# Sentiment Analysis for Marketing

# PHASE -4

| | |
|---|---|
| **DATE** | 24 October 2023 |
| **TEAM ID** | Proj-212173-Team-1 |
| **PROJECT NAME** | Sentiment analysis for Marketing |

```
[13] MODEL = 'bert-base-uncased'
     tokenizer = BertTokenizer.from_pretrained(MODEL, do_lower_case=True)
```

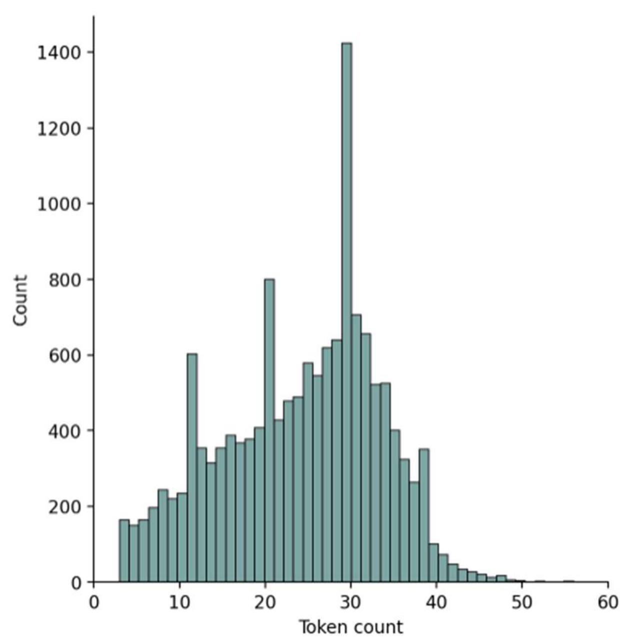
Downloading (…)okenizer_config.json: 100% 28.0/28.0 [00:00<00:00, 664B/s]

Downloading (…)solve/main/vocab.txt: 100% 232k/232k [00:00<00:00, 819kB/s]

Downloading (…)/main/tokenizer.json: 100% 466k/466k [00:00<00:00, 12.5MB/s]

Downloading (…)lve/main/config.json: 100% 570/570 [00:00<00:00, 19.6kB/s]

```
[14] sns.displot(tokens)
     plt.xlim([0, 60]);
     plt.xlabel('Token count');
```



```python
from torch.utils.data import Dataset, DataLoader

# Define a custom dataset, more info on how to build custom dataset can be
# found at https://pytorch.org/tutorials/beginner/data_loading_tutorial.html
class CustomDataset(Dataset):

    def __init__(
        self,
        tweets,
        labels,
        tokenizer,
        max_length
    ):
        self.tweets = tweets
        self.labels = labels
        self.tokenizer = tokenizer
        self.max_length = max_length

    def __len__(self):
        return len(self.tweets)

    def __getitem__(self, idx):
        tweet = self.tweets[idx]
        label = self.labels[idx]
        tokenize = self.tokenizer.encode_plus(
            tweet,
            add_special_tokens=True,
            max_length=self.max_length,
            return_token_type_ids=False,
            padding='max_length',
            return_attention_mask=True,
            return_tensors='pt'
        )
        return {
            'tweet': tweet,
            'input_ids': tokenize['input_ids'].flatten(),
            'attention_mask': tokenize['attention_mask'].flatten(),
            'targets': torch.tensor(label, dtype=torch.long)}
```

```python
MAX_LENGTH = 64
TEST_SIZE = 0.1
VALID_SIZE = 0.5
BATCH_SIZE = 16
NUM_WORKERS = 2

train_sampler, test_sampler = train_test_split(df, test_size=TEST_SIZE, random_state=RANDOM_STATE)
valid_sampler, test_sampler = train_test_split(test_sampler, test_size=VALID_SIZE, random_state=RANDOM_STATE)

train_set = CustomDataset(
    train_sampler['text'].to_numpy(),
    train_sampler['labels'].to_numpy(),
    tokenizer,
    MAX_LENGTH
)
test_set = CustomDataset(
    test_sampler['text'].to_numpy(),
    test_sampler['labels'].to_numpy(),
    tokenizer,
    MAX_LENGTH
)
valid_set = CustomDataset(
    valid_sampler['text'].to_numpy(),
    valid_sampler['labels'].to_numpy(),
    tokenizer,
    MAX_LENGTH
)
```

```python
train_loader = DataLoader(train_set, batch_size=BATCH_SIZE, num_workers=NUM_WORKERS)
test_loader = DataLoader(test_set, batch_size=BATCH_SIZE, num_workers=NUM_WORKERS)
valid_loader = DataLoader(valid_set, batch_size=BATCH_SIZE, num_workers=NUM_WORKERS)
```

```python
from torch import nn
class AirlineSentimentClassifier(nn.Module):

    def __init__(self, num_labels):
        super (AirlineSentimentClassifier, self).__init__()
        self.bert = BertModel.from_pretrained(MODEL)
        self.dropout = nn.Dropout(p=0.2)
        self.classifier = nn.Linear(self.bert.config.hidden_size, num_labels)

    def forward(self, input_ids, attention_mask):
        outputs = self.bert(
            input_ids=input_ids,
            attention_mask=attention_mask
        )
        pooled_output = outputs[1]
        pooled_output = self.dropout(pooled_output)
        out = self.classifier(pooled_output)
        return out
```

[19]

```python
model = AirlineSentimentClassifier(len(labels_map))
print(model)

# Move tensors to GPU on CUDA enables devices
if device:
    model.cuda()
```

Downloading model.safetensors: 100% 440M/440M [00:04<00:00, 33.2MB/s]

```
AirlineSentimentClassifier(
  (bert): BertModel(
    (embeddings): BertEmbeddings(
      (word_embeddings): Embedding(30522, 768, padding_idx=0)
      (position_embeddings): Embedding(512, 768)
      (token_type_embeddings): Embedding(2, 768)
      (LayerNorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
      (dropout): Dropout(p=0.1, inplace=False)
    )
    (encoder): BertEncoder(
      (layer): ModuleList(
        (0-11): 12 x BertLayer(
          (attention): BertAttention(
            (self): BertSelfAttention(
              (query): Linear(in_features=768, out_features=768, bias=True)
              (key): Linear(in_features=768, out_features=768, bias=True)
              (value): Linear(in_features=768, out_features=768, bias=True)
              (dropout): Dropout(p=0.1, inplace=False)
            )
            (output): BertSelfOutput(
              (dense): Linear(in_features=768, out_features=768, bias=True)
              (LayerNorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
              (dropout): Dropout(p=0.1, inplace=False)
            )
          )
```

```
          (intermediate): BertIntermediate(
            (dense): Linear(in_features=768, out_features=3072, bias=True)
            (intermediate_act_fn): GELUActivation()
          )
          (output): BertOutput(
            (dense): Linear(in_features=3072, out_features=768, bias=True)
            (LayerNorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
            (dropout): Dropout(p=0.1, inplace=False)
          )
        )
      )
    )
    (pooler): BertPooler(
      (dense): Linear(in_features=768, out_features=768, bias=True)
      (activation): Tanh()
    )
  )
  (dropout): Dropout(p=0.2, inplace=False)
  (classifier): Linear(in_features=768, out_features=3, bias=True)
)
```

```
n_epochs = 10
learning_rate =2e-5

# Loss function
criterion = nn.CrossEntropyLoss()

# Optimizer
optimizer = AdamW(model.parameters(), lr=learning_rate, correct_bias=False)

# Define scheduler
training_steps = len(train_loader)*n_epochs
scheduler = get_linear_schedule_with_warmup(
    optimizer,
    num_warmup_steps=0,
    num_training_steps=training_steps
)
```

```
/usr/local/lib/python3.10/dist-packages/transformers/optimization.py:411: FutureWarning: This implementation of AdamW is de
  warnings.warn(
```

```python
# Track changes in validation loss
valid_loss_min = np.Inf

for epoch in range(1, n_epochs+1):

    # Setting training and validation loss
    train_loss = []
    validation_loss = []
    tr_predictions = 0
    acc = 0
    val_predictions = 0

    ####################
    #  Train the model #
    ####################
    model = model.train()
    for data in train_loader:

        # Moving tensors to GPU on CUDA enabled devices
        if device:
            input_ids, attention_mask, targets = data["input_ids"].cuda(), data["attention_mask"].cuda(), data["targets
        # Clear the gradients of variables
        optimizer.zero_grad()
```

```python
    #### Forward pass
    # Pass input through the model
    output = model(
        input_ids=input_ids,
        attention_mask=attention_mask
    )
    # Compute batch loss
    loss = criterion(output, targets)
    # Convert output probabilities to class probabilities
    _, pred = torch.max(output, 1)
    # Track correct predictions
    tr_predictions += torch.sum(pred == targets)

    #### Backward Pass
    # Compute gradients wrt to model parameters
    loss.backward()
    # To avoid exploding gradients, we clip the gradients of the model
    nn.utils.clip_grad_norm_(model.parameters(), max_norm=1.0)
    # Perform parameter update
    optimizer.step()
    # Update learning rate
    scheduler.step()
    # Update loss per mini batches
    train_loss.append(loss.item())

######################
# Validate the model #
######################
model.eval()
with torch.no_grad():
    for data in valid_loader:
```

```python
        # Moving tensors to GPU on CUDA enabled devices
        if device:
            input_ids, attention_mask, targets = data["input_ids"].cuda(), data["attention_mask"].cuda(), data["tar

        #### Forward pass
        # Pass input through the model
        output = model(
            input_ids=input_ids,
            attention_mask=attention_mask
        )
        # Compute batch loss
        loss = criterion(output, targets)
        # Convert output probabilities to class probabilities
        _, pred = torch.max(output, 1)
        # Update loss per mini batches
        validation_loss.append(loss.item())
        # Track correct predictions
        val_predictions += torch.sum(pred == targets)
```

```python
    # Compute accuracy
    train_accuracy = tr_predictions.double()/len(train_sampler)
    val_accuracy = val_predictions.double()/len(valid_sampler)

    # Print loss statistics
    print('Epoch: {}/{} \n\tTraining Loss: {:.6f} \n\tValidation Loss: {:.6f} \n\tTrain Accuracy: {:.6f} \n\tVal Accura

    # Save model if validation loss is decreased
    if val_accuracy > acc:
        print('Saving model...')
        torch.save(model.state_dict(), 'bert_base_fine_tuned.pt')
        acc = val_accuracy
```

```
Epoch: 1/10
        Training Loss: 0.478485
        Validation Loss: 0.426510
        Train Accuracy: 0.813221
        Val Accuracy: 0.848361
Saving model...
Epoch: 2/10
        Training Loss: 0.251598
        Validation Loss: 0.587404
        Train Accuracy: 0.912720
        Val Accuracy: 0.837432
Saving model...
Epoch: 3/10
        Training Loss: 0.147462
        Validation Loss: 0.694001
        Train Accuracy: 0.958333
        Val Accuracy: 0.848361
Saving model...
Epoch: 4/10
        Training Loss: 0.095958
        Validation Loss: 0.852052
        Train Accuracy: 0.976548
        Val Accuracy: 0.841530
Saving model...
Epoch: 5/10
        Training Loss: 0.062927
        Validation Loss: 0.967488
        Train Accuracy: 0.985504
        Val Accuracy: 0.842896
Saving model...
Epoch: 6/10
        Training Loss: 0.042360
        Validation Loss: 1.066000
        Train Accuracy: 0.990437
        Val Accuracy: 0.840164
Saving model...
Epoch: 7/10
        Training Loss: 0.032142
        Validation Loss: 1.132496
        Train Accuracy: 0.992410
        Val Accuracy: 0.833333
Saving model...
Epoch: 8/10
        Training Loss: 0.024429
        Validation Loss: 1.184951
        Train Accuracy: 0.993777
        Val Accuracy: 0.829235
Saving model...
Epoch: 9/10
        Training Loss: 0.018996
        Validation Loss: 1.230268
        Train Accuracy: 0.994991
        Val Accuracy: 0.831967
Saving model...
Epoch: 10/10
        Training Loss: 0.015075
        Validation Loss: 1.244014
        Train Accuracy: 0.995826
        Val Accuracy: 0.830601
Saving model...
```

```python
# Track test loss
test_loss = 0.0
class_predictions = list(0. for i in range(3))
class_total = list(0. for i in range(3))
predictions = []
labels = []

model.eval()
with torch.no_grad():
    for data in test_loader:

        # Moving tensors to GPU on CUDA enabled devices
        if device:
            input_ids, attention_mask, targets = data["input_ids"].cuda(), data["attention_mask"].cuda(), data["targets

        #### Forward pass
        # Pass input through the model
        output = model(
            input_ids=input_ids,
            attention_mask=attention_mask
        )
        # Compute batch loss
        loss = criterion(output, targets)
        # Update loss
        test_loss += loss.item()
        # convert output probabilities to predicted class
        _, pred = torch.max(output, 1)

        predictions.extend(pred)
        labels.extend(targets)

predictions = torch.stack(predictions) if not device else torch.stack(predictions).cpu()
labels = torch.stack(labels) if not device else torch.stack(labels).cpu()
```

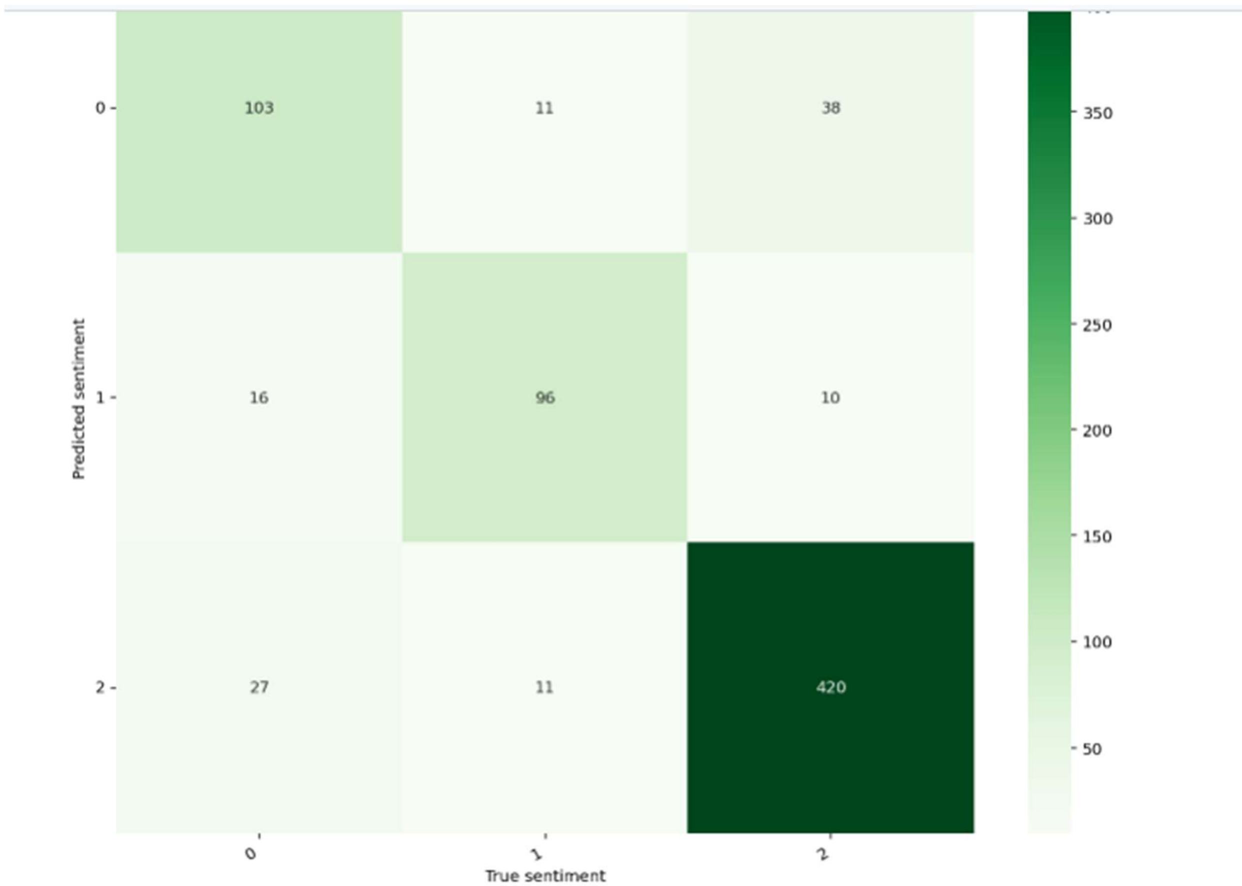
```python
print(classification_report(predictions, labels, target_names=['neutral', 'positive','negative']))
```

```
              precision    recall  f1-score   support

     neutral       0.68      0.71      0.69       146
    positive       0.79      0.81      0.80       118
    negative       0.92      0.90      0.91       468

    accuracy                           0.85       732
   macro avg       0.79      0.81      0.80       732
weighted avg       0.85      0.85      0.85       732
```

```python
cm = confusion_matrix(labels, predictions)
heatmap = sns.heatmap(cm, annot=True, fmt='d', cmap='Greens')
heatmap.yaxis.set_ticklabels(heatmap.yaxis.get_ticklabels(), rotation=0, ha='right')
heatmap.xaxis.set_ticklabels(heatmap.xaxis.get_ticklabels(), rotation=30, ha='right')
plt.xlabel('True sentiment')
plt.ylabel('Predicted sentiment');
```



Predicted sentiment
True sentiment
0
1
2
103
11
38
16
96
10
27
11
420
350
300
250
200
150
100
50