Scrip3

February 28, 2024

SENTIMENT ANALYSIS with Transformers

[1]:
```
#@title Main Imports for Functionality

import os
import re

from typing import Union, List
from tqdm import tqdm

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

from sklearn.model_selection import train_test_split

import torch

import nltk
nltk.download("stopwords")
from nltk.corpus import stopwords

import pandas as pd
from wordcloud import WordCloud
import seaborn as sns

import string
from collections import Counter, defaultdict

from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer

import plotly.express as px
from plotly.subplots import make_subplots
import plotly.graph_objects as go
from plotly.offline import plot

import matplotlib.gridspec as gridspec
from matplotlib.ticker import MaxNLocator
```

```
import matplotlib.patches as mpatches
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')

import pandas as pd
import numpy as np
import os
import random
from pathlib import Path
import json
import torch
from tqdm.notebook import tqdm

from transformers import BertTokenizer
from torch.utils.data import TensorDataset

from transformers import BertForSequenceClassification

%matplotlib inline
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data…
[nltk_data]   Unzipping corpora/stopwords.zip.
```

[2]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[3]:
```
os.chdir("/content/drive/MyDrive/NLP/")
```

[ ]:
```
#@title Aquire and convert sentiement to integers
data_all = pd.read_excel('/content/drive/MyDrive/NLP/IMDB Dataset.xlsx')

# # splitting dataframe by row index
# set_validate = data_all.iloc[:5000,:]
# set_training = data_all.iloc[5000:,:]
# print("Shape of new dataframes - {} , {}".format(set_validate.shape,␣
 ↪set_training.shape))

# prepare Training set and view first 3 entries
sentiement_list = list(data_all["sentiment"])
sentiement_binary = []

for item in sentiement_list:
  if item == "positive":
    sentiement_binary.append(1)
```

```
  else:
    sentiement_binary.append(0)

sentiement_list = list(data_all["sentiment"])

data_all["label"] = sentiement_binary
data_all.drop(["sentiment"], inplace=True, axis=1)

print(data_all.sample(3))
print(" ")

# # prepare Validation set and view first 3 entries
# set_validate.drop(["sentiment"], inplace=True, axis=1)

# print(set_validate.sample(3))
# print(" ")
```

```
                                                  review  label
17143  The Hollow is a wonderful murder mystery that …      1
29274  One of the best records of Israel's response t…      1
9292   This film revolves as much around Japanese cul…      1
```

2. EDA

[ ]:
```
import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords
stopWords_nltk = set(stopwords.words('english'))
```

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

[ ]:
```
# Check GPU avalibility Stuff

if torch.cuda.is_available():
    device = torch.device("cuda")
    print(f'There are {torch.cuda.device_count()} GPU(s) available.')
    print('Device name:', torch.cuda.get_device_name(0))

else:
    print('No GPU available, using the CPU instead.')
    device = torch.device("cpu")
```

```
There are 1 GPU(s) available.
Device name: Tesla T4
```

[ ]:
```
# Text preprocessing

def text_preprocessing(s):
    """
    - Lowercase the sentence
    - Change "'t" to "not"
    - Remove "@name"
    - Isolate and remove punctuations except "?"
    - Remove other special characters
    - Remove stop words except "not" and "can"
    - Remove trailing whitespace
    """
    s = s.lower()
    # Change 't to 'not'
    s = re.sub(r"\'t", " not", s)
    # Remove @name
    s = re.sub(r'(@.*?)[\s]', ' ', s)
    # Isolate and remove punctuations except '?'
    s = re.sub(r'([\'\"\.\(\)\!\?\\\/\,])', r' ', s)
    s = re.sub(r'[^\w\s\?]', ' ', s)
    # Remove some special characters
    s = re.sub(r'([\;\:\|•«\n]<br /><br />)', ' ', s)
    # Remove stopwords except 'not' and 'can'
    s = " ".join([word for word in s.split()
                  if word not in stopwords.words('english')
                  or word in ['not', 'can']])
    # Remove trailing whitespace
    s = re.sub(r'\s+', ' ', s).strip()

    return s
```

[4]:
```
data_all = pd.read_excel('/content/drive/MyDrive/NLP/data_all.xlsx')
```

[5]:
```
data_all.head()
```

[5]:

	label	review2
0	1	one reviewers mentioned watching 1 oz episode …
1	1	wonderful little production br br filming tech…
2	1	thought wonderful way spend time hot summer we…
3	0	basically family little boy jake thinks zombie…
4	1	petter mattei love time money visually stunnin…

[ ]:
```
# basic info
data_all.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 50000 entries, 0 to 49999
```

```
Data columns (total 2 columns):
 #   Column   Non-Null Count  Dtype
---  ------   --------------  -----
 0   label    50000 non-null  int64
 1   review2  50000 non-null  object
dtypes: int64(1), object(1)
memory usage: 781.4+ KB
```

[ ]:
```
# Preprocess text
data_all['review2'] = ([text_preprocessing(text) for text in␣
 ↪data_all['review']])
```

[ ]:
```
data_all.drop(["review"], inplace=True, axis=1)
```

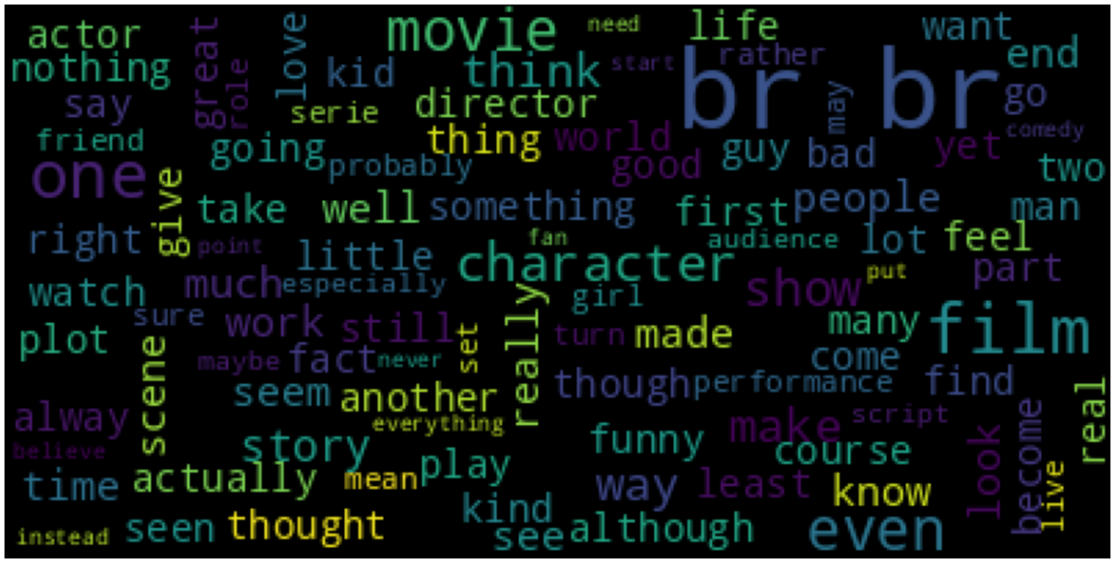
[ ]:
```
data_all.to_excel('/content/drive/MyDrive/NLP/data_all.xlsx', index=False)
```

Visualizations

0.1 Word Cloud

[ ]:
```
def show_wordcloud(data, title = None):
    wordcloud = WordCloud(
        background_color='black',
        max_words=100,
        max_font_size=40,
        scale=1,
        random_state=1
).generate(" ".join(data))

    fig = plt.figure(1, figsize=(15, 15))
    plt.axis('off')
    if title:
        fig.suptitle(title, fontsize=20)
        fig.subplots_adjust(top=2.3)

    plt.imshow(wordcloud)
    plt.show()
```

[ ]:
```
show_wordcloud(data_all["review2"])
```



[ ]:
```
data_all.head()
```

[ ]:

	label	review2
0	1	one reviewers mentioned watching 1 oz episode …
1	1	wonderful little production br br filming tech…
2	1	thought wonderful way spend time hot summer we…
3	0	basically family little boy jake thinks zombie…
4	1	petter mattei love time money visually stunnin…

0.2 Counts of labesl in training data

[ ]:
```
fig = make_subplots(rows=1, cols=2, specs=[[{"type": "pie"}, {"type": "bar"}]])
colors = ['pink', 'blue'] #
fig.add_trace(go.Pie(labels=data_all.label.value_counts().index,
                             values=data_all.label.value_counts().values), 1, 1)

fig.update_traces(hoverinfo='label+percent', textfont_size=20,
                  marker=dict(colors=colors, line=dict(color='#000000',␣
 ↪width=2)))

fig.add_trace(go.Bar(x=data_all.label.value_counts().index, y=data_all.label.
 ↪value_counts().values, marker_color = colors), 1,2)

fig.show()
```

0.3 BERT tokenizer

[6]:
```
from transformers import BertTokenizer
tokenizer = BertTokenizer.from_pretrained('bert-base-uncased',
                                          do_lower_case=True)
```

```
tokenizer_config.json:   0%|          | 0.00/48.0 [00:00<?, ?B/s]
vocab.txt:   0%|          | 0.00/232k [00:00<?, ?B/s]
tokenizer.json:   0%|          | 0.00/466k [00:00<?, ?B/s]
config.json:   0%|          | 0.00/570 [00:00<?, ?B/s]
```

[7]:
```
# data tokenize with bert tokenizer
data_all["Token_length"] = data_all["review2"].apply(lambda x: len(tokenizer(x,␣
 ↪add_special_tokens=False)["input_ids"]))
```

```
Token indices sequence length is longer than the specified maximum sequence
length for this model (582 > 512). Running this sequence through the model will
result in indexing errors
```

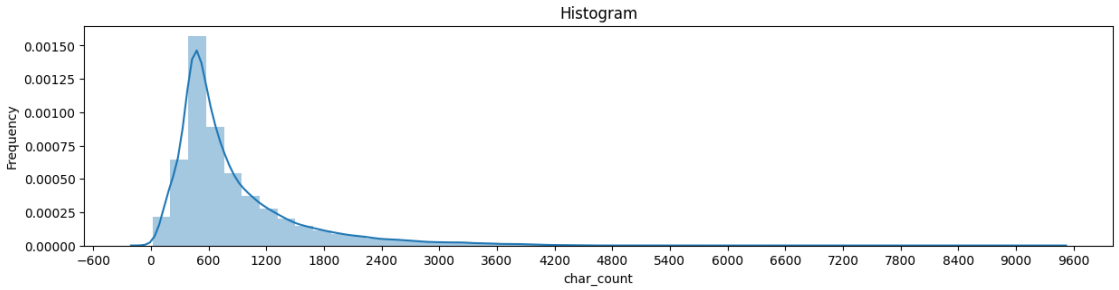
[ ]:
```
fig = px.histogram(data_all, x="Token_length", nbins=20,␣
 ↪color_discrete_sequence=px.colors.cmocean.algae, barmode='group',␣
 ↪histnorm="percent")
fig.show()
```

0.4 Characters Count in the Data

Let's look at the frequency of the number of characters. It will give us information about the overall size of our data

[ ]:
```
# valvulate char count for each review
data_all['char_count'] = data_all['review2'].apply(lambda x: len(str(x)))


def plot_dist3(df, feature):
    fig = plt.figure(constrained_layout=True, figsize=(18, 8))
    grid = gridspec.GridSpec(ncols=3, nrows=3, figure=fig)
    ax1 = fig.add_subplot(grid[0, :2])
    ax1.set_title('Histogram')
    sns.distplot(df.loc[:, feature],
                 hist=True,
                 kde=True,
                 ax=ax1,
                 )
    ax1.set(ylabel='Frequency')
    ax1.xaxis.set_major_locator(MaxNLocator(nbins=20))
```

[ ]:
```
plot_dist3(data_all, 'char_count')
```

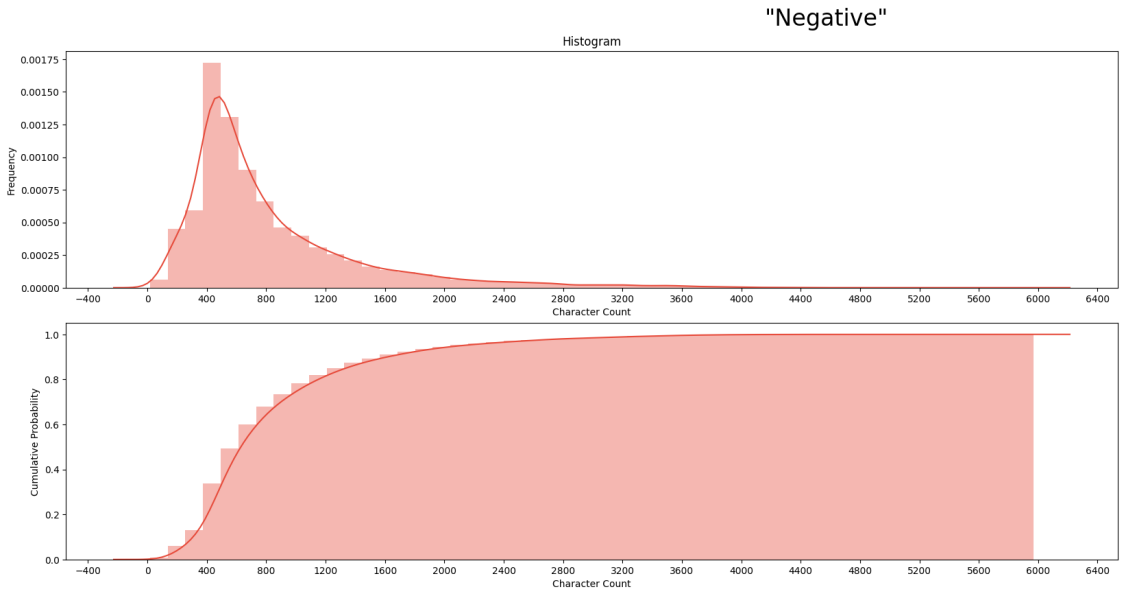


0.5 Reviews Lengths

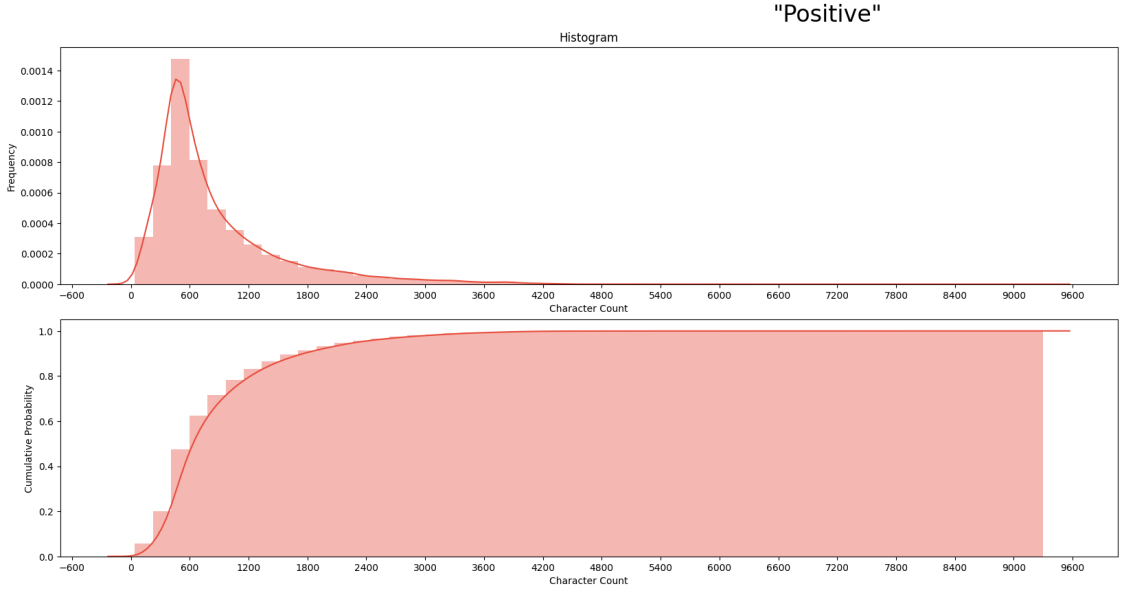
[8]:
```
# Creating a new feature for the visualization.
data_all['Character Count'] = data_all['review2'].apply(lambda x: len(str(x)))


def plot_dist3(df, feature, title):
    # Creating a customized chart. and giving in figsize and everything.
    fig = plt.figure(constrained_layout=True, figsize=(24, 12))
    # Creating a grid of 3 cols and 3 rows.
    grid = gridspec.GridSpec(ncols=3, nrows=3, figure=fig)

    # Customizing the histogram grid.
    ax1 = fig.add_subplot(grid[0, :2])
    # Set the title.
    ax1.set_title('Histogram')
    # plot the histogram.
    sns.distplot(df.loc[:, feature],
                 hist=True,
                 kde=True,
                 ax=ax1,
                 color='#e74c3c')
    ax1.set(ylabel='Frequency')
    ax1.xaxis.set_major_locator(MaxNLocator(nbins=20))


    ax2 = fig.add_subplot(grid[1, :2])

    sns.distplot(df.loc[:, feature],
                 ax=ax2,
                 kde_kws={'cumulative': True},
                 hist_kws={'cumulative': True},
                 color='#e74c3c')
    ax2.xaxis.set_major_locator(MaxNLocator(nbins=20))
    ax2.set(ylabel='Cumulative Probability')
```

```
    plt.suptitle(f'{title}', fontsize=24)
```

[ ]:
```
plot_dist3(data_all[data_all['label'] == 0], 'Character Count',
           '"Negative"')
```



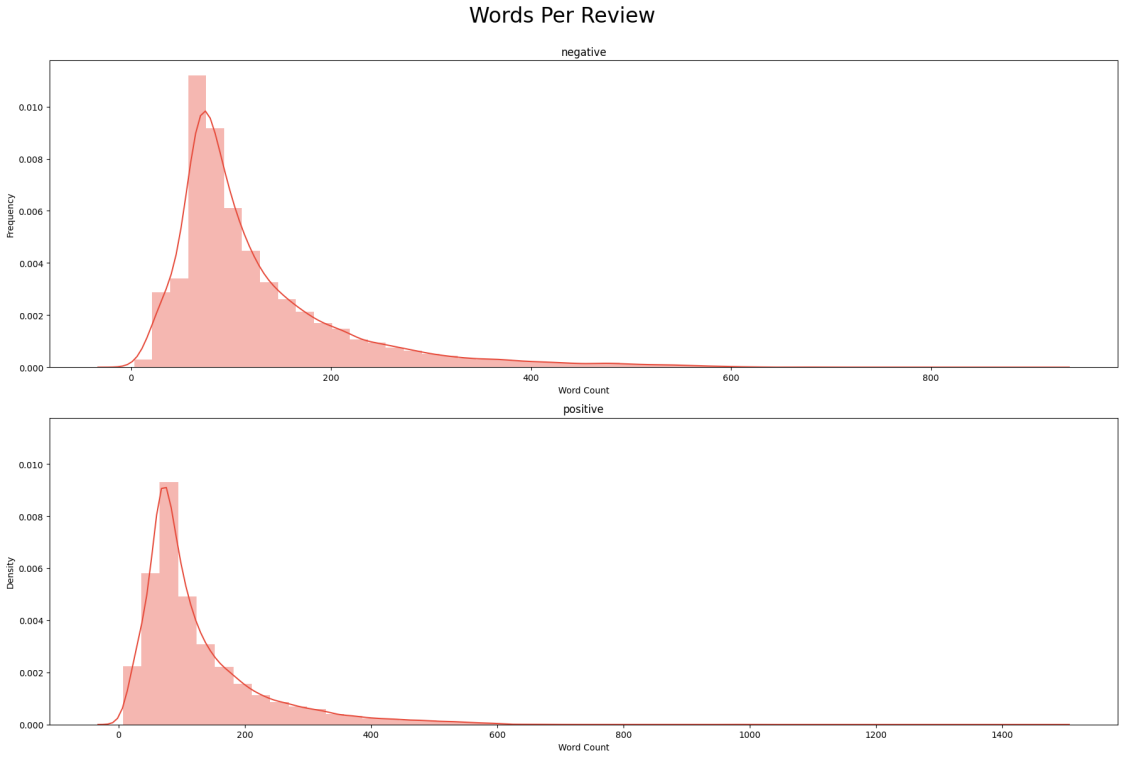
[ ]:
```
plot_dist3(data_all[data_all['label'] == 1], 'Character Count',
           '"Positive"')
```



0.6 Word Counts

[ ]:
```
def plot_word_number_histogram(textno, textye):

    """A function for comparing word counts"""

    fig, axes = plt.subplots(ncols=1, nrows=2, figsize=(18, 12), sharey=True)
    sns.distplot(textno.str.split().map(lambda x: len(x)), ax=axes[0],␣
 ↪color='#e74c3c')
    sns.distplot(textye.str.split().map(lambda x: len(x)), ax=axes[1],␣
 ↪color='#e74c3c')



    axes[0].set_xlabel('Word Count')
    axes[0].set_ylabel('Frequency')
    axes[0].set_title('negative')
    axes[1].set_xlabel('Word Count')
    axes[1].set_title('positive')

    fig.suptitle('Words Per Review', fontsize=24, va='baseline')

    fig.tight_layout()
```

[ ]:
```
plot_word_number_histogram(data_all[data_all['label'] == 0]['review2'],
                           data_all[data_all['label'] == 1]['review2'] )
```



Most Common Words

[ ]:
```
texts = data_all['review2']
new = texts.str.split()
new = new.values.tolist()
corpus = [word for i in new for word in i]
counter = Counter(corpus)
most = counter.most_common()
x, y = [], []
for word, count in most[:30]:
    if word not in stopWords_nltk:
        x.append(word)
        y.append(count)

fig = go.Figure(go.Bar(
            x=y,
            y=x,
            orientation='h',  marker=dict(
        color='rgba(50, 171, 96, 0.6)',
        line=dict(
            color='rgba(50, 171, 96, 1.0)',
            width=1),
    ),
    name='Most common Word',))

fig.update_layout( title={
        'text': "Most Common Words",
        'y':0.9,
        'x':0.5,
        'xanchor': 'center',
        'yanchor': 'top'}, font=dict(
        family="Courier New, monospace",
        size=18,
        color="RebeccaPurple"
    ))

fig.show()
```

0.7 Most Common ngrams

[ ]:
```
fig = make_subplots(rows=1, cols=2)
title_ = ["negative", "positive"]

for i in range(2):
    texts = data_all['review2']
```

```
    new = texts.str.split()
    new = new.values.tolist()
    corpus = [word for i in new for word in i]
    counter = Counter(corpus)
    most = counter.most_common()
    x, y = [], []

    for word, count in most[:30]:
        if word not in stopWords_nltk:
            x.append(word)
            y.append(count)

    fig.add_trace(go.Bar(
                x=y,
                y=x,
                orientation='h', type="bar",
        name=title_[i], marker=dict(color=colors[i])), 1, i+1)

fig.update_layout(
    autosize=False,
    width=2000,
    height=600,title=dict(
        text='<b>Most Common ngrams per Classes</b>',
        x=0.5,
        y=0.95,
        font=dict(
        size=24,
        color="RebeccaPurple"
        )
    ),)


fig.show()
```

[ ]:
```
data_all.head()
```

[ ]:
```
   label                                            review2  char_count  \
0      1  one reviewers mentioned watching 1 oz episode …        1151
1      1  wonderful little production br br filming tech…         686
2      1  thought wonderful way spend time hot summer we…         594
3      0  basically family little boy jake thinks zombie…         456
4      1  petter mattei love time money visually stunnin…         880

   Token_length
0           193
1           107
2            98
```

```
3            80
4           153
```

[ ]:
```python
def _get_top_ngram(corpus, n=None):
    #getting top ngrams
    vec = CountVectorizer(ngram_range=(n, n),
                          max_df=0.9,
                          ).fit(corpus)
    bag_of_words = vec.transform(corpus)
    sum_words = bag_of_words.sum(axis=0)
    words_freq = [(word, sum_words[0, idx])
                  for word, idx in vec.vocabulary_.items()]
    words_freq = sorted(words_freq, key=lambda x: x[1], reverse=True)
    return words_freq[:15]
```

[ ]:
```python
# unigram
fig = make_subplots(rows=1, cols=2)

title_ = ["negative",  "positive"]

for i in range(2):
    texts = data_all[data_all["label"] == i]['review2']

    new = texts.str.split()
    new = new.values.tolist()
    corpus = [word for i in new for word in i]
    top_n_bigrams = _get_top_ngram(texts, 2)[:15]
    x, y = map(list, zip(*top_n_bigrams))


    fig.add_trace(go.Bar(
                x=y,
                y=x,
                orientation='h', type="bar",
        name=title_[i], marker=dict(color=colors[i])), 1, i+1)


fig.update_layout(
    autosize=False,
    width=2000,
    height=600,title=dict(
        text='<b>Most Common unigrams per Classes</b>',
        x=0.5,
        y=0.95,
        font=dict(
        family="Courier New, monospace",
        size=24,
```

```
        color="RebeccaPurple"
        )
    ))
fig.show()
```

[ ]:
```
#trigram

fig = make_subplots(rows=1, cols=2)
title_ = ["negative","positive"]

for i in range(2):
    texts = data_all[data_all["label"] == i]['review2']

    new = texts.str.split()
    new = new.values.tolist()
    corpus = [word for i in new for word in i]

    top_n_bigrams = _get_top_ngram(texts, 3)[:15]
    x, y = map(list, zip(*top_n_bigrams))

    fig.add_trace(go.Bar(
                x=y,
                y=x,
                orientation='h', type="bar",
        name=title_[i], marker=dict(color=colors[i])), 1, i+1),

fig.update_layout(
    autosize=False,
    width=2000,
    height=600,title=dict(
        text='<b>Most Common trigrams per Classes</b>',
        x=0.5,
        y=0.95,
        font=dict(
        family="Courier New, monospace",
        size=24,
        color="RebeccaPurple"
        )
    ))

fig.show()
```

Transformer Model

BERT Train

[9]:
```
class Config():
    seed_val = 17
```

```
    device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
    epochs = 1
    batch_size = 6
    seq_length = 512
    lr = 2e-5
    eps = 1e-8
    pretrained_model = 'bert-base-uncased'
    test_size=0.15
    random_state=42
    add_special_tokens=True
    return_attention_mask=True
    pad_to_max_length=True
    do_lower_case=False
    return_tensors='pt'

config = Config()
```

0.8 Params we will be saving

[10]:
```
params = {"seed_val": config.seed_val,
    "device":str(config.device),
    "epochs":config.epochs,
    "batch_size":config.batch_size,
    "seq_length":config.seq_length,
    "lr":config.lr,
    "eps":config.eps,
    "pretrained_model": config.pretrained_model,
    "test_size":config.test_size,
    "random_state":config.random_state,
    "add_special_tokens":config.add_special_tokens,
    "return_attention_mask":config.return_attention_mask,
    "pad_to_max_length":config.pad_to_max_length,
    "do_lower_case":config.do_lower_case,
    "return_tensors":config.return_tensors,
         }
```

[11]:
```
import random

device = config.device

random.seed(config.seed_val)
np.random.seed(config.seed_val)
torch.manual_seed(config.seed_val)
torch.cuda.manual_seed_all(config.seed_val)
```

Train and Validation Split

[12]:
```
from sklearn.model_selection import train_test_split

train_df, val= train_test_split(data_all,
                                test_size=0.10,
                                random_state=config.random_state,
                            stratify=data_all.label.values)
```

[13]:
```
train_df.head()
```

[13]:
```
       label                                             review2  Token_length  \
14700      0  since little mermaid one favorite disney movie…           211
10733      0  based novel michael chabon mysteries pittsburg…           114
30659      0  makes third errol morris movie seen increasing…           232
10987      0  sitting big wing chair huge book lap one bela …           365
33167      1  kid movie great adult mother enjoyed watching …           162

       Character Count
14700             1334
10733              714
30659             1465
10987             2112
33167             1034
```

[14]:
```
val.head()
```

[14]:
```
       label                                             review2  Token_length  \
30859      1  not kidding summary vote video distributors pa…           268
7217       0  kept waiting film move inspire shock sadden wa…            61
34889      0  movie 90 minute ramones concert brief periods …            55
30806      1  every scene put together perfectly movie wonde…           119
36408      0  uma travolta good together unfortunately left …            96

       Character Count
30859             1595
7217               377
34889              314
30806              741
36408              543
```

[15]:
```
train, test = train_test_split(train_df,
                                test_size=0.10,
                                random_state=42,
                            stratify=train_df.label.values)
```

[16]:
```
# count of unique label  control
print(len(train['label'].unique()))
print(train.shape)
```

```
2
(40500, 4)
```

[17]:
```
# count of unique label  control
print(len(test['label'].unique()))
print(test.shape)
```

```
2
(4500, 4)
```

[18]:
```
# count of unique label  control
print(len(val['label'].unique()))
print(val.shape)
```

```
2
(5000, 4)
```

BertTokenizer

[19]:
```
# create tokenizer
tokenizer = BertTokenizer.from_pretrained(config.pretrained_model,
                                          do_lower_case=config.do_lower_case)
```

[20]:
```
encoded_data_train = tokenizer.batch_encode_plus(
    train.review2.values,
    add_special_tokens=config.add_special_tokens,
    return_attention_mask=config.return_attention_mask,
    pad_to_max_length=config.pad_to_max_length,
    max_length=config.seq_length,
    return_tensors=config.return_tensors
)
encoded_data_val = tokenizer.batch_encode_plus(
    val.review2.values,
    add_special_tokens=config.add_special_tokens,
    return_attention_mask=config.return_attention_mask,
    pad_to_max_length=config.pad_to_max_length,
    max_length=config.seq_length,
    return_tensors=config.return_tensors
)
```

```
Truncation was not explicitly activated but `max_length` is provided a specific
value, please use `truncation=True` to explicitly truncate examples to max
length. Defaulting to 'longest_first' truncation strategy. If you encode pairs
of sequences (GLUE-style) with the tokenizer you can select this strategy more
precisely by providing a specific strategy to `truncation`.
```

[21]:
```
input_ids_train = encoded_data_train['input_ids']
attention_masks_train = encoded_data_train['attention_mask']
labels_train = torch.tensor(train.label.values)
```

```
input_ids_val = encoded_data_val['input_ids']
attention_masks_val = encoded_data_val['attention_mask']
labels_val = torch.tensor(val.label.values)
```

[22]:
```
dataset_train = TensorDataset(input_ids_train, attention_masks_train,␣
↪labels_train)
dataset_val = TensorDataset(input_ids_val, attention_masks_val, labels_val)
```

Creating the Model

[23]:
```
model = BertForSequenceClassification.from_pretrained(config.pretrained_model,
                                                      num_labels=2,
                                                      output_attentions=False,
                                                     ␣
↪output_hidden_states=False)
```

```
model.safetensors:   0%|          | 0.00/440M [00:00<?, ?B/s]
```

```
Some weights of BertForSequenceClassification were not initialized from the
model checkpoint at bert-base-uncased and are newly initialized:
['classifier.bias', 'classifier.weight']
You should probably TRAIN this model on a down-stream task to be able to use it
for predictions and inference.
```

Data Loaders

[24]:
```
from torch.utils.data import DataLoader, RandomSampler, SequentialSampler

dataloader_train = DataLoader(dataset_train,
                              sampler=RandomSampler(dataset_train),
                              batch_size=config.batch_size)

dataloader_validation = DataLoader(dataset_val,
                                   sampler=SequentialSampler(dataset_val),
                                   batch_size=config.batch_size)
```

Optimizer & Scheduler

[25]:
```
from transformers import AdamW, get_linear_schedule_with_warmup

optimizer = AdamW(model.parameters(),
                  lr=config.lr,
                  eps=config.eps)


scheduler = get_linear_schedule_with_warmup(optimizer,
                                            num_warmup_steps=0,
```

```
↪num_training_steps=len(dataloader_train)*config.epochs)
```

Performance Metrics

We will use f1 score as performance metrics.

[26]:
```
from sklearn.metrics import f1_score

def f1_score_func(preds, labels):
    preds_flat = np.argmax(preds, axis=1).flatten()
    labels_flat = labels.flatten()
    return f1_score(labels_flat, preds_flat, average='weighted')

def accuracy_per_class(preds, labels, label_dict):
    label_dict_inverse = {v: k for k, v in label_dict.items()}

    preds_flat = np.argmax(preds, axis=1).flatten()
    labels_flat = labels.flatten()

    for label in np.unique(labels_flat):
        y_preds = preds_flat[labels_flat==label]
        y_true = labels_flat[labels_flat==label]
        print(f'Class: {label_dict_inverse[label]}')
        print(f'Accuracy: {len(y_preds[y_preds==label])}/{len(y_true)}\n')
```

Training Loop

[27]:
```
def evaluate(dataloader_val):

    model.eval()

    loss_val_total = 0
    predictions, true_vals = [], []

    for batch in dataloader_val:

        batch = tuple(b.to(config.device) for b in batch)

        inputs = {'input_ids':      batch[0],
                  'attention_mask': batch[1],
                  'labels':         batch[2],
                 }

        with torch.no_grad():
            outputs = model(**inputs)

        loss = outputs[0]
```

```
        logits = outputs[1]
        loss_val_total += loss.item()

        logits = logits.detach().cpu().numpy()
        label_ids = inputs['labels'].cpu().numpy()
        predictions.append(logits)
        true_vals.append(label_ids)

    # calculate avareage val loss
    loss_val_avg = loss_val_total/len(dataloader_val)

    predictions = np.concatenate(predictions, axis=0)
    true_vals = np.concatenate(true_vals, axis=0)

    return loss_val_avg, predictions, true_vals
```

[32]:
```
config.device
```

[32]:
```
device(type='cuda', index=0)
```

[35]:
```
model.to(config.device)

for epoch in tqdm(range(1, 2)):

    model.train()

    loss_train_total = 0

    progress_bar = tqdm(dataloader_train, desc='Epoch {:1d}'.format(epoch),␣
 ↪leave=False, disable=False)

    for batch in progress_bar:

        model.zero_grad()

        batch = tuple(b.to(config.device) for b in batch)


        inputs = {'input_ids':      batch[0],
                  'attention_mask': batch[1],
                  'labels':         batch[2],
                 }

        outputs = model(**inputs)

        loss = outputs[0]
        loss_train_total += loss.item()
```

```
        loss.backward()

        torch.nn.utils.clip_grad_norm_(model.parameters(), 1.0)

        optimizer.step()
        scheduler.step()

        progress_bar.set_postfix({'training_loss': '{:.3f}'.format(loss.item()/
 ↪len(batch))})


    torch.save(model.state_dict(), f'/content/drive/MyDrive/NLP/
 ↪BERT_epoch_{epoch}.model')

    tqdm.write(f'\nEpoch {epoch}')

    loss_train_avg = loss_train_total/len(dataloader_train)
    tqdm.write(f'Training loss: {loss_train_avg}')

    val_loss, predictions, true_vals = evaluate(dataloader_validation)
    val_f1 = f1_score_func(predictions, true_vals)
    tqdm.write(f'Validation loss: {val_loss}')

    tqdm.write(f'F1 Score (Weighted): {val_f1}');
# save model params and other configs
with Path('/content/drive/MyDrive/NLP/params.json').open("w") as f:
    json.dump(params, f, ensure_ascii=False, indent=4)
```

```
  0%|          | 0/1 [00:00<?, ?it/s]
Epoch 1:   0%|          | 0/6750 [00:00<?, ?it/s]
```

```
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
<ipython-input-35-588152d5240f> in <cell line: 3>()
     29         torch.nn.utils.clip_grad_norm_(model.parameters(), 1.0)
     30
---> 31         optimizer.step()
     32         scheduler.step()
     33

/usr/local/lib/python3.10/dist-packages/torch/optim/lr_scheduler.py in␣
 ↪wrapper(*args, **kwargs)
     66                 instance._step_count += 1
     67                 wrapped = func.__get__(instance, cls)
---> 68                 return wrapped(*args, **kwargs)
     69
```

```
     70             # Note that the returned function here is no longer a bound
 ↪method,

/usr/local/lib/python3.10/dist-packages/torch/optim/optimizer.py in␣
 ↪wrapper(*args, **kwargs)
    371                             )
    372
--> 373                 out = func(*args, **kwargs)
    374                 self._optimizer_step_code()
    375

/usr/local/lib/python3.10/dist-packages/torch/utils/_contextlib.py in␣
 ↪decorate_context(*args, **kwargs)
    113     def decorate_context(*args, **kwargs):
    114         with ctx_factory():
--> 115             return func(*args, **kwargs)
    116
    117     return decorate_context

/usr/local/lib/python3.10/dist-packages/transformers/optimization.py in␣
 ↪step(self, closure)
    484                 exp_avg.mul_(beta1).add_(grad, alpha=(1.0 - beta1))
    485                 exp_avg_sq.mul_(beta2).addcmul_(grad, grad, value=1.0 -
 ↪beta2)
--> 486                 denom = exp_avg_sq.sqrt().add_(group["eps"])
    487
    488                 step_size = group["lr"]

KeyboardInterrupt:
```

Test on validation set

[63]:
```
model.to(config.device)

model.load_state_dict(torch.load('/content/drive/MyDrive/NLP/BERT_epoch_1.
 ↪model'))
# device = torch.device("cuda")
# # model = TheModelClass(*args, **kwargs)
# model.load_state_dict(torch.load(f'/content/drive/MyDrive/NLP/BERT_epoch_1.
 ↪model', map_location="cuda:0"))  # Choose whatever GPU device number you want
```

[63]:
```
<All keys matched successfully>
```

Evaluation

[65]:
```
pred_final = []

for i, row in tqdm(val.iterrows(), total=val.shape[0]):
```

```
    predictions = []

    review = row["review2"]
    encoded_data_test_single = tokenizer.batch_encode_plus(
    [review],
    add_special_tokens=config.add_special_tokens,
    return_attention_mask=config.return_attention_mask,
    pad_to_max_length=config.pad_to_max_length,
    max_length=config.seq_length,
    return_tensors=config.return_tensors
    )
    input_ids_test = encoded_data_test_single['input_ids']
    attention_masks_test = encoded_data_test_single['attention_mask']


    inputs = {'input_ids':      input_ids_test.to(device),
              'attention_mask':attention_masks_test.to(device),
             }

    with torch.no_grad():
        outputs = model(**inputs)

    logits = outputs[0]
    logits = logits.detach().cpu().numpy()
    predictions.append(logits)
    predictions = np.concatenate(predictions, axis=0)
    pred_final.append(np.argmax(predictions, axis=1).flatten()[0])
```

```
  0%|          | 0/429 [00:00<?, ?it/s]
```

[66]:
```
val["pred"] = pred_final
```

[70]:
```
control = val.pred.values == val.label.values
val["control"] = control
```

[38]:
```
#adding prediction col
val["pred"] = pred_final
control = val.pred.values == val.label.values
val["control"] = control
```

[39]:
```
# filtering predictions
val = val[val.control == False]
```

[72]:
```
val = val[val.control == False]
```

[73]:
```
name2label = {"Negative":0,
              "Positive":1
```

```
            }
label2name = {v: k for k, v in name2label.items()}

val["pred_name"] = val.pred.apply(lambda x: label2name.get(x))
```

[75]:
```
from sklearn.metrics import confusion_matrix

# We create a confusion matrix to better observe the classes that the model␣
 ↪confuses.
pred_name_values = val.pred_name.values
label_values = val.pred_name.values
confmat = confusion_matrix(label_values, pred_name_values,␣
 ↪labels=list(name2label.keys()))
```

[76]:
```
confmat
```

[76]:
```
array([[236,   0],
       [  0, 144]])
```

[77]:
```
df_confusion_val = pd.crosstab(label_values, pred_name_values)
df_confusion_val
```

[77]:

col_0	Negative	Positive
row_0		
Negative	236	0
Positive	0	144

[78]:
```
df_confusion_val.to_csv("val_df_confusion.csv")
```

[80]:
```
test.head()
```

[80]:

	label	review2	Token_length	Character Count	pred	control	pred_name
22601	0	one entertaining flick suggest rent buy couple…	70	428	1	False	Positive
36824	0	2000 came close king kong adopted daughter wen…	165	951	1	False	Positive
48367	1	anatomie certainly one better movies seen not …	55	338	0	False	Negative
15745	0	ravaged wasteland future mankind terrorized cy…	133	689	1	False	Positive
22034	1	big gone wind nut disappointed gone wind movie…	89	555	0	False	Negative

[81]:
```
encoded_data_test = tokenizer.batch_encode_plus(
    test.review2.values,
```

```
    add_special_tokens=config.add_special_tokens,
    return_attention_mask=config.return_attention_mask,
    pad_to_max_length=config.pad_to_max_length,
    max_length=config.seq_length,
    return_tensors=config.return_tensors
)
```

[82]:
```
input_ids_test = encoded_data_test['input_ids']
attention_masks_test = encoded_data_test['attention_mask']
labels_test = torch.tensor(test.label.values)
```

[83]:
```
model = BertForSequenceClassification.from_pretrained(config.pretrained_model,
                                                      num_labels=2,
                                                      output_attentions=False,
                                                      ␣
 ↪output_hidden_states=False)

model.to(config.device)

model.load_state_dict(torch.load(f'/content/drive/MyDrive/NLP/BERT_epoch_1.
 ↪model', map_location=torch.device('cpu')))

_, predictions_test, true_vals_test = evaluate(dataloader_validation)
```

```
Some weights of BertForSequenceClassification were not initialized from the
model checkpoint at bert-base-uncased and are newly initialized:
['classifier.bias', 'classifier.weight']
You should probably TRAIN this model on a down-stream task to be able to use it
for predictions and inference.
```

[84]:
```
from sklearn.metrics import classification_report

preds_flat_test = np.argmax(predictions_test, axis=1).flatten()
print(classification_report(preds_flat_test, true_vals_test))
```

```
              precision    recall  f1-score   support

           0       0.94      0.90      0.92      2604
           1       0.90      0.93      0.91      2396

    accuracy                           0.92      5000
   macro avg       0.92      0.92      0.92      5000
weighted avg       0.92      0.92      0.92      5000
```

[85]:
```
pred_final = []
```

```
for i, row in tqdm(test.iterrows(), total=test.shape[0]):
    predictions = []

    review = row["review2"]
    encoded_data_test_single = tokenizer.batch_encode_plus(
    [review],
    add_special_tokens=config.add_special_tokens,
    return_attention_mask=config.return_attention_mask,
    pad_to_max_length=config.pad_to_max_length,
    max_length=config.seq_length,
    return_tensors=config.return_tensors
    )
    input_ids_test = encoded_data_test_single['input_ids']
    attention_masks_test = encoded_data_test_single['attention_mask']


    inputs = {'input_ids':      input_ids_test.to(device),
              'attention_mask':attention_masks_test.to(device),
             }

    with torch.no_grad():
        outputs = model(**inputs)

    logits = outputs[0]
    logits = logits.detach().cpu().numpy()
    predictions.append(logits)
    predictions = np.concatenate(predictions, axis=0)
    pred_final.append(np.argmax(predictions, axis=1).flatten()[0])
```

```
  0%|          | 0/375 [00:00<?, ?it/s]
```

[86]:
```
test["pred"] = pred_final
control = test.pred.values == test.label.values
test["control"] = control
```

[88]:
```
test = test[test.control == False]
```

[89]:
```
test["pred_name"] = test.pred.apply(lambda x: label2name.get(x))
```

[90]:
```
from sklearn.metrics import confusion_matrix

# We create a confusion matrix to better observe the classes that the model␣
 ↪confuses.
pred_name_values = test.pred_name.values
label_values = test.pred_name.values
confmat = confusion_matrix(label_values, pred_name_values,␣
 ↪labels=list(name2label.keys()))
```

[92]:
```
confmat
```

[92]:
```
array([[255,   0],
       [  0, 120]])
```

[93]:
```
df_confusion_test = pd.crosstab(label_values, pred_name_values)
df_confusion_test
```

[93]:

col_0	Negative	Positive
row_0		
Negative	255	0
Positive	0	120

[59]:
```
!apt-get install texlive texlive-xetex texlive-latex-extra pandoc
!pip install pypandoc
```

```
Reading package lists… Done
Building dependency tree… Done
Reading state information… Done
pandoc is already the newest version (2.9.2.1-3ubuntu2).
pandoc set to manually installed.
The following additional packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-
texgyre
  fonts-urw-base35 libapache-pom-java libcommons-logging-java libcommons-parent-
java
  libfontbox-java libfontenc1 libgs9 libgs9-common libidn12 libijs-0.35
libjbig2dec0 libkpathsea6
  libpdfbox-java libptexenc1 libruby3.0 libsynctex2 libteckit0 libtexlua53
libtexluajit2 libwoff1
  libzzip-0-13 lmodern poppler-data preview-latex-style rake ruby ruby-net-
telnet ruby-rubygems
  ruby-webrick ruby-xmlrpc ruby3.0 rubygems-integration t1utils teckit tex-
common tex-gyre
  texlive-base texlive-binaries texlive-fonts-recommended texlive-latex-base
  texlive-latex-recommended texlive-pictures texlive-plain-generic tipa xfonts-
encodings
  xfonts-utils
Suggested packages:
  fonts-noto fonts-freefont-otf | fonts-freefont-ttf libavalon-framework-java
  libcommons-logging-java-doc libexcalibur-logkit-java liblog4j1.2-java poppler-
utils ghostscript
  fonts-japanese-mincho | fonts-ipafont-mincho fonts-japanese-gothic | fonts-
ipafont-gothic
  fonts-arphic-ukai fonts-arphic-uming fonts-nanum ri ruby-dev bundler debhelper
gv
  | postscript-viewer perl-tk xpdf | pdf-viewer xzdec texlive-fonts-recommended-
```

```
doc
  texlive-latex-base-doc python3-pygments icc-profiles libfile-which-perl
  libspreadsheet-parseexcel-perl texlive-latex-extra-doc texlive-latex-
recommended-doc
  texlive-luatex texlive-pstricks dot2tex prerex texlive-pictures-doc vprerex
default-jre-headless
  tipa-doc
The following NEW packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-
texgyre
  fonts-urw-base35 libapache-pom-java libcommons-logging-java libcommons-parent-
java
  libfontbox-java libfontenc1 libgs9 libgs9-common libidn12 libijs-0.35
libjbig2dec0 libkpathsea6
  libpdfbox-java libptexenc1 libruby3.0 libsynctex2 libteckit0 libtexlua53
libtexluajit2 libwoff1
  libzzip-0-13 lmodern poppler-data preview-latex-style rake ruby ruby-net-
telnet ruby-rubygems
  ruby-webrick ruby-xmlrpc ruby3.0 rubygems-integration t1utils teckit tex-
common tex-gyre texlive
  texlive-base texlive-binaries texlive-fonts-recommended texlive-latex-base
texlive-latex-extra
  texlive-latex-recommended texlive-pictures texlive-plain-generic texlive-xetex
tipa
  xfonts-encodings xfonts-utils
0 upgraded, 55 newly installed, 0 to remove and 35 not upgraded.
Need to get 182 MB of archives.
After this operation, 572 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-droid-fallback all
1:6.0.1r16-1.1build1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-lato all 2.0-2.1
[2,696 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy/main amd64 poppler-data all
0.4.11-1 [2,171 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-common all 6.17
[33.7 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-urw-base35 all
20200910-1 [6,367 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9-common
all 9.55.0~dfsg1-0ubuntu5.6 [751 kB]
Get:7 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libidn12 amd64
1.38-4ubuntu1 [60.0 kB]
Get:8 http://archive.ubuntu.com/ubuntu jammy/main amd64 libijs-0.35 amd64
0.35-15build2 [16.5 kB]
Get:9 http://archive.ubuntu.com/ubuntu jammy/main amd64 libjbig2dec0 amd64
0.19-3build2 [64.7 kB]
Get:10 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9 amd64
9.55.0~dfsg1-0ubuntu5.6 [5,031 kB]
```

```
Get:11 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libkpathsea6
amd64 2021.20210626.59705-1ubuntu0.1 [60.3 kB]
Get:12 http://archive.ubuntu.com/ubuntu jammy/main amd64 libwoff1 amd64
1.0.2-1build4 [45.2 kB]
Get:13 http://archive.ubuntu.com/ubuntu jammy/universe amd64 dvisvgm amd64
2.13.1-1 [1,221 kB]
Get:14 http://archive.ubuntu.com/ubuntu jammy/universe amd64 fonts-lmodern all
2.004.5-6.1 [4,532 kB]
Get:15 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-noto-mono all
20201225-1build1 [397 kB]
Get:16 http://archive.ubuntu.com/ubuntu jammy/universe amd64 fonts-texgyre all
20180621-3.1 [10.2 MB]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libapache-pom-java
all 18-1 [4,720 B]
Get:18 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-parent-
java all 43-1 [10.8 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-logging-
java all 1.2-2 [60.3 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/main amd64 libfontenc1 amd64
1:1.1.4-1build3 [14.7 kB]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libptexenc1
amd64 2021.20210626.59705-1ubuntu0.1 [39.1 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy/main amd64 rubygems-integration
all 1.18 [5,336 B]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby3.0 amd64
3.0.2-7ubuntu2.4 [50.1 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby-rubygems all
3.3.5-2 [228 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby amd64 1:3.0~exp1
[5,100 B]
Get:26 http://archive.ubuntu.com/ubuntu jammy/main amd64 rake all 13.0.6-2 [61.7
kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby-net-telnet all
0.1.1-2 [12.6 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy/universe amd64 ruby-webrick all
1.7.0-3 [51.8 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby-xmlrpc all
0.3.2-1ubuntu0.1 [24.9 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libruby3.0
amd64 3.0.2-7ubuntu2.4 [5,113 kB]
Get:31 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libsynctex2
amd64 2021.20210626.59705-1ubuntu0.1 [55.5 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libteckit0 amd64
2.5.11+ds1-1 [421 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libtexlua53
amd64 2021.20210626.59705-1ubuntu0.1 [120 kB]
Get:34 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libtexluajit2
amd64 2021.20210626.59705-1ubuntu0.1 [267 kB]
```

```
Get:35 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libzzip-0-13 amd64
0.13.72+dfsg.1-1.1 [27.0 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy/main amd64 xfonts-encodings all
1:1.0.5-0ubuntu2 [578 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy/main amd64 xfonts-utils amd64
1:7.7+6build2 [94.6 kB]
Get:38 http://archive.ubuntu.com/ubuntu jammy/universe amd64 lmodern all
2.004.5-6.1 [9,471 kB]
Get:39 http://archive.ubuntu.com/ubuntu jammy/universe amd64 preview-latex-style
all 12.2-1ubuntu1 [185 kB]
Get:40 http://archive.ubuntu.com/ubuntu jammy/main amd64 t1utils amd64
1.41-4build2 [61.3 kB]
Get:41 http://archive.ubuntu.com/ubuntu jammy/universe amd64 teckit amd64
2.5.11+ds1-1 [699 kB]
Get:42 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-gyre all
20180621-3.1 [6,209 kB]
Get:43 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 texlive-
binaries amd64 2021.20210626.59705-1ubuntu0.1 [9,848 kB]
Get:44 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-base all
2021.20220204-1 [21.0 MB]
Get:45 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-fonts-
recommended all 2021.20220204-1 [4,972 kB]
Get:46 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-base
all 2021.20220204-1 [1,128 kB]
Get:47 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-
recommended all 2021.20220204-1 [14.4 MB]
Get:48 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive all
2021.20220204-1 [14.3 kB]
Get:49 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libfontbox-java all
1:1.8.16-2 [207 kB]
Get:50 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libpdfbox-java all
1:1.8.16-2 [5,199 kB]
Get:51 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-pictures
all 2021.20220204-1 [8,720 kB]
Get:52 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-extra
all 2021.20220204-1 [13.9 MB]
Get:53 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-plain-
generic all 2021.20220204-1 [27.5 MB]
Get:54 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tipa all 2:1.3-21
[2,967 kB]
Get:55 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-xetex all
2021.20220204-1 [12.4 MB]
Fetched 182 MB in 16s (11.4 MB/s)
Extracting templates from packages: 100%
Preconfiguring packages …
Selecting previously unselected package fonts-droid-fallback.
(Reading database … 121749 files and directories currently installed.)
Preparing to unpack …/00-fonts-droid-fallback_1%3a6.0.1r16-1.1build1_all.deb
```

```
…
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1build1) …
Selecting previously unselected package fonts-lato.
Preparing to unpack …/01-fonts-lato_2.0-2.1_all.deb …
Unpacking fonts-lato (2.0-2.1) …
Selecting previously unselected package poppler-data.
Preparing to unpack …/02-poppler-data_0.4.11-1_all.deb …
Unpacking poppler-data (0.4.11-1) …
Selecting previously unselected package tex-common.
Preparing to unpack …/03-tex-common_6.17_all.deb …
Unpacking tex-common (6.17) …
Selecting previously unselected package fonts-urw-base35.
Preparing to unpack …/04-fonts-urw-base35_20200910-1_all.deb …
Unpacking fonts-urw-base35 (20200910-1) …
Selecting previously unselected package libgs9-common.
Preparing to unpack …/05-libgs9-common_9.55.0~dfsg1-0ubuntu5.6_all.deb …
Unpacking libgs9-common (9.55.0~dfsg1-0ubuntu5.6) …
Selecting previously unselected package libidn12:amd64.
Preparing to unpack …/06-libidn12_1.38-4ubuntu1_amd64.deb …
Unpacking libidn12:amd64 (1.38-4ubuntu1) …
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack …/07-libijs-0.35_0.35-15build2_amd64.deb …
Unpacking libijs-0.35:amd64 (0.35-15build2) …
Selecting previously unselected package libjbig2dec0:amd64.
Preparing to unpack …/08-libjbig2dec0_0.19-3build2_amd64.deb …
Unpacking libjbig2dec0:amd64 (0.19-3build2) …
Selecting previously unselected package libgs9:amd64.
Preparing to unpack …/09-libgs9_9.55.0~dfsg1-0ubuntu5.6_amd64.deb …
Unpacking libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.6) …
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack …/10-libkpathsea6_2021.20210626.59705-1ubuntu0.1_amd64.deb
…
Unpacking libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.1) …
Selecting previously unselected package libwoff1:amd64.
Preparing to unpack …/11-libwoff1_1.0.2-1build4_amd64.deb …
Unpacking libwoff1:amd64 (1.0.2-1build4) …
Selecting previously unselected package dvisvgm.
Preparing to unpack …/12-dvisvgm_2.13.1-1_amd64.deb …
Unpacking dvisvgm (2.13.1-1) …
Selecting previously unselected package fonts-lmodern.
Preparing to unpack …/13-fonts-lmodern_2.004.5-6.1_all.deb …
Unpacking fonts-lmodern (2.004.5-6.1) …
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack …/14-fonts-noto-mono_20201225-1build1_all.deb …
Unpacking fonts-noto-mono (20201225-1build1) …
Selecting previously unselected package fonts-texgyre.
Preparing to unpack …/15-fonts-texgyre_20180621-3.1_all.deb …
Unpacking fonts-texgyre (20180621-3.1) …
```

```
Selecting previously unselected package libapache-pom-java.
Preparing to unpack …/16-libapache-pom-java_18-1_all.deb …
Unpacking libapache-pom-java (18-1) …
Selecting previously unselected package libcommons-parent-java.
Preparing to unpack …/17-libcommons-parent-java_43-1_all.deb …
Unpacking libcommons-parent-java (43-1) …
Selecting previously unselected package libcommons-logging-java.
Preparing to unpack …/18-libcommons-logging-java_1.2-2_all.deb …
Unpacking libcommons-logging-java (1.2-2) …
Selecting previously unselected package libfontenc1:amd64.
Preparing to unpack …/19-libfontenc1_1%3a1.1.4-1build3_amd64.deb …
Unpacking libfontenc1:amd64 (1:1.1.4-1build3) …
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack …/20-libptexenc1_2021.20210626.59705-1ubuntu0.1_amd64.deb
…
Unpacking libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.1) …
Selecting previously unselected package rubygems-integration.
Preparing to unpack …/21-rubygems-integration_1.18_all.deb …
Unpacking rubygems-integration (1.18) …
Selecting previously unselected package ruby3.0.
Preparing to unpack …/22-ruby3.0_3.0.2-7ubuntu2.4_amd64.deb …
Unpacking ruby3.0 (3.0.2-7ubuntu2.4) …
Selecting previously unselected package ruby-rubygems.
Preparing to unpack …/23-ruby-rubygems_3.3.5-2_all.deb …
Unpacking ruby-rubygems (3.3.5-2) …
Selecting previously unselected package ruby.
Preparing to unpack …/24-ruby_1%3a3.0~exp1_amd64.deb …
Unpacking ruby (1:3.0~exp1) …
Selecting previously unselected package rake.
Preparing to unpack …/25-rake_13.0.6-2_all.deb …
Unpacking rake (13.0.6-2) …
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack …/26-ruby-net-telnet_0.1.1-2_all.deb …
Unpacking ruby-net-telnet (0.1.1-2) …
Selecting previously unselected package ruby-webrick.
Preparing to unpack …/27-ruby-webrick_1.7.0-3_all.deb …
Unpacking ruby-webrick (1.7.0-3) …
Selecting previously unselected package ruby-xmlrpc.
Preparing to unpack …/28-ruby-xmlrpc_0.3.2-1ubuntu0.1_all.deb …
Unpacking ruby-xmlrpc (0.3.2-1ubuntu0.1) …
Selecting previously unselected package libruby3.0:amd64.
Preparing to unpack …/29-libruby3.0_3.0.2-7ubuntu2.4_amd64.deb …
Unpacking libruby3.0:amd64 (3.0.2-7ubuntu2.4) …
Selecting previously unselected package libsynctex2:amd64.
Preparing to unpack …/30-libsynctex2_2021.20210626.59705-1ubuntu0.1_amd64.deb
…
Unpacking libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.1) …
Selecting previously unselected package libteckit0:amd64.
```

```
Preparing to unpack …/31-libteckit0_2.5.11+ds1-1_amd64.deb …
Unpacking libteckit0:amd64 (2.5.11+ds1-1) …
Selecting previously unselected package libtexlua53:amd64.
Preparing to unpack …/32-libtexlua53_2021.20210626.59705-1ubuntu0.1_amd64.deb
…
Unpacking libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.1) …
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
…/33-libtexluajit2_2021.20210626.59705-1ubuntu0.1_amd64.deb …
Unpacking libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.1) …
Selecting previously unselected package libzzip-0-13:amd64.
Preparing to unpack …/34-libzzip-0-13_0.13.72+dfsg.1-1.1_amd64.deb …
Unpacking libzzip-0-13:amd64 (0.13.72+dfsg.1-1.1) …
Selecting previously unselected package xfonts-encodings.
Preparing to unpack …/35-xfonts-encodings_1%3a1.0.5-0ubuntu2_all.deb …
Unpacking xfonts-encodings (1:1.0.5-0ubuntu2) …
Selecting previously unselected package xfonts-utils.
Preparing to unpack …/36-xfonts-utils_1%3a7.7+6build2_amd64.deb …
Unpacking xfonts-utils (1:7.7+6build2) …
Selecting previously unselected package lmodern.
Preparing to unpack …/37-lmodern_2.004.5-6.1_all.deb …
Unpacking lmodern (2.004.5-6.1) …
Selecting previously unselected package preview-latex-style.
Preparing to unpack …/38-preview-latex-style_12.2-1ubuntu1_all.deb …
Unpacking preview-latex-style (12.2-1ubuntu1) …
Selecting previously unselected package t1utils.
Preparing to unpack …/39-t1utils_1.41-4build2_amd64.deb …
Unpacking t1utils (1.41-4build2) …
Selecting previously unselected package teckit.
Preparing to unpack …/40-teckit_2.5.11+ds1-1_amd64.deb …
Unpacking teckit (2.5.11+ds1-1) …
Selecting previously unselected package tex-gyre.
Preparing to unpack …/41-tex-gyre_20180621-3.1_all.deb …
Unpacking tex-gyre (20180621-3.1) …
Selecting previously unselected package texlive-binaries.
Preparing to unpack …/42-texlive-
binaries_2021.20210626.59705-1ubuntu0.1_amd64.deb …
Unpacking texlive-binaries (2021.20210626.59705-1ubuntu0.1) …
Selecting previously unselected package texlive-base.
Preparing to unpack …/43-texlive-base_2021.20220204-1_all.deb …
Unpacking texlive-base (2021.20220204-1) …
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack …/44-texlive-fonts-recommended_2021.20220204-1_all.deb …
Unpacking texlive-fonts-recommended (2021.20220204-1) …
Selecting previously unselected package texlive-latex-base.
Preparing to unpack …/45-texlive-latex-base_2021.20220204-1_all.deb …
Unpacking texlive-latex-base (2021.20220204-1) …
Selecting previously unselected package texlive-latex-recommended.
```

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Preparing to unpack …/46-texlive-latex-recommended_2021.20220204-1_all.deb …
Unpacking texlive-latex-recommended (2021.20220204-1) …
Selecting previously unselected package texlive.
Preparing to unpack …/47-texlive_2021.20220204-1_all.deb …
Unpacking texlive (2021.20220204-1) …
Selecting previously unselected package libfontbox-java.
Preparing to unpack …/48-libfontbox-java_1%3a1.8.16-2_all.deb …
Unpacking libfontbox-java (1:1.8.16-2) …
Selecting previously unselected package libpdfbox-java.
Preparing to unpack …/49-libpdfbox-java_1%3a1.8.16-2_all.deb …
Unpacking libpdfbox-java (1:1.8.16-2) …
Selecting previously unselected package texlive-pictures.
Preparing to unpack …/50-texlive-pictures_2021.20220204-1_all.deb …
Unpacking texlive-pictures (2021.20220204-1) …
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack …/51-texlive-latex-extra_2021.20220204-1_all.deb …
Unpacking texlive-latex-extra (2021.20220204-1) …
Selecting previously unselected package texlive-plain-generic.
Preparing to unpack …/52-texlive-plain-generic_2021.20220204-1_all.deb …
Unpacking texlive-plain-generic (2021.20220204-1) …
Selecting previously unselected package tipa.
Preparing to unpack …/53-tipa_2%3a1.3-21_all.deb …
Unpacking tipa (2:1.3-21) …
Selecting previously unselected package texlive-xetex.
Preparing to unpack …/54-texlive-xetex_2021.20220204-1_all.deb …
Unpacking texlive-xetex (2021.20220204-1) …
Setting up fonts-lato (2.0-2.1) …
Setting up fonts-noto-mono (20201225-1build1) …
Setting up libwoff1:amd64 (1.0.2-1build4) …
Setting up libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.1) …
Setting up libijs-0.35:amd64 (0.35-15build2) …
Setting up libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.1) …
Setting up libfontbox-java (1:1.8.16-2) …
Setting up rubygems-integration (1.18) …
Setting up libzzip-0-13:amd64 (0.13.72+dfsg.1-1.1) …
Setting up fonts-urw-base35 (20200910-1) …
Setting up poppler-data (0.4.11-1) …
Setting up tex-common (6.17) …
update-language: texlive-base not installed and configured, doing nothing!
Setting up libfontenc1:amd64 (1:1.1.4-1build3) …
Setting up libjbig2dec0:amd64 (0.19-3build2) …
Setting up libteckit0:amd64 (2.5.11+ds1-1) …
Setting up libapache-pom-java (18-1) …
Setting up ruby-net-telnet (0.1.1-2) …
Setting up xfonts-encodings (1:1.0.5-0ubuntu2) …
Setting up t1utils (1.41-4build2) …
Setting up libidn12:amd64 (1.38-4ubuntu1) …
Setting up fonts-texgyre (20180621-3.1) …
```

```
Setting up libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.1) …
Setting up ruby-webrick (1.7.0-3) …
Setting up fonts-lmodern (2.004.5-6.1) …
Setting up fonts-droid-fallback (1:6.0.1r16-1.1build1) …
Setting up ruby-xmlrpc (0.3.2-1ubuntu0.1) …
Setting up libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.1) …
Setting up libgs9-common (9.55.0~dfsg1-0ubuntu5.6) …
Setting up teckit (2.5.11+ds1-1) …
Setting up libpdfbox-java (1:1.8.16-2) …
Setting up libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.6) …
Setting up preview-latex-style (12.2-1ubuntu1) …
Setting up libcommons-parent-java (43-1) …
Setting up dvisvgm (2.13.1-1) …
Setting up libcommons-logging-java (1.2-2) …
Setting up xfonts-utils (1:7.7+6build2) …
Setting up libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.1) …
Setting up texlive-binaries (2021.20210626.59705-1ubuntu0.1) …
update-alternatives: using /usr/bin/xdvi-xaw to provide /usr/bin/xdvi.bin
(xdvi.bin) in auto mode
update-alternatives: using /usr/bin/bibtex.original to provide /usr/bin/bibtex
(bibtex) in auto mode
Setting up lmodern (2.004.5-6.1) …
Setting up texlive-base (2021.20220204-1) …
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
mktexlsr: Updating /var/lib/texmf/ls-R-TEXLIVEDIST…
mktexlsr: Updating /var/lib/texmf/ls-R-TEXMFMAIN…
mktexlsr: Updating /var/lib/texmf/ls-R…
mktexlsr: Done.
tl-paper: setting paper size for dvips to a4:
/var/lib/texmf/dvips/config/config-paper.ps
tl-paper: setting paper size for dvipdfmx to a4:
/var/lib/texmf/dvipdfmx/dvipdfmx-paper.cfg
tl-paper: setting paper size for xdvi to a4: /var/lib/texmf/xdvi/XDvi-paper
tl-paper: setting paper size for pdftex to a4: /var/lib/texmf/tex/generic/tex-
ini-files/pdftexconfig.tex
Setting up tex-gyre (20180621-3.1) …
Setting up texlive-plain-generic (2021.20220204-1) …
Setting up texlive-latex-base (2021.20220204-1) …
Setting up texlive-latex-recommended (2021.20220204-1) …
Setting up texlive-pictures (2021.20220204-1) …
Setting up texlive-fonts-recommended (2021.20220204-1) …
Setting up tipa (2:1.3-21) …
Setting up texlive (2021.20220204-1) …
Setting up texlive-latex-extra (2021.20220204-1) …
Setting up texlive-xetex (2021.20220204-1) …
```

```
Setting up rake (13.0.6-2) …
Setting up libruby3.0:amd64 (3.0.2-7ubuntu2.4) …
Setting up ruby3.0 (3.0.2-7ubuntu2.4) …
Setting up ruby (1:3.0~exp1) …
Setting up ruby-rubygems (3.3.5-2) …
Processing triggers for man-db (2.10.2-1) …
Processing triggers for fontconfig (2.13.1-4.2ubuntu5) …
Processing triggers for libc-bin (2.35-0ubuntu3.4) …
/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_0.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc.so.2 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_5.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbb.so.12 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc_proxy.so.2 is not a symbolic
link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind.so.3 is not a symbolic link

Processing triggers for tex-common (6.17) …
Running updmap-sys. This may take some time… done.
Running mktexlsr /var/lib/texmf … done.
Building format(s) --all.
        This may take some time… done.
Collecting pypandoc
  Downloading pypandoc-1.13-py3-none-any.whl (21 kB)
Installing collected packages: pypandoc
Successfully installed pypandoc-1.13
```

[95]:
```
!jupyter nbconvert --to PDF "Scrip3.ipynb"
```

```
[NbConvertApp] Converting notebook Scrip3.ipynb to PDF
/usr/local/lib/python3.10/dist-packages/nbconvert/filters/datatypefilter.py:41:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  warn(
/usr/local/lib/python3.10/dist-packages/nbconvert/filters/datatypefilter.py:41:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  warn(
/usr/local/lib/python3.10/dist-packages/nbconvert/filters/datatypefilter.py:41:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  warn(
/usr/local/lib/python3.10/dist-packages/nbconvert/filters/datatypefilter.py:41:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
```

```
to be represented.
  warn(
[NbConvertApp] Support files will be in Scrip3_files/
[NbConvertApp] Making directory ./Scrip3_files
[NbConvertApp] Making directory ./Scrip3_files
[NbConvertApp] Making directory ./Scrip3_files
[NbConvertApp] Making directory ./Scrip3_files
[NbConvertApp] Making directory ./Scrip3_files
[NbConvertApp] Writing 161315 bytes to notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', 'notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', 'notebook']
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no
citations
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 721326 bytes to Scrip3.pdf
```