Setup Environment

```
# Install specific libraries
! pip install transformers
! pip install pycaret
```

Show hidden output

```
import numpy as np
import pandas as pd
import pycaret
import transformers
from transformers import AutoModel, BertTokenizerFast
import matplotlib.pyplot as plt
from sklearn.metrics import plot_confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
import torch
import torch.nn as nn
# specify GPU
device = torch.device("cuda")
```

```
# Mount Google Drive - applicable, if working on Google Drive
from google.colab import drive
drive.mount('/content/drive')
```

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

```
# Set Working Directory - if working on Google Drive
%cd /content/drive/MyDrive/1_LiveProjects/Project11_FakeNewsDetection

# # Set Working Directory - if working on Local Machine
# import os
# os.chdir('/Users//replace_me')
```

```
/content/drive/MyDrive/Project11_FakeNewsDetection
```

Load Dataset

```
# Load Dataset
true_data = pd.read_csv('a1_True.csv')
fake_data = pd.read_csv('a2_Fake.csv')

# Generate labels True/Fake under new Target Column in 'true_data' and 'fake_data'
true_data['Target'] = ['True']*len(true_data)
fake_data['Target'] = ['Fake']*len(fake_data)

# Merge 'true_data' and 'fake_data', by random mixing into a single df called 'data'
data = true_data.append(fake_data).sample(frac=1).reset_index().drop(columns=['index'])

# See how the data looks like
print(data.shape)
data.head()
```

```
(44898, 5)
```

	title	text	subject	date	Target
0	PROOF That Obama Interfered TWICE In Foreign E...	President Barack Obama recently said he told R...	left-news	Jun 8, 2017	Fake
1	Kremlin: no firm date yet for proposed congres...	MOSCOW (Reuters) - No firm date has been set y...	worldnews	November 28, 2017	True
2	TOBY KEITH Has AWESOME Response To Crybaby Att...	Country singer Toby Keith won t be bullied int...	left-news	Jan 16, 2017	Fake
3	BREAKING: Putin Tramples Obama’s Imaginary Red...	We have a weak leader in our White House who s...	Government News	Sep 30, 2015	Fake

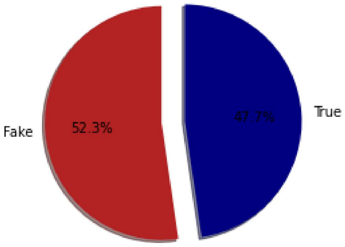
```
# Target column is made of string values True/Fake, let's change it to numbers 0/1 (Fake=1)
data['label'] = pd.get_dummies(data.Target)['Fake']
```

```
data.head()
```

	title	text	subject	date	Target	label
0	PROOF That Obama Interfered TWICE In Foreign E...	President Barack Obama recently said he told R...	left-news	Jun 8, 2017	Fake	1
1	Kremlin: no firm date yet for proposed congres...	MOSCOW (Reuters) - No firm date has been set y...	worldnews	November 28, 2017	True	0
2	TOBY KEITH Has AWESOME Response To Crybaby Att...	Country singer Toby Keith won t be bullied int...	left-news	Jan 16, 2017	Fake	1
3	BREAKING: Putin Tramples Obama's Imaginary Red...	We have a weak leader in our White House who s...	Government News	Sep 30, 2015	Fake	1
4	ULTIMATE HYPOCRITES! RUSSIAN Ambassador Visite...	According to the New Yorker, Bill Clinton rece...	politics	Mar 3, 2017	Fake	1

```
# Checking if our data is well balanced
label_size = [data['label'].sum(),len(data['label'])-data['label'].sum()]
plt.pie(label_size,explode=[0.1,0.1],colors=['firebrick','navy'],startangle=90,shadow=True,labels=['Fake','True'],autopct='%1.1f%%')
```

```
([<matplotlib.patches.Wedge at 0x7ff8f2d78810>,
  <matplotlib.patches.Wedge at 0x7ff8f2d8b310>],
 [Text(-1.1968727067385088, -0.08657778485782335, 'Fake'),
  Text(1.1968726986325005, 0.08657796063754254, 'True')],
 [Text(-0.6981757455974634, -0.05050374500396954, '52.3%'),
  Text(0.6981757408689586, 0.05050381037189981, '47.7%')])
```



Train-test-split

[ ] ↳ *1 cell hidden*

BERT Fine-tuning

Load pretrained BERT Model

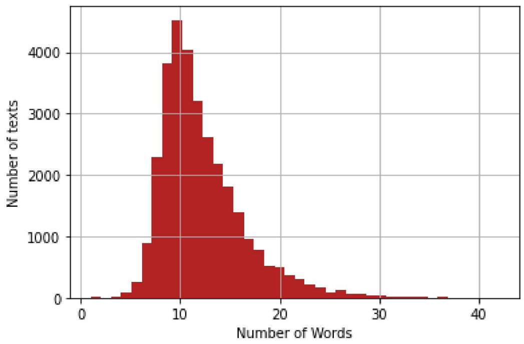
```
# Load BERT model and tokenizer via HuggingFace Transformers
bert = AutoModel.from_pretrained('bert-base-uncased')
tokenizer = BertTokenizerFast.from_pretrained('bert-base-uncased')
```

```
Downloading config.json: 100%                                570/570 [00:00<00:00, 15.7kB/s]

Downloading pytorch_model.bin: 100%                          420M/420M [00:07<00:00, 61.1MB/s]
Some weights of the model checkpoint at bert-base-uncased were not used when initializing BertModel: ['cls.seq_relationship.bias', 'cls.
- This IS expected if you are initializing BertModel from the checkpoint of a model trained on another task or with another architecture
- This IS NOT expected if you are initializing BertModel from the checkpoint of a model that you expect to be exactly identical (initial
Downloading tokenizer_config.json: 100%                      28.0/28.0 [00:00<00:00, 920B/s]

Downloading vocab.txt: 100%                                  226k/226k [00:00<00:00, 1.06MB/s]

Downloading tokenizer.json: 100%                             455k/455k [00:00<00:00, 1.61MB/s]
```

Prepare Input Data

```
# Plot histogram of the number of words in train data 'title'
seq_len = [len(title.split()) for title in train_text]

pd.Series(seq_len).hist(bins = 40,color='firebrick')
plt.xlabel('Number of Words')
plt.ylabel('Number of texts')
```

```
Text(0, 0.5, 'Number of texts')
```



```
# BERT Tokeizer Functionality
sample_data = ["Build fake news model.",
               "Using bert."]                                       # sample data
tokenized_sample_data = tokenizer.batch_encode_plus(sample_data,
                                                    padding=True)     # encode text
print(tokenized_sample_data)

# Ref: https://huggingface.co/docs/transformers/preprocessing
```

```
{'input_ids': [[101, 3857, 8275, 2739, 2944, 1012, 102], [101, 2478, 14324, 1012, 102, 0, 0]], 'token_type_ids': [[0, 0, 0, 0, 0, 0, 0],
```

```
# Majority of titles above have word length under 15. So, we set max title length as 15
MAX_LENGHT = 15
# Tokenize and encode sequences in the train set
tokens_train = tokenizer.batch_encode_plus(
    train_text.tolist(),
    max_length = MAX_LENGHT,
    pad_to_max_length=True,
    truncation=True
)
# tokenize and encode sequences in the validation set
tokens_val = tokenizer.batch_encode_plus(
    val_text.tolist(),
    max_length = MAX_LENGHT,
    pad_to_max_length=True,
    truncation=True
)
# tokenize and encode sequences in the test set
tokens_test = tokenizer.batch_encode_plus(
    test_text.tolist(),
    max_length = MAX_LENGHT,
    pad_to_max_length=True,
    truncation=True
)
```

```
/usr/local/lib/python3.7/dist-packages/transformers/tokenization_utils_base.py:2329: FutureWarning: The `pad_to_max_length` argument is
  FutureWarning,
```

```
# Convert lists to tensors
train_seq = torch.tensor(tokens_train['input_ids'])
train_mask = torch.tensor(tokens_train['attention_mask'])
train_y = torch.tensor(train_labels.tolist())

val_seq = torch.tensor(tokens_val['input_ids'])
val_mask = torch.tensor(tokens_val['attention_mask'])
val_y = torch.tensor(val_labels.tolist())

test_seq = torch.tensor(tokens_test['input_ids'])
test_mask = torch.tensor(tokens_test['attention_mask'])
test_y = torch.tensor(test_labels.tolist())
```

```
# Data Loader structure definition
from torch.utils.data import TensorDataset, DataLoader, RandomSampler, SequentialSampler
batch_size = 32                                               #define a batch size

train_data = TensorDataset(train_seq, train_mask, train_y)    # wrap tensors
train_sampler = RandomSampler(train_data)                     # sampler for sampling the data during training
train_dataloader = DataLoader(train_data, sampler=train_sampler, batch_size=batch_size)
                                                              # dataLoader for train set
val_data = TensorDataset(val_seq, val_mask, val_y)            # wrap tensors
val_sampler = SequentialSampler(val_data)                     # sampler for sampling the data during training
val_dataloader = DataLoader(val_data, sampler = val_sampler, batch_size=batch_size)
                                                              # dataLoader for validation set
```

Freeze Layers

```
# Freezing the parameters and defining trainable BERT structure
for param in bert.parameters():
    param.requires_grad = False    # false here means gradient need not be computed
```

Define Model Architecture

```
class BERT_Arch(nn.Module):
    def __init__(self, bert):
      super(BERT_Arch, self).__init__()
      self.bert = bert
      self.dropout = nn.Dropout(0.1)            # dropout layer
      self.relu =  nn.ReLU()                    # relu activation function
      self.fc1 = nn.Linear(768,512)             # dense layer 1
      self.fc2 = nn.Linear(512,2)               # dense layer 2 (Output layer)
      self.softmax = nn.LogSoftmax(dim=1)       # softmax activation function
    def forward(self, sent_id, mask):           # define the forward pass
      cls_hs = self.bert(sent_id, attention_mask=mask)['pooler_output']
                                                # pass the inputs to the model
      x = self.fc1(cls_hs)
      x = self.relu(x)
      x = self.dropout(x)
      x = self.fc2(x)                           # output layer
      x = self.softmax(x)                       # apply softmax activation
      return x

model = BERT_Arch(bert)
# Defining the hyperparameters (optimizer, weights of the classes and the epochs)
# Define the optimizer
from transformers import AdamW
optimizer = AdamW(model.parameters(),
                  lr = 1e-5)          # learning rate
# Define the loss function
cross_entropy  = nn.NLLLoss()
# Number of training epochs
epochs = 2
```

```
/usr/local/lib/python3.7/dist-packages/transformers/optimization.py:310: FutureWarning: This implementation of AdamW is deprecated and
  FutureWarning,
```

Define Train & Evaluate Function

```
# Defining training and evaluation functions
def train():
  model.train()
  total_loss, total_accuracy = 0, 0

  for step,batch in enumerate(train_dataloader):                # iterate over batches
    if step % 50 == 0 and not step == 0:                        # progress update after every 50 batches.
      print('  Batch {:>5,}  of  {:>5,}.'.format(step, len(train_dataloader)))
    batch = [r for r in batch]                                  # push the batch to gpu
    sent_id, mask, labels = batch
    model.zero_grad()                                           # clear previously calculated gradients
    preds = model(sent_id, mask)                                # get model predictions for current batch
    loss = cross_entropy(preds, labels)                         # compute loss between actual & predicted values
    total_loss = total_loss + loss.item()                       # add on to the total loss
    loss.backward()                                             # backward pass to calculate the gradients
    torch.nn.utils.clip_grad_norm_(model.parameters(), 1.0)     # clip gradients to 1.0. It helps in preventing exploding gradient problem
    optimizer.step()                                            # update parameters
    preds=preds.detach().cpu().numpy()                          # model predictions are stored on GPU. So, push it to CPU

  avg_loss = total_loss / len(train_dataloader)                 # compute training loss of the epoch
                                                                # reshape predictions in form of (# samples, # classes)
  return avg_loss                                 # returns the loss and predictions

def evaluate():
  print("\nEvaluating...")
  model.eval()                                    # Deactivate dropout layers
  total_loss, total_accuracy = 0, 0
  for step,batch in enumerate(val_dataloader):    # Iterate over batches
    if step % 50 == 0 and not step == 0:          # Progress update every 50 batches.
                                                  # Calculate elapsed time in minutes.
                                                  # Elapsed = format_time(time.time() - t0)
      print('  Batch {:>5,}  of  {:>5,}.'.format(step, len(val_dataloader)))
                                                  # Report progress
    batch = [t for t in batch]                    # Push the batch to GPU
    sent_id, mask, labels = batch
    with torch.no_grad():                         # Deactivate autograd
      preds = model(sent_id, mask)                # Model predictions
      loss = cross_entropy(preds,labels)          # Compute the validation loss between actual and predicted values
      total_loss = total_loss + loss.item()
      preds = preds.detach().cpu().numpy()
  avg_loss = total_loss / len(val_dataloader)         # compute the validation loss of the epoch
  return avg_loss
```

Model training

```
# Train and predict
best_valid_loss = float('inf')
train_losses=[]                   # empty lists to store training and validation loss of each epoch
valid_losses=[]

for epoch in range(epochs):
    print('\n Epoch {:} / {:}'.format(epoch + 1, epochs))
    train_loss = train()                       # train model
    valid_loss = evaluate()                    # evaluate model
    if valid_loss < best_valid_loss:              # save the best model
        best_valid_loss = valid_loss
        torch.save(model.state_dict(), 'c2_new_model_weights.pt')
    train_losses.append(train_loss)               # append training and validation loss
    valid_losses.append(valid_loss)

    print(f'\nTraining Loss: {train_loss:.3f}')
    print(f'Validation Loss: {valid_loss:.3f}')
```

Model performance

```
# load weights of best model
path = 'c1_fakenews_weights.pt'
model.load_state_dict(torch.load(path))
```

```
<All keys matched successfully>
```

```
with torch.no_grad():
  preds = model(test_seq, test_mask)
  preds = preds.detach().cpu().numpy()

preds = np.argmax(preds, axis = 1)
print(classification_report(test_y, preds))
```

```
              precision    recall  f1-score   support

           0       0.84      0.92      0.88      3213
           1       0.92      0.84      0.88      3522

    accuracy                           0.88      6735
   macro avg       0.88      0.88      0.88      6735
weighted avg       0.88      0.88      0.88      6735
```

Fake News Predictions

[ ] ↳ *2 cells hidden*