Amazon Clothing Recommendation Engine ¶

Import necessary packages.

In [249]:

```
from PIL import Image
import requests
from io import BytesIO
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import warnings
from bs4 import BeautifulSoup
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
import math
import time
import re
import os
import seaborn as sns
from collections import Counter
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.metrics.pairwise import cosine_similarity
from sklearn.metrics import pairwise_distances
from matplotlib import gridspec
from scipy.sparse import hstack
import plotly
import plotly.figure_factory as ff
from plotly.graph_objs import Scatter, Layout

plotly.offline.init_notebook_mode(connected=True)
warnings.filterwarnings("ignore")
```

In [250]:

```
from pprint import pprint
```

Load Original Data

In [251]:

```
data = pd.read_json('/ilab/users/ak1648/akshat/women_clothing_amazon.json')
```

We will be using the following features

1. asin (Amazon standard identification number)
2. brand (brand to which the product belongs to)
3. color (Color information of apparel, it can contain many colors as a value ex: red and black stripes)
4. product_type_name (type of the apperal, ex: SHIRT/TSHIRT)
5. medium_image_url (url of the image)
6. title (title of the product.)
7. formatted_price (price of the product)

In [252]:

```
data = data[['asin', 'brand', 'color', 'medium_image_url', 'product_type_name', 'tit
print ('Number of data points : ', data.shape[0], \
       'Number of features:', data.shape[1])
data.head()
```

```
Number of data points :  183138 Number of features: 7
```

Out[252]:

	asin	brand	color	medium_image_url	product_type_name	title	form
0	B016I2TS4W	FNC7C	None	https://images-na.ssl-images-amazon.com/images...	SHIRT	Minions Como Superheroes Ironman Long Sleeve R...	
1	B01N49AI08	FIG Clothing	None	https://images-na.ssl-images-amazon.com/images...	SHIRT	FIG Clothing Womens Izo Tunic	
2	B01JDPCOHO	FIG Clothing	None	https://images-na.ssl-images-amazon.com/images...	SHIRT	FIG Clothing Womens Won Top	
3	B01N19U5H5	Focal18	None	https://images-na.ssl-images-amazon.com/images...	SHIRT	Focal18 Sailor Collar Bubble Sleeve Blouse Shi...	
4	B004GSI2OS	FeatherLite	Onyx Black/ Stone	https://images-na.ssl-images-amazon.com/images...	SHIRT	Featherlite Ladies' Long Sleeve Stain Resistan...	

In [253]:

```
data = pd.read_pickle('/ilab/users/ak1648/akshat/180k_apparel_data')
```

Data Preprocessing

Removing Null Values

In [254]:

```
data = data.loc[~data['formatted_price'].isnull()]
print('Number of products fter eliminating NULL price :', data.shape[0])

data =data.loc[~data['color'].isnull()]
print('Number of data points After eliminating NULL color :', data.shape[0])
```

```
Number of products fter eliminating NULL price : 28395
Number of data points After eliminating NULL color : 28385
```

Removing the products with short description

In [255]:

```
data_sorted = data[data['title'].apply(lambda x: len(x.split())>4)]
print("After removal of products with short description:", data_sorted.shape[0])
```

```
After removal of products with short description: 27949
```

Removing the products with duplicate title

In [256]:

```
data = pd.read_pickle('/ilab/users/ak1648/akshat/28k_apparel_data')
print('The number of entries with duplicate title is %d'%sum(data.duplicated('title
# Sort the whole data based on title
data_sorted.sort_values('title',inplace=True, ascending=False)

indices = []
for i,row in data_sorted.iterrows():
    indices.append(i)
import itertools
stage1_dedupe_asins = []
i = 0
j = 0
num_data_points = data_sorted.shape[0]
while i < num_data_points and j < num_data_points:
    previous_i = i
    a = data['title'].loc[indices[i]].split()
    j = i+1
    while j < num_data_points:
        b = data['title'].loc[indices[j]].split()
        length = max(len(a), len(b))
        count  = 0
        for k in itertools.zip_longest(a,b):
            if (k[0] == k[1]):
                count += 1
        # Ignore the products if the number of words in which both strings differ ar
        if (length - count) > 2: # number of words in which both sensences differ
            stage1_dedupe_asins.append(data_sorted['asin'].loc[indices[i]])
            if j == num_data_points-1: stage1_dedupe_asins.append(data_sorted['asin
            i = j
            break
        else:
            j += 1
    if previous_i == i:
        break

data = data.loc[data['asin'].isin(stage1_dedupe_asins)]
print('Number of data points now is: ', data.shape[0])
```

```
The number of entries with duplicate title is 2325
Number of data points now is:  17593
```

Text Preprocessing

In [257]:

```
data = pd.read_pickle('/ilab/users/ak1648/akshat/16k_apperal_data')
```

In [258]:

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

```
[nltk_data] Downloading package stopwords to
[nltk_data]     /ilab/users/ak1648/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Out[258]:

```
True
```

In [259]:

```
# we use the list of stop words that are downloaded from nltk lib.
stop_words = set(stopwords.words('english'))
print ('list of stop words:', stop_words)

def nlp_preprocessing(total_text, index, column):
    if type(total_text) is not int:
        string = ""
        for words in total_text.split():
            # remove the special chars in review like '"#$@!%^&*()_+-~?>< etc.
            word = ("".join(e for e in words if e.isalnum()))
            # Conver all letters to lower-case
            word = word.lower()
            # stop-word removal
            if not word in stop_words:
                string += word + " "
        data[column][index] = string
```

```
list of stop words: {'hers', 'but', 'not', 'above', "wasn't", 'or',
'o', 'most', 'yours', 'he', 'some', 'again', 'be', "doesn't", 'on', "y
ou're", 'below', 'why', 't', 'weren', 'because', 'being', 'any', 'fo
r', 'ain', 'what', 'shan', "mustn't", "should've", 'mightn', "aren't",
'of', 'very', 'than', 'ma', "wouldn't", 'over', 'it', 'up', 'did', "ha
ven't", 'have', 'didn', 'haven', 'against', 'had', 'wasn', 'his', "wo
n't", 'its', 'yourself', 'before', 'will', 'then', 'they', 'so', 've',
'whom', 'from', "mightn't", "you'll", 'm', 'couldn', 'the', 'only', 'b
een', 'between', 'itself', 'this', 'ours', 'was', "it's", 'more', 'wh
o', 'is', 'there', 'few', 'too', 'until', 'theirs', 'y', 'should', 'al
l', 'through', 'both', 's', 'after', 'were', 'and', 'with', 'doesn',
'in', 'themselves', 'once', 'are', 'other', 'if', "that'll", 'him', 'w
hen', 'nor', 'no', "don't", 'can', 'needn', "weren't", 'i', "she's",
'me', 'those', 'hadn', 'off', 'how', 'under', 'you', 'at', 'into', "co
uldn't", "you'd", 'your', "didn't", 'has', 'having', 'her', 'myself',
'won', 'these', 'hasn', 'my', 'we', 'here', 'd', 'about', "needn't",
'does', "shan't", 'our', 'ourselves', 'now', 'do', 'mustn', 'don', 'wh
ile', 'a', 'that', 'such', "shouldn't", 'by', "hadn't", 'doing', 'as',
'own', 'himself', 'she', 'where', 'their', 'just', 'isn', 'to', 're',
'which', 'each', 'aren', 'further', 'll', 'wouldn', 'same', 'them', 'd
own', 'out', "isn't", 'an', 'yourselves', 'herself', 'during', 'should
n', "you've", "hasn't", 'am'}
```

In [260]:

```
start_time = time.clock()
# we take each title and we text-preprocess it.
for index, row in data.iterrows():
    nlp_preprocessing(row['title'], index, 'title')
# we print the time it took to preprocess whole titles
print(time.clock() - start_time, "seconds")

data.head()
```

```
9.900000000000034 seconds
```

Out[260]:

	asin	brand	color	medium_image_url	product_type_name	title	for
4	B004GSI2OS	FeatherLite	Onyx Black/ Stone	https://images-na.ssl-images-amazon.com/images...	SHIRT	featherlite ladies long sleeve stain resistant...	
6	B012YX2ZPI	HX-Kingdom Fashion T-shirts	White	https://images-na.ssl-images-amazon.com/images...	SHIRT	womens unique 100 cotton special olympics wor...	
15	B003BSRPB0	FeatherLite	White	https://images-na.ssl-images-amazon.com/images...	SHIRT	featherlite ladies moisture free mesh sport sh...	
27	B014ICEJ1Q	FNC7C	Purple	https://images-na.ssl-images-amazon.com/images...	SHIRT	supernatural chibis sam dean castiel neck tshi...	
46	B01NACPBG2	Fifth Degree	Black	https://images-na.ssl-images-amazon.com/images...	SHIRT	fifth degree womens gold foil graphic tees jun...	

Utility Functions

In [261]:

```
#Display an image
def display_img(url,ax,fig):
    # we get the url of the apparel and download it
    response = requests.get(url)
    img = Image.open(BytesIO(response.content))
    # we will display it in notebook
    plt.imshow(img)

#plotting code to understand the decision
def plot_image(keys, values, labels, url, text):
        gs = gridspec.GridSpec(2, 2, width_ratios=[4,1], height_ratios=[4,1])
        fig = plt.figure(figsize=(25,3))

        # plotting image of the the apparel
        ax = plt.subplot(gs[0])
        ax.grid(False)
        ax.set_xticks([])
        ax.set_yticks([])

        display_img(url, ax, fig)

        plt.show()

def plot_condition(doc_id, vec1, vec2, url, text, model):
    # doc_id : index of the title1
    # vec1 : input apparels's vector, it is of a dict type {word:count}
    # vec2 : recommended apparels's vector, it is of a dict type {word:count}
    # url : apparels image url
    # text: title of recomonded apparel (used to keep title of image)
    # model, Bag of Words or TF-IDF
    intersection = set(vec1.keys()) & set(vec2.keys())
    for i in vec2:
        if i not in intersection:
            vec2[i]=0
    keys = list(vec2.keys())
    values = [vec2[x] for x in vec2.keys()]
        # if model == 'bag of words': labels(i) = values(i)
        # if model == 'tfidf weighted bag of words':labels(i) = tfidf(keys(i))
    if model == 'bag_of_words':
        labels = values
    elif model == 'tfidf':
        labels = []
        for x in vec2.keys():
            if x in  tfidf_title_vectorizer.vocabulary_:
                labels.append(tfidf_title_features[doc_id, tfidf_title_vectorizer.vo
            else:
                labels.append(0)
    plot_image(keys, values, labels, url, text)

# this function gets a list of wrods along with the frequency of each word given "te
def text_to_vector(text):
    word = re.compile(r'\w+')
    words = word.findall(text)
    return Counter(words)

def get_result(doc_id, content_a, content_b, url, model):
    text1 = content_a
    text2 = content_b
    vector1 = text_to_vector(text1)
```

```
    vector2 = text_to_vector(text2)
    plot_condition(doc_id, vector1, vector2, url, text2, model)
```

Textual Recommendation based on Product Titles

Bag of Words model on Product Titles

In [262]:

```
from sklearn.feature_extraction.text import CountVectorizer
title_vectorizer = CountVectorizer()
title_features   = title_vectorizer.fit_transform(data['title'])
title_features.get_shape() # get number of rows and columns in feature matrix.
bag_of_words_euclidean=[]
def bag_of_words_model(doc_id, num_results):
    # doc_id: apparel's id in given corpus
    # pairwise_dist will store the distance from given input apparel to all remainir
    # cosine distance for similarity
    pairwise_dist = pairwise_distances(title_features,title_features[doc_id])

    # np.argsort will return indices of the smallest distances
    indices = np.argsort(pairwise_dist.flatten())[0:num_results]
    # pdists will store the smallest distances
    pdists  = np.sort(pairwise_dist.flatten())[0:num_results]

    df_indices = list(data.index[indices])

    for i in range(0,len(indices)):
        # Pass 1. doc_id, 2. title1, 3. title2, url, model
        get_result(indices[i],data['title'].loc[df_indices[0]], data['title'].loc[df
        print ('Title:', data['title'].loc[df_indices[i]])
        bag_of_words_euclidean.append(pdists[i])
        print ('Euclidean similarity with the input image :', pdists[i])
    print('Average euclidean distance is ',sum(bag_of_words_euclidean)/num_results)
```

Top 10 Recommendation using Bag of Words Model

In [263]:

```
print('First one is input image and the rest 10 are recommended clothing')
bag_of_words_model(12562, 10)
```

```
First one is input image and the rest 10 are recommended clothing
```


```
Title: im huckleberry doc holliday 34sleeve raglan long sleeve
Euclidean similarity with the input image : 0.0
============================================================
```

```
Title: incredibles 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.23606797749979
============================================================
```


```
Title: moo im goat 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.23606797749979
============================================================
```

Title: pizza 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.23606797749979
==========

Title: maxpower 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.23606797749979
==========

Title: choose violence 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.449489742783178
==========

Title: get nothing 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.449489742783178
==========

Title: love husband 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.449489742783178
==========

Title: revolution logo 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.449489742783178
==========

Title: metallica justice 34sleeve raglan long sleeve
Euclidean similarity with the input image : 2.449489742783178

```
============================================================
Average euclidean distance is  2.119172062391505
```

TF-IDF Model on Product Titles

In [264]:

```
ctorizer = TfidfVectorizer(min_df = 0)
atures = tfidf_title_vectorizer.fit_transform(data['title'])
an=[]
l(doc_id, num_results):
ist = pairwise_distances(tfidf_title_features,tfidf_title_features[doc_id])

np.argsort(pairwise_dist.flatten())[0:num_results]
np.sort(pairwise_dist.flatten())[0:num_results]
 = list(data.index[indices])

ange(0,len(indices)):
sult(indices[i], data['title'].loc[df_indices[0]], data['title'].loc[df_indices[i]],
('Title:', data['title'].loc[df_indices[i]])
_euclidean.append(pdists[i])
('Eucliden distance from the given image :', pdists[i])
rage euclidean distance is',sum(tf_idf_euclidean)/num_results)
```

Top 10 Recommendations using TF-IDF Model

In [265]:

```
print('First one is input image and the rest 10 are recommended clothing')
tfidf_model(12562, 10)
```

```
First one is input image and the rest 10 are recommended clothing
```


```
Title: im huckleberry doc holliday 34sleeve raglan long sleeve
Eucliden distance from the given image : 0.0
```


```
Title: im weird im unicorn 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.0649487461630645
```


```
Title: moo im goat 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.133575440305773
```

Title: pizza 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.1627003249587693

Title: incredibles 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.1872291620915076

Title: maxpower 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.1872291620915076

Title: love husband 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.1960847619438466

Title: revolution logo 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.2023792573811647

Title: get nothing 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.2117794081962616

Title: flower life galaxy 34sleeve raglan long sleeve
Eucliden distance from the given image : 1.21205545761381
Average euclidean distance is 1.0557981720745704

Visual Recommendation based on Product Images

In [ ]:

```
import numpy as np
from keras.preprocessing.image import ImageDataGenerator
from keras.models import Sequential
from keras.layers import Dropout, Flatten, Dense
from keras import applications
from sklearn.metrics import pairwise_distances
import matplotlib.pyplot as plt
import requests
from PIL import Image
import pandas as pd
import pickle
```

Feature Extraction from Product Images using VGG16 CNN

In [ ]:

```
# each image is converted into 25088 length dense-vector

# dimensions of our images.
img_width, img_height = 224, 224

top_model_weights_path = '/ilab/users/ak1648/akshat/images/bottleneck_fc_model.h5'
train_data_dir = '/ilab/users/ak1648/akshat/images/'
nb_train_samples = 16042
epochs = 50
batch_size = 1


def save_bottlebeck_features():

    #Function to compute VGG-16 CNN for image feature extraction.

    asins = []
    datagen = ImageDataGenerator(rescale=1. / 255)

    # build the VGG16 network
    model = applications.VGG16(include_top=False, weights='imagenet')
    generator = datagen.flow_from_directory(
        train_data_dir,
        target_size=(img_width, img_height),
        batch_size=batch_size,
        class_mode=None,
        shuffle=False)

    for i in generator.filenames:
        asins.append(i[2:-5])

    bottleneck_features_train = model.predict_generator(generator, nb_train_samples
    bottleneck_features_train = bottleneck_features_train.reshape((16042,25088))

    np.save(open('/ilab/users/ak1648/akshat/16k_data_cnn_features.npy', 'wb'), bottl
    np.save(open('/ilab/users/ak1648/akshat/16k_data_cnn_feature_asins.npy', 'wb'),


save_bottlebeck_features()
```

VGG16 CNN model on Product Images

In [267]:

```
#load the features and corresponding ASINS info.
bottleneck_features_train = np.load('/ilab/users/ak1648/akshat/16k_data_cnn_features
asins = np.load('/ilab/users/ak1648/akshat/16k_data_cnn_feature_asins.npy')
asins = list(asins)

# load the original 16K dataset
data = pd.read_pickle('/ilab/users/ak1648/akshat/16k_apperal_data_preprocessed')
df_asins = list(data['asin'])


from IPython.display import display, Image, SVG, Math, YouTubeVideo

cnn_euclidean=[]
#get similar products using CNN features (VGG-16)
def get_similar_products_cnn(doc_id, num_results):
    doc_id = asins.index(df_asins[doc_id])
    pairwise_dist = pairwise_distances(bottleneck_features_train, bottleneck_feature

    indices = np.argsort(pairwise_dist.flatten())[0:num_results]
    pdists  = np.sort(pairwise_dist.flatten())[0:num_results]

    for i in range(len(indices)):
        rows = data[['medium_image_url','title']].loc[data['asin']==asins[indices[i]
        for indx, row in rows.iterrows():
            display(Image(url=row['medium_image_url'], embed=True))
            print('Product Title: ', row['title'])
            cnn_euclidean.append(pdists[i])
            print('Euclidean Distance from input image:', pdists[i])
    print('Average euclidean distance is ',sum(cnn_euclidean)/num_results)
```

Top 10 Recommendations using VGG16 CNN Model

In [268]:

```
print('First one is input image and the rest 10 are recommended clothing')
get_similar_products_cnn(12562, 10)
```

```
First one is input image and the rest 10 are recommended clothing
```


```
Product Title:  im huckleberry doc holliday 34sleeve raglan long sleev
e
Euclidean Distance from input image: 0.0625
```


```
Product Title:  chubby unicorn need love 34sleeve raglan long sleeve
Euclidean Distance from input image: 17.071169
```


```
Product Title:  bibliophile literary like party 34sleeve raglan long s
leeve
Euclidean Distance from input image: 18.06369
```


```
Product Title:  rip harambe cartoon 17th birthday killed 34sleeve ragl
an long sleeve
Euclidean Distance from input image: 18.658527
```

0

Product Title: jesus drank wine 34sleeve raglan long sleeve
Euclidean Distance from input image: 18.854345

Product Title: kanye west pinterest 34sleeve raglan long sleeve
Euclidean Distance from input image: 18.991518

Product Title: xjbd womens peaky drama series long sleeve blended bas
eball shirt size xl
Euclidean Distance from input image: 19.783867

Product Title: engineer good math 34sleeve raglan long sleeve
Euclidean Distance from input image: 20.048672


```
Product Title:  tell time pm 34sleeve raglan long sleeve
Euclidean Distance from input image: 20.094067
```


```
Product Title:  choose violence 34sleeve raglan long sleeve
Euclidean Distance from input image: 20.477503
Average euclidean distance is  17.21058578491211
```

Performance Comparison using Eucledian Distance

In [269]:

```
euclidean_distance=[]
num_results=10
euclidean_distance.append(sum(bag_of_words_euclidean)/num_results)
euclidean_distance.append(sum(tf_idf_euclidean)/num_results)
euclidean_distance.append(sum(cnn_euclidean)/num_results)
x=euclidean_distance
```

In [270]:

```
euclidean_distance
```

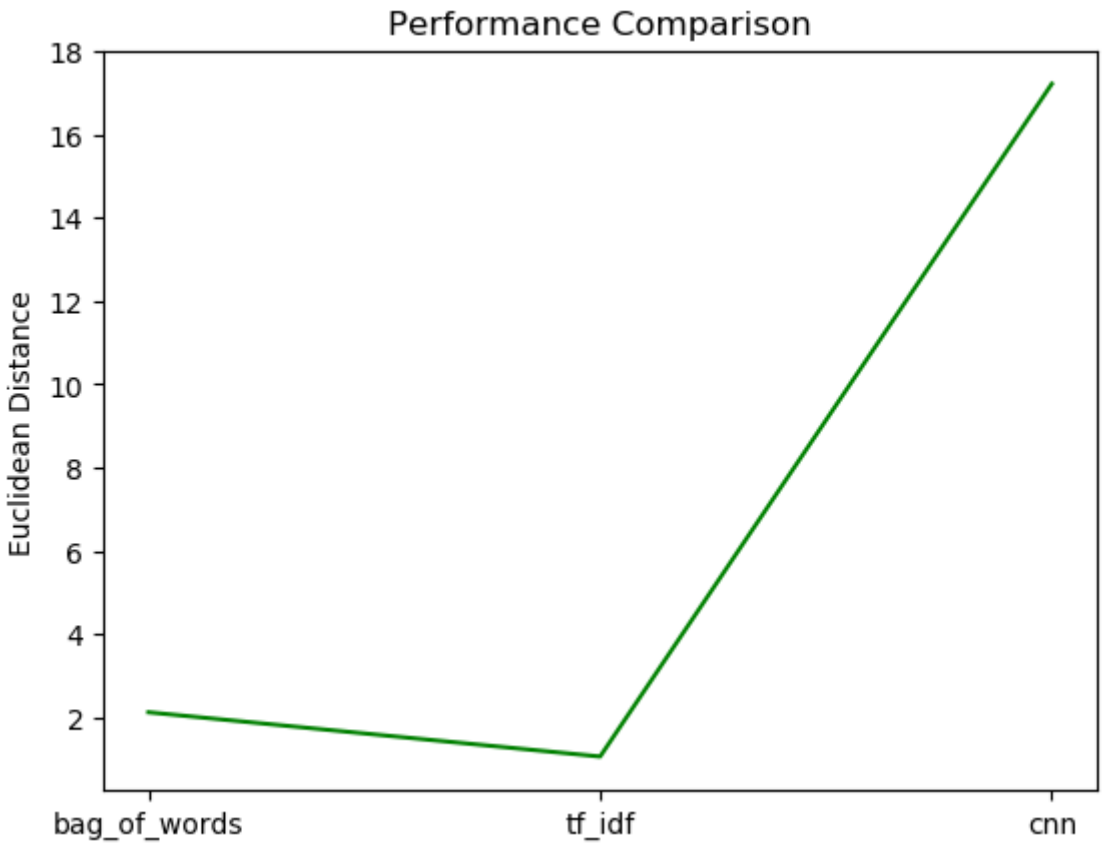
Out[270]:

```
[2.119172062391505, 1.0557981720745704, 17.21058578491211]
```

In [280]:

```
import matplotlib.pyplot as plt; plt.rcdefaults()
import numpy as np
import matplotlib.pyplot as plt
objects = ('bag_of_words', 'tf_idf','cnn')
y_pos = np.arange(len(objects))
plt.plot(y_pos,x,color='green')
plt.xticks(y_pos, objects)
plt.ylabel('Euclidean Distance')
plt.title('Performance Comparison')

plt.show()
```

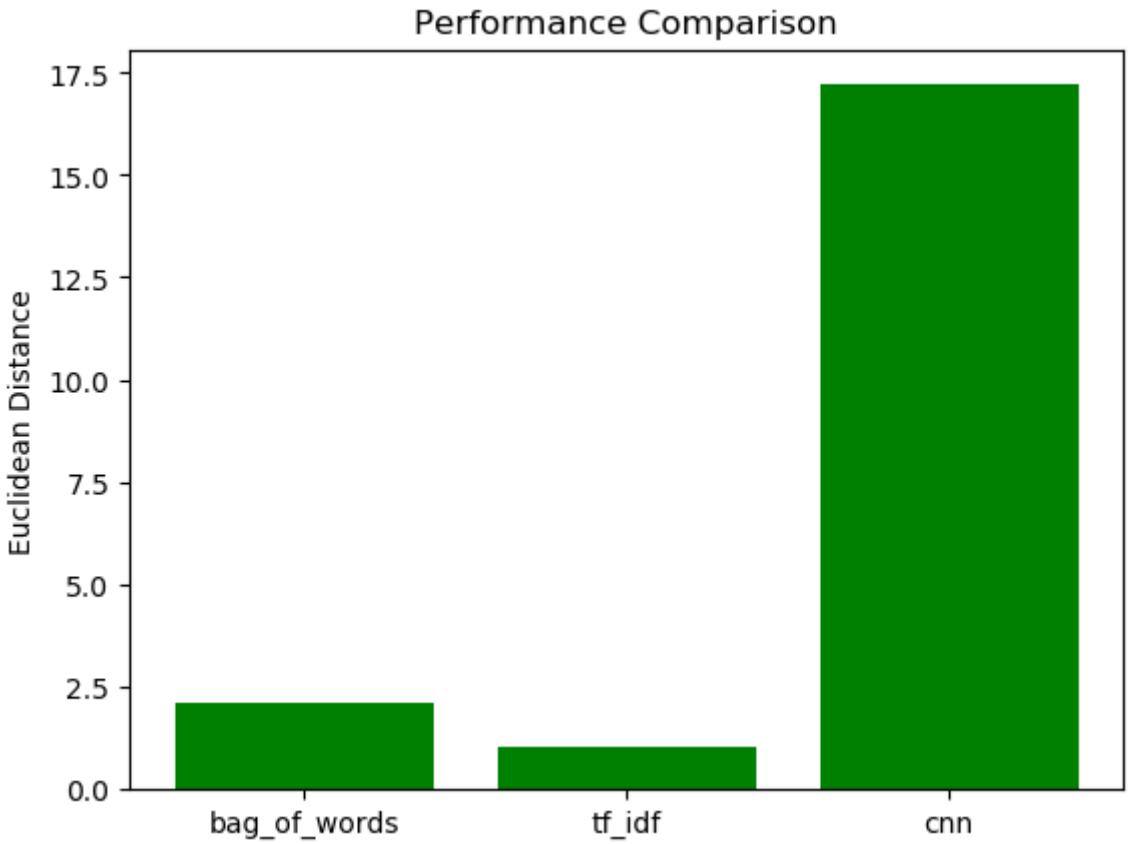


In [281]:

```
plt.ylabel('Euclidean Distance')
plt.title('Performance Comparison')
plt.bar(objects,x,color = 'green')
```

Out[281]:

```
<BarContainer object of 3 artists>
```



In [ ]: