette bernie manuelito formerly tribal police border patrol chee afraid tell feel fear rejection aforementioned
bernadette manuuelito love jim chee also afraid express love due fear retire legendary lieutenant ever present map analytical mind
always pleasure meet three again powerful businessman criminal money political connections evil intentions let anything anyone sta
nd way couple ex c i a agents one operate incognito murder almost book open work amoral rich man throw character pot mix search b
illion dollars miss royalties never pay various indigenous tribes c i a man s murder drug smuggle plot mystery or perhaps mysterie
s require best leaphorn s analytical abilities chee s intuition begin get bottom things well that s plot nutshell make story well
worth read but something miss come anticipate hillerman s novels majority previous novels include integral part plot information w
idely know navajo occasionally hopi customs mythological history religious rites always felt get cultural education well read good
mystery unique aspect previous book miss here i one miss aspect knowledge usually share us even unique aspect write miss the sini
ster pig novel worth read a complex suspenseful plot'
```

We can observe that the merged text has been lemmatized.

Example:

Standing -> Stand

found -> find

Convert the corpus into a bag-of-words TF-IDF weighted vector representation.

In [72]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
v = TfidfVectorizer()
x = v.fit_transform(min_dataset['text_lemmatized'])
```

Build a model to predict overall score

The task that we are solving is relevant to Regression since we will be predicting a continuous feature - 'overall score'

Let's determine the correlation between 'Overall Score' and the other features in the dataframe

References:

1. Seaborn Histogram Plots
2. Sort Bar Plots by a Column's values

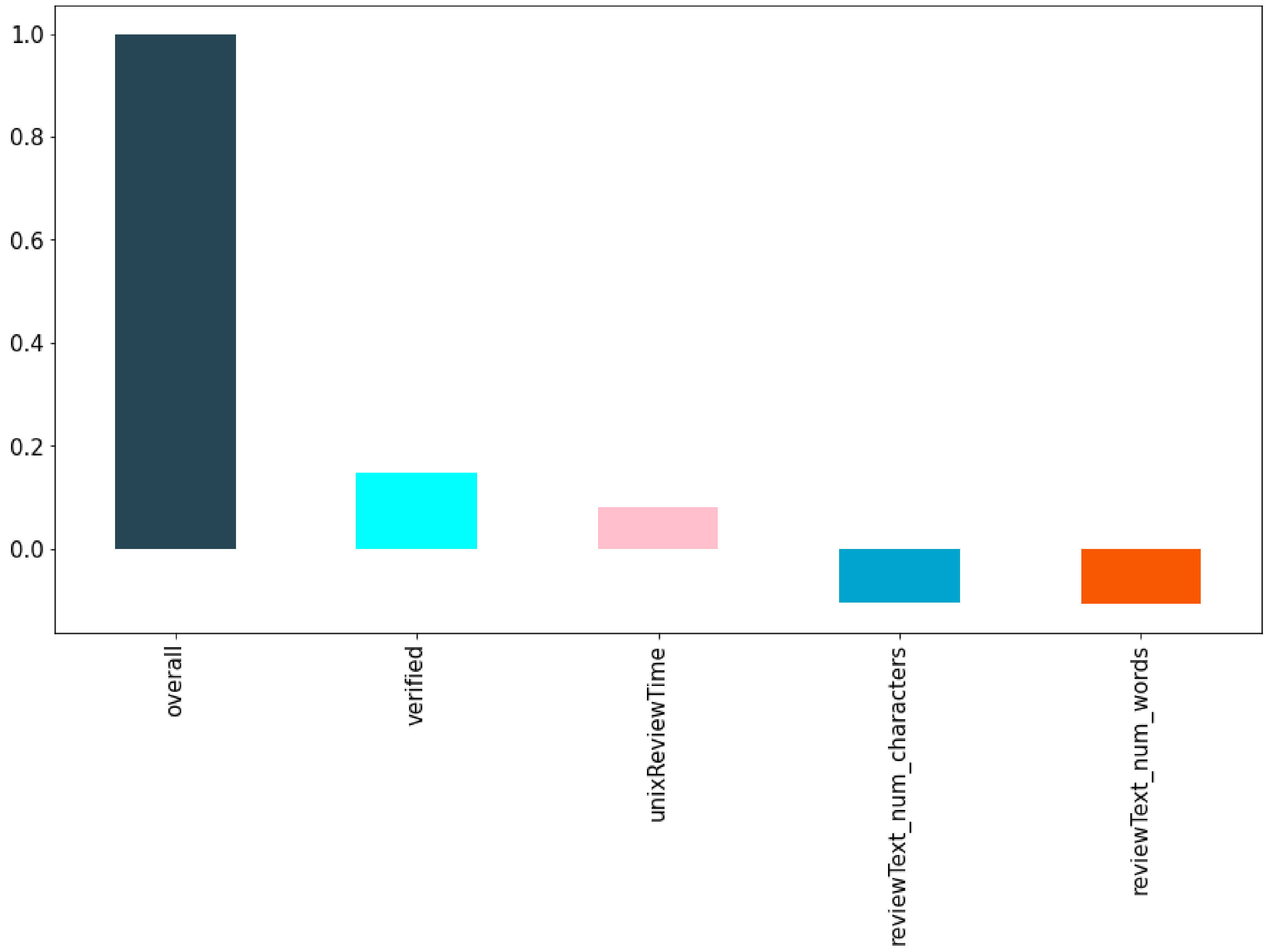
In [73]:

```
plt.figure(figsize=(15,8))
```

```
colors = ['#264653','cyan', 'pink','#00A4CCFF', '#F95700FF','#101820FF', '#FEE715FF', 'brown','#00539CFF', '#EEA47FFF','gold', 's
ilver','#ED2B33FF', '#2C5F2D']
min_dataset.corr()['overall'].sort_values(ascending = False).plot(kind = 'bar', color = colors)
```

Out[73]:

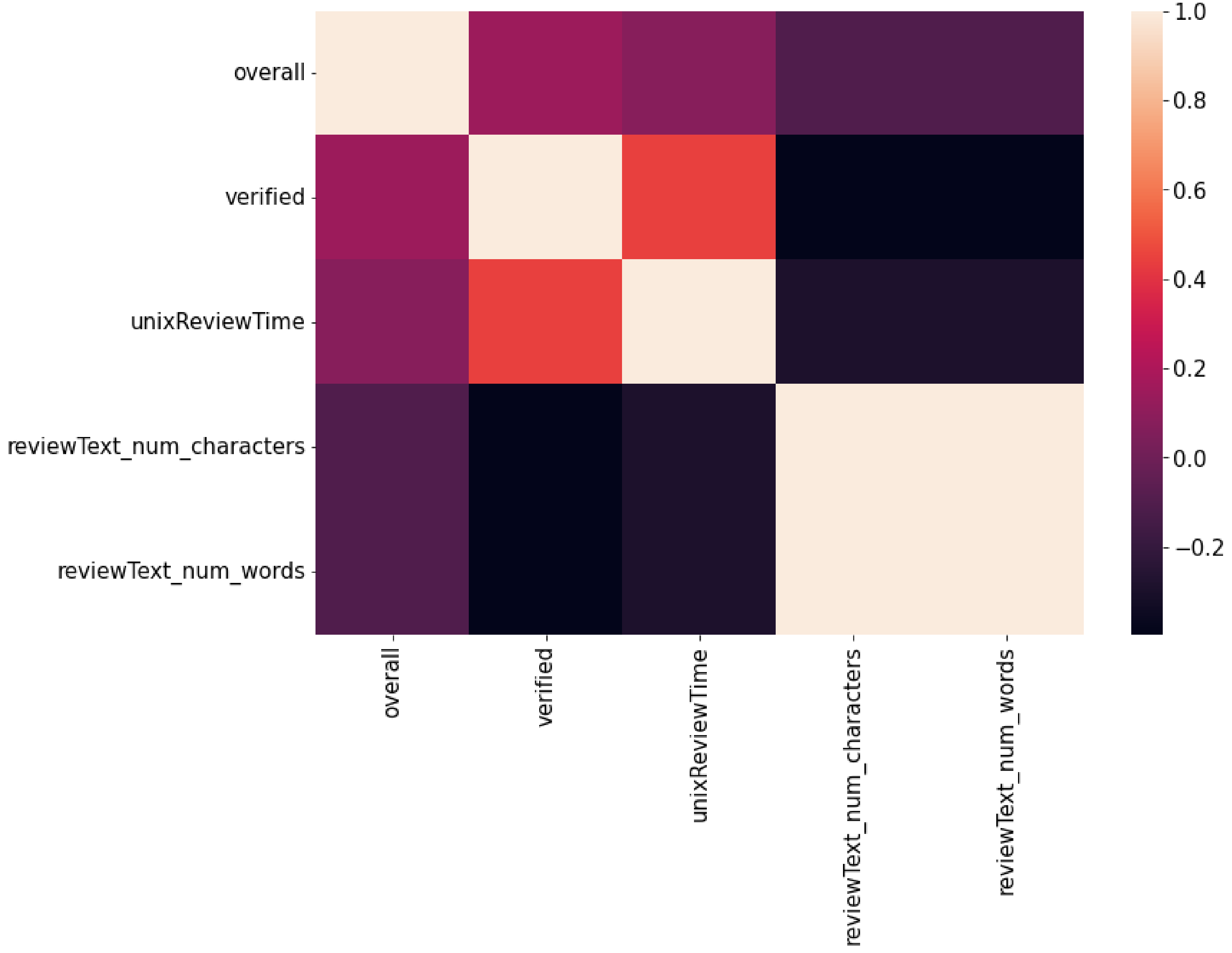
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3e74476090>
```



Feature Transformation

In [74]:

```
min_dataset.style
import matplotlib.pyplot as plt
import seaborn as sb
dataplot=sb.heatmap(min_dataset.corr())
plt.show()
```



Before we perform feature selection let us drop columns that are obviously irrelevant to score prediction as these features might have an adverse effect on the model.

Let's also seprarate the Target Feature (overall score) from the Input Features.

In [75]:

```
min_dataset.head(10)
```

Out[75]:

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format	reviewText_num_characters	reviewText_num
0	3	0	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	School & Library Binding	617	
1	5	1	12 11, 2014	A12Q7B7NT716RV	0001712799	True Value Girl	Love it	Five Stars	1418256000	Hardcover	7	
2	4	0	01 6, 2006	A1DK5AZMXS1QA3	0002006448	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	Hardcover	1419	
3	4	0	12 8, 2014	A1JMSX54DO3LOP	0002005263	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	Kindle Edition	314	
4	2	1	03 3, 2014	A2IP27AZB3D1SM	0002005263	J. A. Drummond	I have read many of the Hillerman books and en...	Tony missed the mark	1393804800	Kindle Edition	235	
5	4	0	06 22, 2004	A2KSU7OOJ5C479	0002005263	Loren D. Morrison	I, like many of the other reviewers here, am a...	A COMPLEX , SUSPENSEFUL PLOT, BUT	1087862400	Hardcover	2244	
6	5	1	01 21, 2004	A3FT7WR9YGU4RK	0002005263	Anne Melvin	I had the CD read by George Guidall who does a...	A good mystery.	1074643200	Audio CD	462	
							I am a huge					

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime	format	reviewText_num_characters	reviewText_num
7	1	1	06 10, 2003	AMFB2GBB2O84X	0002005263	Brakaian	I am a huge Tony Hillerman fan -- I've read ea...	Easily Hillerman's worst -- very disappointing	1055203200	Hardcover	1781	
8	5	1	12 18, 2017	A243JAEFC50KWI	0001384198	dorothy	We all love the classics.	Classics never die.	1513555200	Hardcover	25	
9	5	1	09 6, 2017	A25B7XXSTTN1IY	0001384198	Snake	I love it	Five Stars	1504656000	Hardcover	9	

We will remove irrelevant features like reviewTime and reviewer information. Also we will be removing the original review text and summary since we have merged these two columns, removed stop words and lemmatized the text into one column which is the column - "text_lemmatized".

In [78]:

```
# Y=min_dataset.overall
# X=min_dataset.drop(['overall','verified','reviewText_num_characters','reviewText_num_words','reviewTime','reviewerID','asin','r
eviewerName','unixReviewTime','contains_Non_AlphaNumeric','reviewText','summary','reviewText_filtered','summary_filtered','merged
_review_summary','format'],axis=1)
# print(type(X))
# X.head(5)
# Y.head(5)

X = min_dataset['text_lemmatized'].tolist()
Y = min_dataset['overall'].values
```

2.Baseline Model

Training and evaluate the model on test data

In [80]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.2, random_state=101)
```

In [ ]:

```
import numpy as np

import nltk
# import the snowball stemmer which is more complex than porter
from nltk.stem.snowball import SnowballStemmer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.pipeline import Pipeline
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.svm import SVC
from sklearn.datasets import fetch_20newsgroups
from sklearn.metrics import classification_report

# download the stopwords
nltk.download('stopwords')

# create a snowball stemmer for English text that does not stem stopwords
stemmer = SnowballStemmer("english", ignore_stopwords=True)

# get newsgroups dataset (categorical classification dataset)
twenty_train = fetch_20newsgroups(subset='train', shuffle=True)
twenty_test = fetch_20newsgroups(subset='test', shuffle=True)

# create a class to vectorize stemmed text by frequency counts
class StemmedCountVectorizer(CountVectorizer):
    # function to create an analyzer function
    def build_analyzer(self):
        # initialize CountVectorizer and call build_analyzer on it
        analyzer = super(StemmedCountVectorizer, self).build_analyzer()
        # return a function that stems each token of input and counts
        return lambda doc: ([stemmer.stem(w) for w in analyzer(doc)])

# create an instance of the StemmedCountVectorizer using English stopwords
stemmed_count_vect = StemmedCountVectorizer(stop_words='english')

# create a pipeline to take the results of the StemmedCountVectorizer (the stem frequency)
# pass it to a TfidfTransformer to calculate tf-idf weighting, and pass that to a
# SVC to train the classifier on the vectorized corpus.
text_svc_stemmed = Pipeline([('vect', stemmed_count_vect),
                             ('tfidf', TfidfTransformer()),
                             ('svc', SVC())])
y_train=y_train.astype('int')
y_test=y_test.astype('int')
# fit the model to the data
text_svc_stemmed = text_svc_stemmed.fit(twenty_train.data, twenty_train.target)
# predict on new data
predicted_svc_stemmed = text_svc_stemmed.predict(twenty_test.data)

# output performace metrics
print(classification_report(twenty_test.target, predicted_svc_stemmed))
```

```
              precision    recall  f1-score   support

           1       0.00      0.00      0.00         3
           2       0.00      0.00      0.00         3
           3       0.00      0.00      0.00        10
           4       0.00      0.00      0.00        11
           5       0.59      1.00      0.74        39
```

```
    accuracy                           0.59        66
   macro avg       0.12      0.20      0.15        66
weighted avg       0.35      0.59      0.44        66
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/feature_extraction/text.py:401: UserWarning: Your stop_words may be inconsistent wi
th your preprocessing. Tokenizing the stop words generated tokens ['b', 'c', 'd', 'e', 'f', 'g', 'h', 'k', 'l', 'm', 'n', 'o', 'p'
, 'r', 's', 't', 'u', 'v', 'w', 'x', 'y'] not in stop_words.
  % sorted(inconsistent)
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision and F-score are
ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision and F-score are
ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision and F-score are
ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Perform part-of-speech tagging

In [ ]:

```
import pandas as pd
import io
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

In [ ]:

```
source_dataset = pd.read_json('/content/drive/MyDrive/Colab Notebooks/sample.jsonl', lines=True)
```

In [ ]:

```
source_dataset.head(10)
source_dataset=source_dataset.drop(source_dataset.index[100000:])
```

In [ ]:

```
source_dataset.info()
source_dataset = source_dataset.convert_dtypes()
source_dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 100000 entries, 0 to 99999
Data columns (total 12 columns):
 #   Column          Non-Null Count   Dtype 
---  ------          --------------   ----- 
 0   overall         100000 non-null  int64 
 1   vote            21431 non-null   object
 2   verified        100000 non-null  bool  
 3   reviewTime      100000 non-null  object
 4   reviewerID      100000 non-null  object
 5   asin            100000 non-null  object
 6   style           98182 non-null   object
 7   reviewerName    99997 non-null   object
 8   reviewText      99981 non-null   object
 9   summary         99986 non-null   object
 10  unixReviewTime  100000 non-null  int64 
 11  image           140 non-null     object
dtypes: bool(1), int64(2), object(9)
memory usage: 9.3+ MB
<class 'pandas.core.frame.DataFrame'>
Int64Index: 100000 entries, 0 to 99999
Data columns (total 12 columns):
 #   Column          Non-Null Count   Dtype  
---  ------          --------------   -----  
 0   overall         100000 non-null  Int64  
 1   vote            21431 non-null   string 
 2   verified        100000 non-null  boolean
 3   reviewTime      100000 non-null  string 
 4   reviewerID      100000 non-null  string 
 5   asin            100000 non-null  string 
 6   style           98182 non-null   object 
 7   reviewerName    99997 non-null   string 
 8   reviewText      99981 non-null   string 
 9   summary         99986 non-null   string 
 10  unixReviewTime  100000 non-null  Int64  
 11  image           140 non-null     object 
dtypes: Int64(2), boolean(1), object(2), string(7)
memory usage: 9.5+ MB
```

In [ ]:

```
source_dataset['reviewText']
```

Out[ ]:

```
0        Dr. Seuss has some really brilliant books.  Th...
1                                                  Love it
2        Hand-woven carpets are one of the few products...
3        Compelling, twisting mystery involving several...
4        I have read many of the Hillerman books and en...
                               ...                        
99995    The book was lousy.  Didn't even finish just s...
99996    About the Book
```

```
A city is hit by an epidemic o...
99997    Simply stunning. Continues from the previous b...
99998    Great and excellent.. I'm very confortable wit...
99999         I read it in a couple days. Hard to put down
Name: reviewText, Length: 100000, dtype: string
```

In [ ]:

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

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data]     /root/nltk_data...
[nltk_data]   Package averaged_perceptron_tagger is already up-to-
[nltk_data]       date!
```

Out[ ]:

```
True
```

In [ ]:

```
def custom_tokenize(text):
    if pd.isna(text):
        print('The text to be tokenized is a None type. Defaulting to blank string.')
        text = ''
    return nltk.word_tokenize(text)
source_dataset['tokenized_reviewText'] = source_dataset['reviewText'].apply(custom_tokenize)
```

```
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
The text to be tokenized is a None type. Defaulting to blank string.
```

```
In [ ]:
```

```python
def custom_pos(tokenText):
    return [word for word,pos in nltk.pos_tag(tokenText) if pos == 'NN']

source_dataset['pos_tag_reviewText'] = source_dataset['tokenized_reviewText'].apply(custom_pos)
```

```
In [ ]:
```

```python
source_dataset.head(10)
```

```
Out[ ]:
```

	overall	vote	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText	summary	unixReviewTime	image	tokenized_reviewText	pos_ta
0	3	2	False	05 18, 2002	AJ8AQG2X9JJ2Y	0001712799	{'Format:': ' School & Library Binding'}	Donald Gillies	Dr. Seuss has some really brilliant books. Th...	A below-average Dr. Seuss Book	1021680000	NaN	[Dr., Seuss, has, some, really, brilliant, boo...	
1	5	<NA>	True	12 11, 2014	A12Q7B7NT716RV	0001712799	{'Format:': ' Hardcover'}	True Value Girl	Love it	Five Stars	1418256000	NaN	[Love, it]	
2	4	3	False	01 6, 2006	A1DK5AZMXS1QA3	0002006448	{'Format:': ' Hardcover'}	Newton Ooi	Hand-woven carpets are one of the few products...	Tourism as history	1136505600	NaN	[Hand-woven, carpets, are, one, of, the, few, ...	[re w
3	4	<NA>	False	12 8, 2014	A1JMSX54DO3LOP	0002005263	{'Format:': ' Kindle Edition'}	Bookzilla	Compelling, twisting mystery involving several...	Compelling, twisting mystery	1417996800	NaN	[Compelling, ,, twisting, mystery, involving, ...	auth
4	2	2	True	03 3, 2014	A2IP27AZB3D1SM	0002005263	{'Format:': ' Kindle Edition'}	J. A. Drummond	I have read many of the Hillerman books and en...	Tony missed the mark	1393804800	NaN	[I, have, read, many, of, the, Hillerman, book...	[wo so
5	4	4	False	06 22, 2004	A2KSU7OOJ5C479	0002005263	{'Format:': ' Hardcover'}	Loren D. Morrison	I, like many of the other reviewers here, am a...	A COMPLEX , SUSPENSEFUL PLOT, BUT	1087862400	NaN	[I, ,, like, many, of, the, other, reviewers, ...	| myst
6	5	2	True	01 21, 2004	A3FT7WR9YGU4RK	0002005263	{'Format:': ' Audio CD'}	Anne Melvin	I had the CD read by George Guidall who does a...	A good mystery.	1074643200	NaN	[I, had, the, CD, read, by, George, Guidall, w...	impr n

	overall	vote	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText	summary	unixReviewTime	image	tokenized_reviewText	pos_ta
7	1	9	True	06 10, 2003	AMFB2GBB2O84X	0002005263	{'Format:': ' Hardcover'}	Brakaian	I am a huge Tony Hillerman fan -- I've read ea...	Easily Hillerman's worst -- very disappointing	1055203200	NaN	[I, am, a, huge, Tony, Hillerman, fan, --, I, ...	[fa
8	5	<NA>	True	12 18, 2017	A243JAEFC50KWI	0001384198	{'Format:': ' Hardcover'}	dorothy	We all love the classics.	Classics never die.	1513555200	NaN	[We, all, love, the, classics, .]	
9	5	<NA>	True	09 6, 2017	A25B7XXSTTN1IY	0001384198	{'Format:': ' Hardcover'}	Snake	I love it	Five Stars	1504656000	NaN	[I, love, it]	

In [ ]:

```python
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.pipeline import Pipeline
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.svm import SVC
from sklearn.metrics import classification_report

X = source_dataset['pos_tag_reviewText'].tolist()
y = source_dataset['overall'].values

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, random_state=42)
```

In [ ]:

```python
# # create a class to vectorize stemmed text by frequency counts
# class StemmedCountVectorizer(CountVectorizer):
#     # function to create an analyzer function
#     def build_analyzer(self):
#         # initialize CountVectorizer and call build_analyzer on it
#         analyzer = super(StemmedCountVectorizer, self).build_analyzer()
#         # return a function that stems each token of input and counts
#         return lambda doc: ([stemmer.stem(w) for w in analyzer(doc)])

# create an instance of the StemmedCountVectorizer using English stopwords
# stemmed_count_vect = StemmedCountVectorizer(stop_words='english')

def identity_tokenizer(text):
    return text

text_svc_stemmed = Pipeline([('vect', CountVectorizer(tokenizer=identity_tokenizer, stop_words='english', lowercase=False)),
                            ('tfidf', TfidfTransformer()),
                           #  ('tfidf', TfidfVectorizer()),
                            ('svc', SVC())
```

```
                              ])
y_train=y_train.astype('int')
y_test=y_test.astype('int')
# fit the model to the data
text_svc_stemmed = text_svc_stemmed.fit(X_train, y_train)
# predict on new data
predicted_svc_stemmed = text_svc_stemmed.predict(X_test)

# output performace metrics
print(classification_report(y_test, predicted_svc_stemmed))
```

```
              precision    recall  f1-score   support

           1       0.00      0.00      0.00         3
           2       0.00      0.00      0.00         3
           3       0.00      0.00      0.00        10
           4       0.00      0.00      0.00        11
           5       0.59      1.00      0.74        39

    accuracy                           0.59        66
   macro avg       0.12      0.20      0.15        66
weighted avg       0.35      0.59      0.44        66
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/feature_extraction/text.py:401: UserWarning: Your stop_words may be inconsistent wi
th your preprocessing. Tokenizing the stop words generated tokens ['b', 'c', 'd', 'e', 'f', 'g', 'h', 'k', 'l', 'm', 'n', 'o', 'p'
, 'r', 's', 't', 'u', 'v', 'w', 'x', 'y'] not in stop_words.
  % sorted(inconsistent)
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision and F-score are
ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision and F-score are
ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision and F-score are
ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

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