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Emotion detection from text using PyTorch and Federated Learning

For this project, we are going to implement an NLP task of creating a model to detect the emotion from text. We will develop this using the PyTorch library and the Federated Learning framework for decentralized training.

We will create an emotion detection for the following 5 emotions:

Emotion	Emoji	Label
Loving	♡	0
Playful	⚽	1
Happy	😄	2
Annoyed	😣	3
Foodie	🍽	4

The Model

We will build an LSTM model that takes as input word sequences that will take word ordering into account. We will use 50-dimensional GloVe pre-trained word embeddings to represent words. We will then feed those as an input into an LSTM that will predict the most appropiate emotion for the text.

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import csv
import torch
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim


# HELPER FUNCTIONS

def read_glove_vecs(glove_file):
    with open(glove_file, 'r') as f:
```

```
        words = set()
        word_to_vec_map = {}
        for line in f:
            line = line.strip().split()
            curr_word = line[0]
            words.add(curr_word)
            word_to_vec_map[curr_word] = np.array(line[1:], dtype=np.float64)

        i = 1
        words_to_index = {}
        index_to_words = {}
        for w in sorted(words):
            words_to_index[w] = i
            index_to_words[i] = w
            i = i + 1
    return words_to_index, index_to_words, word_to_vec_map

def convert_to_one_hot(Y, C):
    Y = np.eye(C)[Y.reshape(-1)]
    return Y

def read_csv(filename):
    phrase = []
    emoji = []

    with open (filename) as csvDataFile:
        csvReader = csv.reader(csvDataFile)

        for row in csvReader:
            phrase.append(row[0])
            emoji.append(row[1])

    X = np.asarray(phrase)
    Y = np.asarray(emoji, dtype=int)

    return X, Y


X_train, Y_train = read_csv('train.csv')
X_test, Y_test = read_csv('test.csv')


Y_oh_train = convert_to_one_hot(Y_train, C = 5)
```

```
Y_oh_test = convert_to_one_hot(Y_test, C = 5)


word_to_index, index_to_word, word_to_vec_map = read_glove_vecs('glove.6B.50d.txt')


def sentences_to_indices(X, word_to_index, max_len):
    """
    Converts an array of sentences (strings) into an array of indices corresponding to words in the sentences.
    """

    m = X.shape[0]  # number of training examples

    # Initialize X_indices as a numpy matrix of zeros and the correct shape
    X_indices = np.zeros((m,max_len))

    for i in range(m):  # loop over training examples

        # Convert the ith sentence in lower case and split into a list of words
        sentence_words = X[i].lower().split()

        # Initialize j to 0
        j = 0

        # Loop over the words of sentence_words
        for w in sentence_words:
            # Set the (i,j)th entry of X_indices to the index of the correct word.
            X_indices[i, j] = word_to_index[w]
            # Increment j to j + 1
            j = j + 1

    return X_indices


X1 = np.array(["lol", "I love you", "this is very yummy"])
X1_indices = sentences_to_indices(X1,word_to_index, max_len = 5)
print("X1 =", X1)
print("X1_indices =", X1_indices)
```

```
X1 = ['lol' 'I love you' 'this is very yummy']
X1_indices = [[225122.      0.      0.      0.      0.]
 [185457. 226278. 394475.      0.      0.]
 [358160. 192973. 377946. 394957.      0.]]
```

Defining the Network using Pretrained Embedding Layer using GloVe Word Embeddings

```
class NN(nn.Module):
  def __init__(self, embedding, embedding_dim, hidden_dim, vocab_size, output_dim, batch_size):
      super(NN, self).__init__()

      self.batch_size = batch_size

      self.hidden_dim = hidden_dim

      self.word_embeddings = embedding

      # The LSTM takes word embeddings as inputs, and outputs hidden states
      # with dimensionality hidden_dim.
      self.lstm = nn.LSTM(embedding_dim,
                          hidden_dim,
                          num_layers=2,
                          dropout = 0.5,
                          batch_first = True)

      # The linear layer that maps from hidden state space to output space
      self.fc = nn.Linear(hidden_dim, output_dim)

  def forward(self, sentence):

      #sentence = sentence.type(torch.LongTensor)
      #print ('Shape of sentence is:', sentence.shape)

      sentence = sentence.to(device)

      embeds = self.word_embeddings(sentence)
      #print ('Embedding layer output shape', embeds.shape)

      # initializing the hidden state to 0
      #hidden=None

      h0 = torch.zeros(2, sentence.size(0), hidden_dim).requires_grad_().to(device)
      c0 = torch.zeros(2, sentence.size(0), hidden_dim).requires_grad_().to(device)
```

```
        lstm_out, h = self.lstm(embeds, (h0, c0))
        # get info from last timestep only
        lstm_out = lstm_out[:, -1, :]
        #print ('LSTM layer output shape', lstm_out.shape)
        #print ('LSTM layer output ', lstm_out)

        # Dropout
        lstm_out = F.dropout(lstm_out, 0.5)

        fc_out = self.fc(lstm_out)
        #print ('FC layer output shape', fc_out.shape)
        #print ('FC layer output ', fc_out)

        out = fc_out
        out = F.softmax(out, dim=1)
        #print ('Output layer output shape', out.shape)
        #print ('Output layer output ', out)
        return out
```

Creating the Glove Embedding Layer

```
pretrained_embedding_layer(word_to_vec_map, word_to_index, non_trainable=True):
num_embeddings = len(word_to_index) + 1
embedding_dim = word_to_vec_map["cucumber"].shape[0]  #  dimensionality of GloVe word vectors (= 50)

# Initialize the embedding matrix as a numpy array of zeros of shape (num_embeddings, embedding_dim)
weights_matrix = np.zeros((num_embeddings, embedding_dim))

# Set each row "index" of the embedding matrix to be the word vector representation of the "index"th word of the vocabular
for word, index in word_to_index.items():
    weights_matrix[index, :] = word_to_vec_map[word]

embed = nn.Embedding.from_pretrained(torch.from_numpy(weights_matrix).type(torch.FloatTensor), freeze=non_trainable)

return embed, num_embeddings, embedding_dim
```

Training the model

```
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")

def train(model, trainloader, criterion, optimizer, epochs=10):

    model.to(device)
    running_loss = 0

    train_losses, test_losses, accuracies = [], [], []
    for e in range(epochs):

        running_loss = 0

        model.train()

        for sentences, labels in trainloader:

            sentences, labels = sentences.to(device), labels.to(device)

            # 1) erase previous gradients (if they exist)
            optimizer.zero_grad()

            # 2) make a prediction
            pred = model.forward(sentences)

            # 3) calculate how much we missed
            loss = criterion(pred, labels)

            # 4) figure out which weights caused us to miss
            loss.backward()

            # 5) change those weights
            optimizer.step()

            # 6) log our progress
            running_loss += loss.item()


        else:

            model.eval()
```

```
        model.eval()

        test_loss = 0
        accuracy = 0

        # Turn off gradients for validation, saves memory and computations
        with torch.no_grad():
            for sentences, labels in test_loader:
                sentences, labels = sentences.to(device), labels.to(device)
                log_ps = model(sentences)
                test_loss += criterion(log_ps, labels)

                ps = torch.exp(log_ps)
                top_p, top_class = ps.topk(1, dim=1)
                equals = top_class == labels.view(*top_class.shape)
                accuracy += torch.mean(equals.type(torch.FloatTensor))

        train_losses.append(running_loss/len(train_loader))
        test_losses.append(test_loss/len(test_loader))
        accuracies.append(accuracy / len(test_loader) * 100)

        print("Epoch: {}/{}.. ".format(e+1, epochs),
              "Training Loss: {:.3f}.. ".format(running_loss/len(train_loader)),
              "Test Loss: {:.3f}.. ".format(test_loss/len(test_loader)),
              "Test Accuracy: {:.3f}".format(accuracy/len(test_loader)))

# Plot
plt.figure(figsize=(20, 5))
plt.plot(train_losses, c='b', label='Training loss')
plt.plot(test_losses, c='r', label='Testing loss')
plt.xticks(np.arange(0, epochs))
plt.title('Losses')
plt.legend(loc='upper right')
plt.show()
plt.figure(figsize=(20, 5))
plt.plot(accuracies)
plt.xticks(np.arange(0, epochs))
plt.title('Accuracy')
plt.show()
```

```
X_train_indices.shape
```

```
(132, 10)
```

```
Y_train_oh.shape
```

```
(132, 5)
```

```
Y_train.shape
```

```
(132,)
```

```
X_test_indices.shape
```

```
(56, 10)
```

```
X_train.shape
```

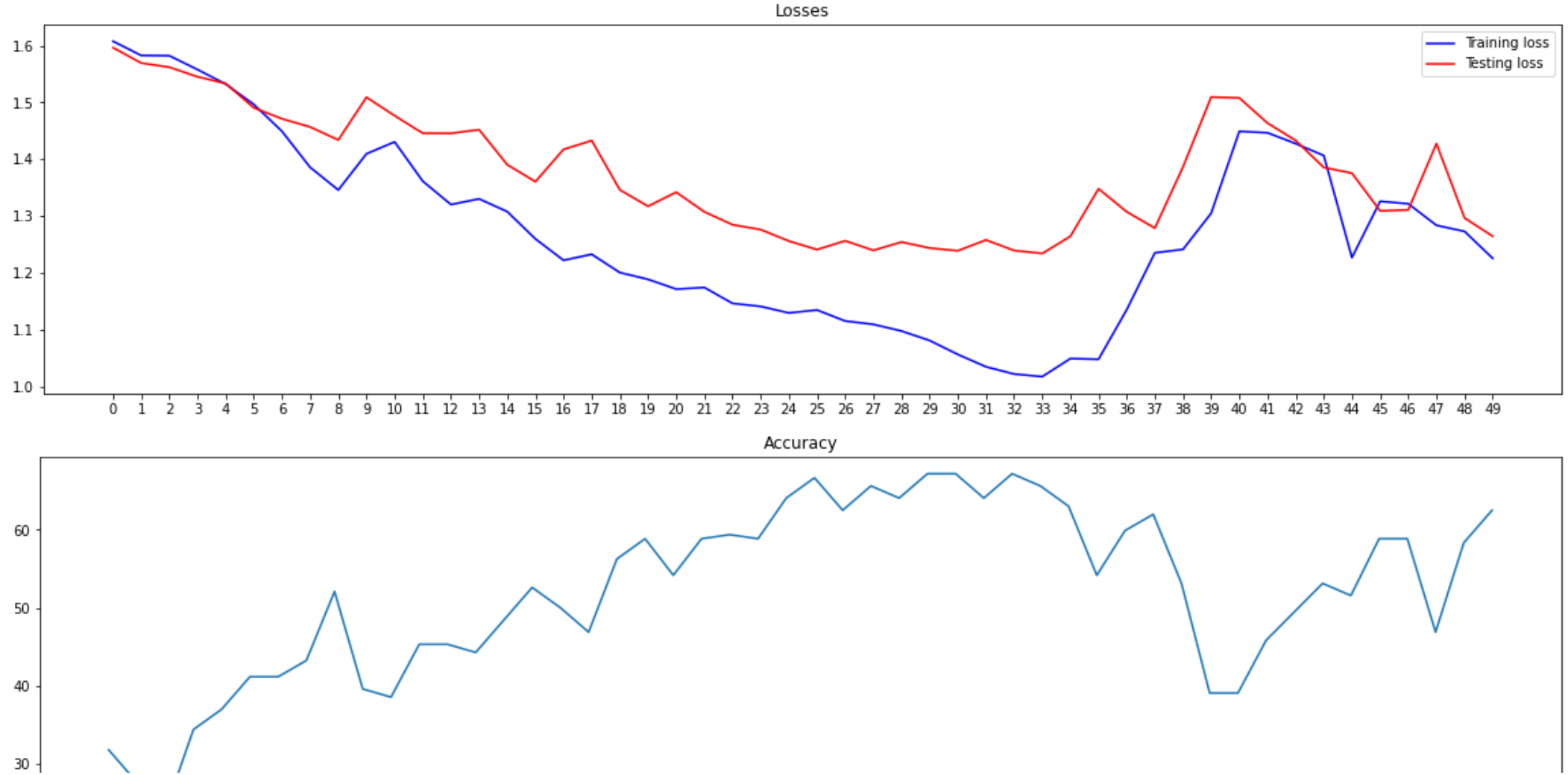
```
(132,)
```

```
mport torch.utils.data

axLen = len(max(X_train, key=len).split())
_train_indices = sentences_to_indices(X_train, word_to_index, maxLen)
_train_oh = convert_to_one_hot(Y_train, C = 5)

_test_indices = sentences_to_indices(X_test, word_to_index, maxLen)
_test_oh = convert_to_one_hot(Y_test, C = 5)

mbedding, vocab_size, embedding_dim = pretrained_embedding_layer(word_to_vec_map, word_to_index, non_trainable=True)

idden_dim=128
utput_size=5
atch_size = 32
```

```
print ('Embedding layer is ', embedding)
print ('Embedding layer weights ', embedding.weight.shape)

odel = NN(embedding, embedding_dim, hidden_dim, vocab_size, output_size, batch_size)
riterion = nn.CrossEntropyLoss()
ptimizer = optim.Adam(model.parameters(), lr=0.002)
pochs = 50
rain_dataset = torch.utils.data.TensorDataset(torch.tensor(X_train_indices).type(torch.LongTensor), torch.tensor(Y_train).
rain_loader = torch.utils.data.DataLoader(train_dataset, batch_size=batch_size)

est_dataset = torch.utils.data.TensorDataset(torch.tensor(X_test_indices).type(torch.LongTensor), torch.tensor(Y_test).typ
est_loader = torch.utils.data.DataLoader(test_dataset, batch_size=batch_size)

rain(model, train_loader, criterion, optimizer, epochs)
```

```
Epoch: 1/50..  Training Loss: 1.608..  Test Loss: 1.596..  Test Accuracy: 0.318
Epoch: 2/50..  Training Loss: 1.583..  Test Loss: 1.569..  Test Accuracy: 0.276
Epoch: 3/50..  Training Loss: 1.582..  Test Loss: 1.562..  Test Accuracy: 0.240
Epoch: 4/50..  Training Loss: 1.558..  Test Loss: 1.545..  Test Accuracy: 0.344
Epoch: 5/50..  Training Loss: 1.532..  Test Loss: 1.533..  Test Accuracy: 0.370
Epoch: 6/50..  Training Loss: 1.496..  Test Loss: 1.490..  Test Accuracy: 0.411
Epoch: 7/50..  Training Loss: 1.449..  Test Loss: 1.471..  Test Accuracy: 0.411
Epoch: 8/50..  Training Loss: 1.386..  Test Loss: 1.457..  Test Accuracy: 0.432
Epoch: 9/50..  Training Loss: 1.346..  Test Loss: 1.434..  Test Accuracy: 0.521
Epoch: 10/50..  Training Loss: 1.410..  Test Loss: 1.509..  Test Accuracy: 0.396
Epoch: 11/50..  Training Loss: 1.431..  Test Loss: 1.477..  Test Accuracy: 0.385
Epoch: 12/50..  Training Loss: 1.361..  Test Loss: 1.446..  Test Accuracy: 0.453
Epoch: 13/50..  Training Loss: 1.320..  Test Loss: 1.446..  Test Accuracy: 0.453
Epoch: 14/50..  Training Loss: 1.330..  Test Loss: 1.452..  Test Accuracy: 0.443
Epoch: 15/50..  Training Loss: 1.308..  Test Loss: 1.390..  Test Accuracy: 0.484
Epoch: 16/50..  Training Loss: 1.260..  Test Loss: 1.361..  Test Accuracy: 0.526
Epoch: 17/50..  Training Loss: 1.222..  Test Loss: 1.417..  Test Accuracy: 0.500
Epoch: 18/50..  Training Loss: 1.233..  Test Loss: 1.433..  Test Accuracy: 0.469
Epoch: 19/50..  Training Loss: 1.201..  Test Loss: 1.346..  Test Accuracy: 0.562
Epoch: 20/50..  Training Loss: 1.189..  Test Loss: 1.317..  Test Accuracy: 0.589
Epoch: 21/50..  Training Loss: 1.172..  Test Loss: 1.342..  Test Accuracy: 0.542
Epoch: 22/50..  Training Loss: 1.174..  Test Loss: 1.308..  Test Accuracy: 0.589
Epoch: 23/50..  Training Loss: 1.147..  Test Loss: 1.285..  Test Accuracy: 0.594
Epoch: 24/50..  Training Loss: 1.141..  Test Loss: 1.276..  Test Accuracy: 0.589
Epoch: 25/50..  Training Loss: 1.130..  Test Loss: 1.256..  Test Accuracy: 0.641
Epoch: 26/50..  Training Loss: 1.135..  Test Loss: 1.241..  Test Accuracy: 0.667
Epoch: 27/50..  Training Loss: 1.115..  Test Loss: 1.257..  Test Accuracy: 0.625
Epoch: 28/50..  Training Loss: 1.110..  Test Loss: 1.240..  Test Accuracy: 0.656
Epoch: 29/50..  Training Loss: 1.098..  Test Loss: 1.254..  Test Accuracy: 0.641
Epoch: 30/50..  Training Loss: 1.081..  Test Loss: 1.244..  Test Accuracy: 0.672
Epoch: 31/50..  Training Loss: 1.057..  Test Loss: 1.239..  Test Accuracy: 0.672
Epoch: 32/50..  Training Loss: 1.035..  Test Loss: 1.258..  Test Accuracy: 0.641
Epoch: 33/50..  Training Loss: 1.022..  Test Loss: 1.240..  Test Accuracy: 0.672
Epoch: 34/50..  Training Loss: 1.018..  Test Loss: 1.234..  Test Accuracy: 0.656
Epoch: 35/50..  Training Loss: 1.049..  Test Loss: 1.264..  Test Accuracy: 0.630
Epoch: 36/50..  Training Loss: 1.048..  Test Loss: 1.348..  Test Accuracy: 0.542
Epoch: 37/50..  Training Loss: 1.135..  Test Loss: 1.308..  Test Accuracy: 0.599
Epoch: 38/50..  Training Loss: 1.235..  Test Loss: 1.279..  Test Accuracy: 0.620
Epoch: 39/50..  Training Loss: 1.241..  Test Loss: 1.387..  Test Accuracy: 0.531
Epoch: 40/50..  Training Loss: 1.305..  Test Loss: 1.509..  Test Accuracy: 0.391
Epoch: 41/50..  Training Loss: 1.449..  Test Loss: 1.508..  Test Accuracy: 0.391
Epoch: 42/50..  Training Loss: 1.447..  Test Loss: 1.464..  Test Accuracy: 0.458
Epoch: 43/50..  Training Loss: 1.428..  Test Loss: 1.433..  Test Accuracy: 0.495
Epoch: 44/50..  Training Loss: 1.407..  Test Loss: 1.386..  Test Accuracy: 0.531
Epoch: 45/50..  Training Loss: 1.227..  Test Loss: 1.376..  Test Accuracy: 0.516
Epoch: 46/50..  Training Loss: 1.326..  Test Loss: 1.309..  Test Accuracy: 0.589
```

```
Epoch: 47/50..  Training Loss: 1.322..  Test Loss: 1.311..  Test Accuracy: 0.589
Epoch: 48/50..  Training Loss: 1.284..  Test Loss: 1.427..  Test Accuracy: 0.469
Epoch: 49/50..  Training Loss: 1.273..  Test Loss: 1.297..  Test Accuracy: 0.583
Epoch: 50/50..  Training Loss: 1.226..  Test Loss: 1.265..  Test Accuracy: 0.625
```



Testing the Model Accuracy

```
test_loss = 0
accuracy = 0
model.eval()
with torch.no_grad():
    for sentences, labels in test_loader:
        sentences, labels = sentences.to(device), labels.to(device)
```

```
        ps = model(sentences)
        test_loss += criterion(ps, labels).item()

        # Accuracy
        top_p, top_class = ps.topk(1, dim=1)
        equals = top_class == labels.view(*top_class.shape)
        accuracy += torch.mean(equals.type(torch.FloatTensor))
model.train()
print("Test Loss: {:.3f}.. ".format(test_loss/len(test_loader)),
      "Test Accuracy: {:.3f}".format(accuracy/len(test_loader)))
running_loss = 0
```

```
Test Loss: 1.268..  Test Accuracy: 0.625
```

Testing the model with any sentence

```
def predict(input_text, print_sentence=True):
  labels_dict = {
    0 : "♡ Loving",
    1 : "⚽ Playful",
    2 : "😁 Happy",
    3 : "😣 Annoyed",
    4 : "🍽 Foodie",
  }

  # Convert the input to the model
  x_test = np.array([input_text])
  X_test_indices = sentences_to_indices(x_test, word_to_index, maxLen)
  sentences = torch.tensor(X_test_indices).type(torch.LongTensor)

  # Get the class label
  ps = model(sentences)
  top_p, top_class = ps.topk(1, dim=1)
  label = int(top_class[0][0])

  if print_sentence:
    print("\nInput Text: \t"+ input_text +'\nEmotion: \t'+  labels_dict[label])

  return label
```

```
# Change the sentence below to see your prediction. Make sure all the words are in the Glove embeddings.
print("-----------------------------------")
predict("I hate you")
predict("I want a pizza")
predict("Lets see the game")
predict("I love you Lisa")
predict("This is the best day of my life")
predict("leave me alone")
print("\n-----------------------------------")
```

```
-----------------------------------

    Input Text:     I hate you
    Emotion:        ♡ Loving

    Input Text:     I want a pizza
    Emotion:        🍽 Foodie

    Input Text:     Lets see the game
    Emotion:        ⚽ Playful

    Input Text:     I love you Lisa
    Emotion:        ♡ Loving

    Input Text:     This is the best day of my life
    Emotion:        😄 Happy

    Input Text:     leave me alone
    Emotion:        😄 Happy

    -----------------------------------
```

Federated Learning

```
!pip install syft
import syft as sy  # <-- import the Pysyft library
hook = sy.TorchHook(torch)  # <-- hook PyTorch to add extra functionalities to support Federated Learning
bob = sy.VirtualWorker(hook, id="bob")  # <-- define remote worker bob
alice = sy.VirtualWorker(hook, id="alice")  # <-- define remote worker alice
```

```
Requirement already satisfied: syft in /usr/local/lib/python3.6/dist-packages (0.2.4)
Requirement already satisfied: numpy~=1.18.1 in /usr/local/lib/python3.6/dist-packages (from syft) (1.18.2)
Requirement already satisfied: tblib~=1.6.0 in /usr/local/lib/python3.6/dist-packages (from syft) (1.6.0)
Requirement already satisfied: msgpack~=1.0.0 in /usr/local/lib/python3.6/dist-packages (from syft) (1.0.0)
Requirement already satisfied: syft-proto~=0.2.5.a1 in /usr/local/lib/python3.6/dist-packages (from syft) (0.2.5a1)
Requirement already satisfied: flask-socketio~=4.2.1 in /usr/local/lib/python3.6/dist-packages (from syft) (4.2.1)
Requirement already satisfied: lz4~=3.0.2 in /usr/local/lib/python3.6/dist-packages (from syft) (3.0.2)
Requirement already satisfied: Pillow~=6.2.2 in /usr/local/lib/python3.6/dist-packages (from syft) (6.2.2)
Requirement already satisfied: websockets~=8.1.0 in /usr/local/lib/python3.6/dist-packages (from syft) (8.1)
Requirement already satisfied: Flask~=1.1.1 in /usr/local/lib/python3.6/dist-packages (from syft) (1.1.1)
Requirement already satisfied: scipy~=1.4.1 in /usr/local/lib/python3.6/dist-packages (from syft) (1.4.1)
Requirement already satisfied: torch~=1.4.0 in /usr/local/lib/python3.6/dist-packages (from syft) (1.4.0)
Requirement already satisfied: tornado==4.5.3 in /usr/local/lib/python3.6/dist-packages (from syft) (4.5.3)
Requirement already satisfied: websocket-client~=0.57.0 in /usr/local/lib/python3.6/dist-packages (from syft) (0.57.0)
Requirement already satisfied: torchvision~=0.5.0 in /usr/local/lib/python3.6/dist-packages (from syft) (0.5.0)
Requirement already satisfied: phe~=1.4.0 in /usr/local/lib/python3.6/dist-packages (from syft) (1.4.0)
Requirement already satisfied: requests~=2.22.0 in /usr/local/lib/python3.6/dist-packages (from syft) (2.22.0)
Requirement already satisfied: protobuf>=3.11.1 in /usr/local/lib/python3.6/dist-packages (from syft-proto~=0.2.5.a1->syft) (3.11.3)
Requirement already satisfied: python-socketio>=4.3.0 in /usr/local/lib/python3.6/dist-packages (from flask-socketio~=4.2.1->syft) (4.5.1
Requirement already satisfied: Werkzeug>=0.15 in /usr/local/lib/python3.6/dist-packages (from Flask~=1.1.1->syft) (1.0.1)
Requirement already satisfied: click>=5.1 in /usr/local/lib/python3.6/dist-packages (from Flask~=1.1.1->syft) (7.1.1)
Requirement already satisfied: itsdangerous>=0.24 in /usr/local/lib/python3.6/dist-packages (from Flask~=1.1.1->syft) (1.1.0)
Requirement already satisfied: Jinja2>=2.10.1 in /usr/local/lib/python3.6/dist-packages (from Flask~=1.1.1->syft) (2.11.1)
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (from websocket-client~=0.57.0->syft) (1.12.0)
Requirement already satisfied: chardet<3.1.0,>=3.0.2 in /usr/local/lib/python3.6/dist-packages (from requests~=2.22.0->syft) (3.0.4)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.6/dist-packages (from requests~=2.22.0->syft) (2019.11.28)
Requirement already satisfied: idna<2.9,>=2.5 in /usr/local/lib/python3.6/dist-packages (from requests~=2.22.0->syft) (2.8)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in /usr/local/lib/python3.6/dist-packages (from requests~=2.22.0->
Requirement already satisfied: setuptools in /usr/local/lib/python3.6/dist-packages (from protobuf>=3.11.1->syft-proto~=0.2.5.a1->syft) (
Requirement already satisfied: python-engineio>=3.9.0 in /usr/local/lib/python3.6/dist-packages (from python-socketio>=4.3.0->flask-socke
Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/python3.6/dist-packages (from Jinja2>=2.10.1->Flask~=1.1.1->syft) (1.1.
```

```
size = len(X_train_indices)
```

```
bobs_data = sy.BaseDataset(torch.tensor(X_train_indices[:size//2]).type(torch.LongTensor), torch.tensor(Y_train[:size//2])
alices_data = sy.BaseDataset(torch.tensor(X_train_indices[size//2+1:]).type(torch.LongTensor), torch.tensor(Y_train[size//
federated_train_dataset = sy.FederatedDataset([bobs_data, alices_data])
federated_train_loader = sy.FederatedDataLoader(federated_train_dataset, batch_size=batch_size)

test_dataset = torch.utils.data.TensorDataset(torch.tensor(X_test_indices).type(torch.LongTensor), torch.tensor(Y_test).ty
test_loader = torch.utils.data.DataLoader(test_dataset, batch_size=batch_size)


def federated_train(model, trainloader, criterion, optimizer, epochs=10):

    running_loss = 0

    train_losses, test_losses, accuracies = [], [], []
    for e in range(epochs):

        running_loss = 0

        model.train()

        for batch_idx, (sentences, labels) in enumerate(federated_train_loader):

            model.send(sentences.location)

            # 1) erase previous gradients (if they exist)
            optimizer.zero_grad()

            # 2) make a prediction
            pred = model(sentences)

            # 3) calculate how much we missed
            loss = criterion(pred, labels)

            # 4) figure out which weights caused us to miss
            loss.backward()

            # 5) change those weights
            optimizer.step()

            # 6) get the model and loss back
            model.get()
            loss = loss.get()
```

```
        # 7) log our progress
        running_loss += loss.item()


    else:

      model.eval()

      test_loss = 0
      accuracy = 0

      # Turn off gradients for validation, saves memory and computations
      with torch.no_grad():
          for sentences, labels in test_loader:

              log_ps = model(sentences)
              test_loss += criterion(log_ps, labels)

              ps = torch.exp(log_ps)
              top_p, top_class = ps.topk(1, dim=1)
              equals = top_class == labels.view(*top_class.shape)
              accuracy += torch.mean(equals.type(torch.FloatTensor))

      train_losses.append(running_loss/len(train_loader))
      test_losses.append(test_loss/len(test_loader))
      accuracies.append(accuracy / len(test_loader) * 100)

      print("Epoch: {}/{}.. ".format(e+1, epochs),
            "Training Loss: {:.3f}.. ".format(running_loss/len(train_loader)),
            "Test Loss: {:.3f}.. ".format(test_loss/len(test_loader)),
            "Test Accuracy: {:.3f}".format(accuracy/len(test_loader)))

# Plot
plt.figure(figsize=(20, 5))
plt.plot(train_losses, c='b', label='Training loss')
plt.plot(test_losses, c='r', label='Testing loss')
plt.xticks(np.arange(0, epochs))
plt.title('Losses')
plt.legend(loc='upper right')
plt.show()
plt.figure(figsize=(20, 5))
```

```
    plt.plot(accuracies)
    plt.xticks(np.arange(0, epochs))
    plt.title('Accuracy')
    plt.show()


device = torch.device("cpu")
embedding, vocab_size, embedding_dim = pretrained_embedding_layer(word_to_vec_map, word_to_index, non_trainable=False)
federated_model = NN(embedding, embedding_dim, hidden_dim, vocab_size, output_size, batch_size)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(federated_model.parameters(), lr=0.002)
epochs = 50

federated_train(federated_model, train_loader, criterion, optimizer, epochs)
```

```
---------------------------------------------------------------------------
RuntimeError                              Traceback (most recent call last)
<ipython-input-25-f4c128254a96> in <module>()
      6 epochs = 50
      7
----> 8 federated_train(federated_model, train_loader, criterion, optimizer, epochs)

                                    6 frames
/usr/local/lib/python3.6/dist-packages/torch/nn/modules/rnn.py in check_input(self, input, batch_sizes)
    157             raise RuntimeError(
    158                 'input.size(-1) must be equal to input_size. Expected {}, got {}'.format(
--> 159                     self.input_size, input.size(-1)))
    160
    161     def get_expected_hidden_size(self, input, batch_sizes):

RuntimeError: input.size(-1) must be equal to input_size. Expected 50, got 0
```

SEARCH STACK OVERFLOW

```
data = pd.read_csv('iseardataset.csv')
```

different dataset with 7000 entries and classified into 7 emotions,not using any pre-trained word-embedings like glove,used LSTM

```
data = data[['text','label']]
```

```
data.label.value_counts()
```

```
joy        1092
sadness    1082
anger      1079
fear       1076
shame      1071
disgust    1066
guilt      1050
Name: label, dtype: int64
```

```
data['labels'] = 0


data.loc[data['label'] =='joy' , 'labels'] = 0
data.loc[data['label'] =='sadness' , 'labels'] = 1
data.loc[data['label'] =='anger' , 'labels'] = 2
data.loc[data['label'] =='fear' , 'labels'] = 3
data.loc[data['label'] =='shame' , 'labels'] = 4
data.loc[data['label'] =='disgust' , 'labels'] = 5
data.loc[data['label'] =='guilt' , 'labels'] = 6



from keras.utils.np_utils import to_categorical
labels = to_categorical(data['labels'], num_classes=7)
```

```
Using TensorFlow backend.
```

```
labels
```

```
     array([[1., 0., 0., ..., 0., 0., 0.],
            [0., 0., 0., ..., 0., 0., 0.],
            [0., 0., 1., ..., 0., 0., 0.],
```

```
maxLen = len(max(data['text'], key=len).split())
```

```
            [0.  0.  0.        0.  0.  1.]
```

```
print(maxLen)
```

```
168
```

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
```

```
from sklearn.feature_extraction.text import CountVectorizer
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from keras.models import Sequential
from keras.layers import Dense, Embedding, LSTM
from sklearn.model_selection import train_test_split
from keras.utils.np_utils import to_categorical
import re
```

```
n_most_common_words = 25000
max_len = maxLen
tokenizer = Tokenizer(num_words=n_most_common_words, filters='!"#$%&()*+,-./:;<=>?@[\]^_`{|}~', lower=True)
tokenizer.fit_on_texts(data['text'].values)
sequences = tokenizer.texts_to_sequences(data['text'].values)
word_index = tokenizer.word_index
print('Found %s unique tokens.' % len(word_index))

X = pad_sequences(sequences, maxlen=max_len)
```

```
Found 11242 unique tokens.
```

```
X_train, X_test, y_train, y_test = train_test_split(X , labels, test_size=0.25, random_state=42)
```

```
epochs = 10
```

```
emb_dim = 128
batch_size = 256
labels[:2]
```

```
array([[1., 0., 0., 0., 0., 0., 0.],
       [0., 0., 0., 1., 0., 0., 0.]], dtype=float32)
```

```
print((X_train.shape, y_train.shape, X_test.shape, y_test.shape))
```

```
((5637, 168), (5637, 7), (1879, 168), (1879, 7))
```

```
%tensorflow_version 1.x
```

```
TensorFlow 1.x selected.
```

```
print((X_train.shape, y_train.shape, X_test.shape, y_test.shape))

model = Sequential()
model.add(Embedding(n_most_common_words, emb_dim, input_length=X.shape[1]))
model.add(LSTM(64, dropout=0.7, recurrent_dropout=0.7))
model.add(Dense(7, activation='softmax'))
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc'])
print(model.summary())
history = model.fit(X_train, y_train, epochs=epochs, batch_size=batch_size,validation_split=0.2)
```

```
((5637, 168), (5637, 7), (1879, 168), (1879, 7))
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_3 (Embedding)      (None, 168, 128)          3200000
_________________________________________________________________
lstm_2 (LSTM)                (None, 64)                49408
_________________________________________________________________
dense_2 (Dense)              (None, 7)                 455
=================================================================
Total params: 3,249,863
Trainable params: 3,249,863
Non-trainable params: 0
_________________________________________________________________
None
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/python/ops/math_grad.py:1424: where (from tensorflow.python.ops.arra
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:1033: The name tf.assign_add is deprec

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:1020: The name tf.assign is deprecated

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:3005: The name tf.Session is deprecate

Train on 4509 samples, validate on 1128 samples
Epoch 1/10
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:190: The name tf.get_default_session i

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:197: The name tf.ConfigProto is deprec

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:207: The name tf.global_variables is d

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:216: The name tf.is_variable_initializ

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:223: The name tf.variables_initializer

4509/4509 [==============================] - 9s 2ms/step - loss: 1.9444 - acc: 0.1608 - val_loss: 1.9403 - val_acc: 0.2021
Epoch 2/10
4509/4509 [==============================] - 7s 2ms/step - loss: 1.9343 - acc: 0.2351 - val_loss: 1.9329 - val_acc: 0.2828
Epoch 3/10
4509/4509 [==============================] - 7s 2ms/step - loss: 1.9183 - acc: 0.3007 - val_loss: 1.9176 - val_acc: 0.2988
Epoch 4/10
4509/4509 [==============================] - 8s 2ms/step - loss: 1.8892 - acc: 0.3615 - val_loss: 1.8854 - val_acc: 0.3298
Epoch 5/10
4509/4509 [==============================] - 8s 2ms/step - loss: 1.8319 - acc: 0.3963 - val_loss: 1.8287 - val_acc: 0.3493
```

```
Epoch 6/10
4509/4509 [==============================] - 8s 2ms/step - loss: 1.7417 - acc: 0.4340 - val_loss: 1.7462 - val_acc: 0.3785
Epoch 7/10
4509/4509 [==============================] - 7s 2ms/step - loss: 1.6273 - acc: 0.4766 - val_loss: 1.6686 - val_acc: 0.3980
Epoch 8/10
4509/4509 [==============================] - 8s 2ms/step - loss: 1.4820 - acc: 0.5447 - val_loss: 1.5804 - val_acc: 0.4202
Epoch 9/10
4509/4509 [==============================] - 8s 2ms/step - loss: 1.3542 - acc: 0.5651 - val_loss: 1.5222 - val_acc: 0.4406
Epoch 10/10
4509/4509 [==============================] - 8s 2ms/step - loss: 1.1971 - acc: 0.6440 - val_loss: 1.4669 - val_acc: 0.4566
```

```
history=model.fit(X_train, y_train, epochs=epochs, batch_size=batch_size,validation_split=0.2,verbose = 2)
```

```
data = pd.read_csv('data.csv')
```

```
 - 7s - loss: 1.0610 - acc: 0.6766 - val_loss: 1.4319 - val_acc: 0.4681
```

used a dataset with 40k entries and are classified into 5 emotions.Glove embeddings are used for text pre-processing. Choice of Neural Network Model: RNNs, especially LSTMs, are preferred for many NLP tasks as it "learns" the significance of order of sequential data(text) CNNs extract features from data to identify them. Previous approaches either use one method. Hybrid approach by using both in the same model.

===>We take elements from each of the above models and extend the idea of creating multi-channel networks where we allow the model to attempt to self-learn which channels allow it to get better predictions for certain classes of data. We call our prototype neural network **BalanceNet.**

```
data.shape
```

```
(47287, 2)
```

```
data.columns = ['First','Second']
```

```
type(data['First'])
```

```
pandas.core.series.Series
```

```
data['Second'].value_counts()
```

```
1    16297
2    15938
0     9643
3     4301
4     1108
Name: Second, dtype: int64
```

```
MAX_NB_WORDS = 40000 # max no. of words for tokenizer
MAX_SEQUENCE_LENGTH = 30 # max length of text (words) including padding
VALIDATION_SPLIT = 0.2
EMBEDDING_DIM = 200 # embedding dimensions for word vectors (word2vec/GloVe)
GLOVE_DIR = "/content/glove.6B.50d.txt"
print("[i] Loaded Parameters:\n",
```

```
      MAX_NB_WORDS,MAX_SEQUENCE_LENGTH+5,
      VALIDATION_SPLIT,EMBEDDING_DIM,"\n",
      GLOVE_DIR)
```

```
 [i] Loaded Parameters:
      40000 35 0.2 200
      /content/glove.6B.50d.txt
```

```
import numpy as np
import pandas as pd
import re, sys, os, csv, keras, pickle


from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from keras.utils.np_utils import to_categorical
from keras.layers import Embedding
from keras.layers import Dense, Input, Flatten, Concatenate
from keras.layers import Conv1D, MaxPooling1D,Add, Embedding, Dropout, LSTM, GRU, Bidirectional
from keras.models import Model
from keras import backend as K
from keras.engine.topology import Layer, InputSpec
print("[+] Using Keras version",keras.__version__)
```

```
 [+] Using Keras version 2.2.5
     ERROR! Session/line number was not unique in database. History logging moved to new session 61
```

```
texts, labels = [], []
print("[i] Reading from csv file...", end="")
with open('data.csv') as csvfile:
    readCSV = csv.reader(csvfile, delimiter=',')
    for row in readCSV:
        texts.append(row[0])
        labels.append(row[1])
print("Done!")
```

```
 [i] Reading from csv file...Done!
```

```
tokenizer = Tokenizer(num_words=MAX_NB_WORDS)
tokenizer.fit_on_texts(texts)
with open('tokenizer.pickle', 'wb') as handle:
    pickle.dump(tokenizer, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

```
print("[i] Saved word tokenizer to file: tokenizer.pickle")
```

```
[i] Saved word tokenizer to file: tokenizer.pickle
```

```
with open('tokenizer.pickle', 'rb') as handle:
    tokenizer = pickle.load(handle)


sequences = tokenizer.texts_to_sequences(texts)
word_index = tokenizer.word_index
print('[i] Found %s unique tokens.' % len(word_index))
data_int = pad_sequences(sequences, padding='pre', maxlen=(MAX_SEQUENCE_LENGTH-5))
data = pad_sequences(data_int, padding='post', maxlen=(MAX_SEQUENCE_LENGTH))
```

```
[i] Found 34359 unique tokens.
```

```
labels = to_categorical(np.asarray(labels)) # convert to one-hot encoding vectors
print('[+] Shape of data tensor:', data.shape)
print('[+] Shape of label tensor:', labels.shape)
```

```
[+] Shape of data tensor: (47288, 30)
[+] Shape of label tensor: (47288, 5)
```

```
indices = np.arange(data.shape[0])
np.random.shuffle(indices)
data = data[indices]
labels = labels[indices]
nb_validation_samples = int(VALIDATION_SPLIT * data.shape[0])


x_train = data[:-nb_validation_samples]
y_train = labels[:-nb_validation_samples]
x_val = data[-nb_validation_samples:]
y_val = labels[-nb_validation_samples:]

print('[i] Number of entries in each category:')
print("[+] Training:\n",y_train.sum(axis=0))
print("[+] Validation:\n",y_val.sum(axis=0))
```

```
```

```
     [i] Number of entries in each category:
     [+] Training:
     [ 7799  13029  12693   3423    887 ]
```

```
EMBEDDING_DIM = 50
```

```
embeddings_index = {}
f = open(GLOVE_DIR)
print("[i] Loading GloVe from:",GLOVE_DIR,"...",end="")
for line in f:
    values = line.split()
    word = values[0]
    embeddings_index[word] = np.asarray(values[1:], dtype='float32')
f.close()
print("Done.\n[+] Proceeding with Embedding Matrix...", end="")
embedding_matrix = np.random.random((len(word_index) + 1, EMBEDDING_DIM))
for word, i in word_index.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        # words not found in embedding index will be all-zeros.
        embedding_matrix[i] = embedding_vector
print("[i] Completed!")
```

```
[i] Loading GloVe from: /content/glove.6B.50d.txt ...Done.
[+] Proceeding with Embedding Matrix...[i] Completed!
```

```
def get_lr_metric(optimizer):
    def lr(y_true, y_pred):
        return optimizer.lr
    return lr


def initial_boost(epoch):
    if epoch==0: return float(8.0)
    elif epoch==1: return float(4.0)
    elif epoch==2: return float(2.0)
    elif epoch==3: return float(1.5)
    else: return float(1.0)


def step_cyclic(epoch):
    try:
        l_r, decay = 1.0, 0.0001
```

```
        if epoch%33==0:multiplier = 10
        else:multiplier = 1
        rate = float(multiplier * l_r * 1/(1 + decay * epoch))
        #print("Epoch",epoch+1,"- learning_rate",rate)
        return rate
    except Exception as e:
        print("Error in lr_schedule:",str(e))
        return float(1.0)


embedding_matrix_ns = np.random.random((len(word_index) + 1, EMBEDDING_DIM))
for word, i in word_index.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        # words not found in embedding index will be all-zeros.
        embedding_matrix_ns[i] = embedding_vector
print("Completed!")
```

```
Completed!
```

```
sequence_input = Input(shape=(MAX_SEQUENCE_LENGTH,), dtype='int32')

# static channel
embedding_layer_frozen = Embedding(len(word_index) + 1,
                            EMBEDDING_DIM,
                            weights=[embedding_matrix],
                            input_length=MAX_SEQUENCE_LENGTH,
                            trainable=False)
embedded_sequences_frozen = embedding_layer_frozen(sequence_input)

# non-static channel
embedding_layer_train = Embedding(len(word_index) + 1,
                            EMBEDDING_DIM,
                            weights=[embedding_matrix_ns],
                            input_length=MAX_SEQUENCE_LENGTH,
                            trainable=True)
embedded_sequences_train = embedding_layer_train(sequence_input)


l_lstm1f = Bidirectional(LSTM(6,return_sequences=True,dropout=0.3, recurrent_dropout=0.0))(embedded_sequences_frozen)
l_lstm1t = Bidirectional(LSTM(6,return_sequences=True,dropout=0.3, recurrent_dropout=0.0))(embedded_sequences_train)
l_lstm1 = Concatenate(axis=1)([l_lstm1f, l_lstm1t])
```

```
from keras import regularizers


l_conv_2 = Conv1D(filters=24,kernel_size=2,activation='relu')(l_lstm1)
l_conv_2 = Dropout(0.3)(l_conv_2)
l_conv_3 = Conv1D(filters=24,kernel_size=3,activation='relu')(l_lstm1)
l_conv_3 = Dropout(0.3)(l_conv_3)

l_conv_5 = Conv1D(filters=24,kernel_size=5,activation='relu',)(l_lstm1)
l_conv_5 = Dropout(0.3)(l_conv_5)
l_conv_6 = Conv1D(filters=24,kernel_size=6,activation='relu',kernel_regularizer=regularizers.l2(0.0001))(l_lstm1)
l_conv_6 = Dropout(0.3)(l_conv_6)

l_conv_8 = Conv1D(filters=24,kernel_size=8,activation='relu',kernel_regularizer=regularizers.l2(0.0001))(l_lstm1)
l_conv_8 = Dropout(0.3)(l_conv_8)

conv_1 = [l_conv_6,l_conv_5, l_conv_8,l_conv_2,l_conv_3]

l_lstm_c = Concatenate(axis=1)(conv_1)


l_conv_4f = Conv1D(filters=12,kernel_size=4,activation='relu',kernel_regularizer=regularizers.l2(0.0001))(embedded_sequenc
l_conv_4f = Dropout(0.3)(l_conv_4f)
l_conv_4t = Conv1D(filters=12,kernel_size=4,activation='relu',kernel_regularizer=regularizers.l2(0.0001))(embedded_sequenc
l_conv_4t = Dropout(0.3)(l_conv_4t)

l_conv_3f = Conv1D(filters=12,kernel_size=3,activation='relu',)(embedded_sequences_frozen)
l_conv_3f = Dropout(0.3)(l_conv_3f)
l_conv_3t = Conv1D(filters=12,kernel_size=3,activation='relu',)(embedded_sequences_train)
l_conv_3t = Dropout(0.3)(l_conv_3t)

l_conv_2f = Conv1D(filters=12,kernel_size=2,activation='relu')(embedded_sequences_frozen)
l_conv_2f = Dropout(0.3)(l_conv_2f)
l_conv_2t = Conv1D(filters=12,kernel_size=2,activation='relu')(embedded_sequences_train)
l_conv_2t = Dropout(0.3)(l_conv_2t)

conv_2 = [l_conv_4f, l_conv_4t,l_conv_3f, l_conv_3t, l_conv_2f, l_conv_2t]

l_merge_2 = Concatenate(axis=1)(conv_2)
l_c_lstm = Bidirectional(LSTM(12,return_sequences=True,dropout=0.3, recurrent_dropout=0.0))(l_merge_2)
```

```
l_merge = Concatenate(axis=1)([l_lstm_c, l_c_lstm])
l_pool = MaxPooling1D(4)(l_merge)
l_drop = Dropout(0.5)(l_pool)
l_flat = Flatten()(l_drop)
l_dense = Dense(26, activation='relu')(l_flat)
preds = Dense(5, activation='softmax')(l_dense)
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:4267: The name tf.nn.max_pool is depre
```

```
from keras import optimizers


model = Model(sequence_input, preds)
adadelta = optimizers.Adadelta(lr=0.9, rho=0.95, epsilon=None, decay=0.002)
lr_metric = get_lr_metric(adadelta)
model.compile(loss='categorical_crossentropy',
              optimizer=adadelta,
              metrics=['acc'])


from keras import callbacks
```

```
ERROR! Session/line number was not unique in database. History logging moved to new session 62
```

```
tensorboard = callbacks.TensorBoard(log_dir='./logs', histogram_freq=0, batch_size=16, write_grads=True , write_graph=True
model_checkpoints = callbacks.ModelCheckpoint("checkpoint-{val_loss:.3f}.h5", monitor='val_loss', verbose=0, save_best_onl
lr_schedule = callbacks.LearningRateScheduler(initial_boost)


model.summary()
model.save('BalanceNet.h5')
```

Model: "model_2"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	(None, 30)	0	
embedding_4 (Embedding)	(None, 30, 50)	1718000	input_1[0][0]
embedding_5 (Embedding)	(None, 30, 50)	1718000	input_1[0][0]
bidirectional_1 (Bidirectional)	(None, 30, 12)	2736	embedding_4[0][0]
bidirectional_2 (Bidirectional)	(None, 30, 12)	2736	embedding_5[0][0]
concatenate_1 (Concatenate)	(None, 60, 12)	0	bidirectional_1[0][0] bidirectional_2[0][0]
conv1d_9 (Conv1D)	(None, 27, 12)	2412	embedding_4[0][0]
conv1d_10 (Conv1D)	(None, 27, 12)	2412	embedding_5[0][0]
conv1d_11 (Conv1D)	(None, 28, 12)	1812	embedding_4[0][0]
conv1d_12 (Conv1D)	(None, 28, 12)	1812	embedding_5[0][0]
conv1d_13 (Conv1D)	(None, 29, 12)	1212	embedding_4[0][0]
conv1d_14 (Conv1D)	(None, 29, 12)	1212	embedding_5[0][0]
conv1d_7 (Conv1D)	(None, 55, 24)	1752	concatenate_1[0][0]
conv1d_6 (Conv1D)	(None, 56, 24)	1464	concatenate_1[0][0]
conv1d_8 (Conv1D)	(None, 53, 24)	2328	concatenate_1[0][0]
conv1d_4 (Conv1D)	(None, 59, 24)	600	concatenate_1[0][0]
conv1d_5 (Conv1D)	(None, 58, 24)	888	concatenate_1[0][0]
dropout_10 (Dropout)	(None, 27, 12)	0	conv1d_9[0][0]
dropout_11 (Dropout)	(None, 27, 12)	0	conv1d_10[0][0]
dropout_12 (Dropout)	(None, 28, 12)	0	conv1d_11[0][0]
dropout_13 (Dropout)	(None, 28, 12)	0	conv1d_12[0][0]

dropout_14 (Dropout)	(None, 29, 12)	0	conv1d_13[0][0]
dropout_15 (Dropout)	(None, 29, 12)	0	conv1d_14[0][0]
dropout_8 (Dropout)	(None, 55, 24)	0	conv1d_7[0][0]
dropout_7 (Dropout)	(None, 56, 24)	0	conv1d_6[0][0]
dropout_9 (Dropout)	(None, 53, 24)	0	conv1d_8[0][0]
dropout_5 (Dropout)	(None, 59, 24)	0	conv1d_4[0][0]
dropout_6 (Dropout)	(None, 58, 24)	0	conv1d_5[0][0]
concatenate_3 (Concatenate)	(None, 168, 12)	0	dropout_10[0][0] dropout_11[0][0] dropout_12[0][0] dropout_13[0][0] dropout_14[0][0] dropout_15[0][0]
concatenate_2 (Concatenate)	(None, 281, 24)	0	dropout_8[0][0] dropout_7[0][0] dropout_9[0][0] dropout_5[0][0] dropout_6[0][0]
bidirectional_3 (Bidirectional)	(None, 168, 24)	2400	concatenate_3[0][0]
concatenate_4 (Concatenate)	(None, 449, 24)	0	concatenate_2[0][0] bidirectional_3[0][0]
max_pooling1d_1 (MaxPooling1D)	(None, 112, 24)	0	concatenate_4[0][0]
dropout_16 (Dropout)	(None, 112, 24)	0	max_pooling1d_1[0][0]
flatten_1 (Flatten)	(None, 2688)	0	dropout_16[0][0]
dense_3 (Dense)	(None, 26)	69914	flatten_1[0][0]
dense_4 (Dense)	(None, 5)	135	dense_3[0][0]

Total params: 3,531,825
Trainable params: 1,813,825
Non-trainable params: 1,718,000

```
print("Training Progress:")
model_log = model.fit(x_train, y_train, validation_data=(x_val, y_val),
          epochs=35, batch_size=128,
          callbacks=[tensorboard, model_checkpoints])

pandas.DataFrame(model_log.history).to_csv("history-balance.csv")
```

```
print("Training Progress:")
model_log = model.fit(x_train, y_train, validation_data=(x_val, y_val),
          epochs=25, batch_size=128,
          callbacks=[tensorboard, model_checkpoints])

pandas.DataFrame(model_log.history).to_csv("history-balance.csv")
```

```
Training Progress:
Train on 37831 samples, validate on 9457 samples
Epoch 1/25
37831/37831 [==============================] - 86s 2ms/step - loss: 0.9549 - acc: 0.6025 - val_loss: 0.9594 - val_acc: 0.6000
Epoch 2/25
37831/37831 [==============================] - 82s 2ms/step - loss: 0.9546 - acc: 0.6042 - val_loss: 0.9585 - val_acc: 0.6012
Epoch 3/25
37831/37831 [==============================] - 83s 2ms/step - loss: 0.9536 - acc: 0.6051 - val_loss: 0.9583 - val_acc: 0.6007
Epoch 4/25
37831/37831 [==============================] - 82s 2ms/step - loss: 0.9538 - acc: 0.6029 - val_loss: 0.9573 - val_acc: 0.6024
Epoch 5/25
37831/37831 [==============================] - 83s 2ms/step - loss: 0.9542 - acc: 0.6027 - val_loss: 0.9581 - val_acc: 0.6005
Epoch 6/25
37831/37831 [==============================] - 82s 2ms/step - loss: 0.9521 - acc: 0.6020 - val_loss: 0.9569 - val_acc: 0.6034
Epoch 7/25
37831/37831 [==============================] - 81s 2ms/step - loss: 0.9512 - acc: 0.6046 - val_loss: 0.9559 - val_acc: 0.6029
Epoch 8/25
37831/37831 [==============================] - 84s 2ms/step - loss: 0.9514 - acc: 0.6047 - val_loss: 0.9557 - val_acc: 0.6029
Epoch 9/25
37831/37831 [==============================] - 83s 2ms/step - loss: 0.9490 - acc: 0.6034 - val_loss: 0.9568 - val_acc: 0.6011
Epoch 10/25
37831/37831 [==============================] - 82s 2ms/step - loss: 0.9490 - acc: 0.6051 - val_loss: 0.9560 - val_acc: 0.6015
Epoch 11/25
37831/37831 [==============================] - 81s 2ms/step - loss: 0.9499 - acc: 0.6048 - val_loss: 0.9564 - val_acc: 0.6016
Epoch 12/25
37831/37831 [==============================] - 79s 2ms/step - loss: 0.9472 - acc: 0.6067 - val_loss: 0.9545 - val_acc: 0.6025
Epoch 13/25
37831/37831 [==============================] - 79s 2ms/step - loss: 0.9454 - acc: 0.6093 - val_loss: 0.9549 - val_acc: 0.6021
Epoch 14/25
37831/37831 [==============================] - 79s 2ms/step - loss: 0.9484 - acc: 0.6067 - val_loss: 0.9549 - val_acc: 0.6016
Epoch 15/25
37831/37831 [==============================] - 81s 2ms/step - loss: 0.9469 - acc: 0.6072 - val_loss: 0.9540 - val_acc: 0.6034
Epoch 16/25
37831/37831 [==============================] - 85s 2ms/step - loss: 0.9460 - acc: 0.6075 - val_loss: 0.9542 - val_acc: 0.6025
Epoch 17/25
37831/37831 [==============================] - 81s 2ms/step - loss: 0.9455 - acc: 0.6096 - val_loss: 0.9542 - val_acc: 0.6034
Epoch 18/25
37831/37831 [==============================] - 80s 2ms/step - loss: 0.9437 - acc: 0.6108 - val_loss: 0.9556 - val_acc: 0.6015
Epoch 19/25
37831/37831 [==============================] - 79s 2ms/step - loss: 0.9430 - acc: 0.6082 - val_loss: 0.9546 - val_acc: 0.6021
Epoch 20/25
37831/37831 [==============================] - 80s 2ms/step - loss: 0.9449 - acc: 0.6093 - val_loss: 0.9531 - val_acc: 0.6044
Epoch 21/25
37831/37831 [==============================] - 80s 2ms/step - loss: 0.9437 - acc: 0.6094 - val_loss: 0.9527 - val_acc: 0.6045
Epoch 22/25
37831/37831 [==============================] - 80s 2ms/step - loss: 0.9442 - acc: 0.6075 - val_loss: 0.9540 - val_acc: 0.6030
```

```
Epoch 23/25
37831/37831 [==============================] - 80s 2ms/step - loss: 0.9443 - acc: 0.6084 - val_loss: 0.9534 - val_acc: 0.6019
Epoch 24/25
37831/37831 [==============================] - 79s 2ms/step - loss: 0.9438 - acc: 0.6078 - val_loss: 0.9517 - val_acc: 0.6051
Epoch 25/25
37831/37831 [==============================] - 78s 2ms/step - loss: 0.9417 - acc: 0.6095 - val_loss: 0.9531 - val_acc: 0.6035
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-107-36c6486f3703> in <module>()
      4           callbacks=[tensorboard, model_checkpoints])
      5
----> 6 pandas.DataFrame(model_log.history).to_csv("history-balance.csv")

NameError: name 'pandas' is not defined
```

SEARCH STACK OVERFLOW

```
pd.DataFrame(model_log.history).to_csv("history-balance.csv")


from keras.models import load_model
from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
import numpy as np
%config InlineBackend.figure_format = 'retina'
import itertools, pickle

with open('tokenizer.pickle', 'rb') as handle:
    tokenizer = pickle.load(handle)

classes = ["neutral", "happy", "sad", "hate","anger"]


!ls
```

```
BalanceNet.h5        checkpoint-0.969.h5  checkpoint-1.041.h5
checkpoint-0.952.h5  checkpoint-0.971.h5  checkpoint-1.056.h5
checkpoint-0.953.h5  checkpoint-0.974.h5  checkpoint-1.073.h5
checkpoint-0.954.h5  checkpoint-0.975.h5  checkpoint-1.103.h5
checkpoint-0.956.h5  checkpoint-0.978.h5  checkpoint-1.190.h5
checkpoint-0.957.h5  checkpoint-0.981.h5  data.csv
checkpoint-0.958.h5  checkpoint-0.982.h5  glove.6B.50d.txt
checkpoint-0.959.h5  checkpoint-0.988.h5  history-balance.csv
checkpoint-0.960.h5  checkpoint-0.992.h5  iseardataset.csv
checkpoint-0.962.h5  checkpoint-0.997.h5  logs
checkpoint-0.964.h5  checkpoint-1.002.h5  sample_data
checkpoint-0.965.h5  checkpoint-1.007.h5  test.csv
checkpoint-0.966.h5  checkpoint-1.018.h5  tokenizer.pickle
checkpoint-0.967.h5  checkpoint-1.026.h5  train.csv
```

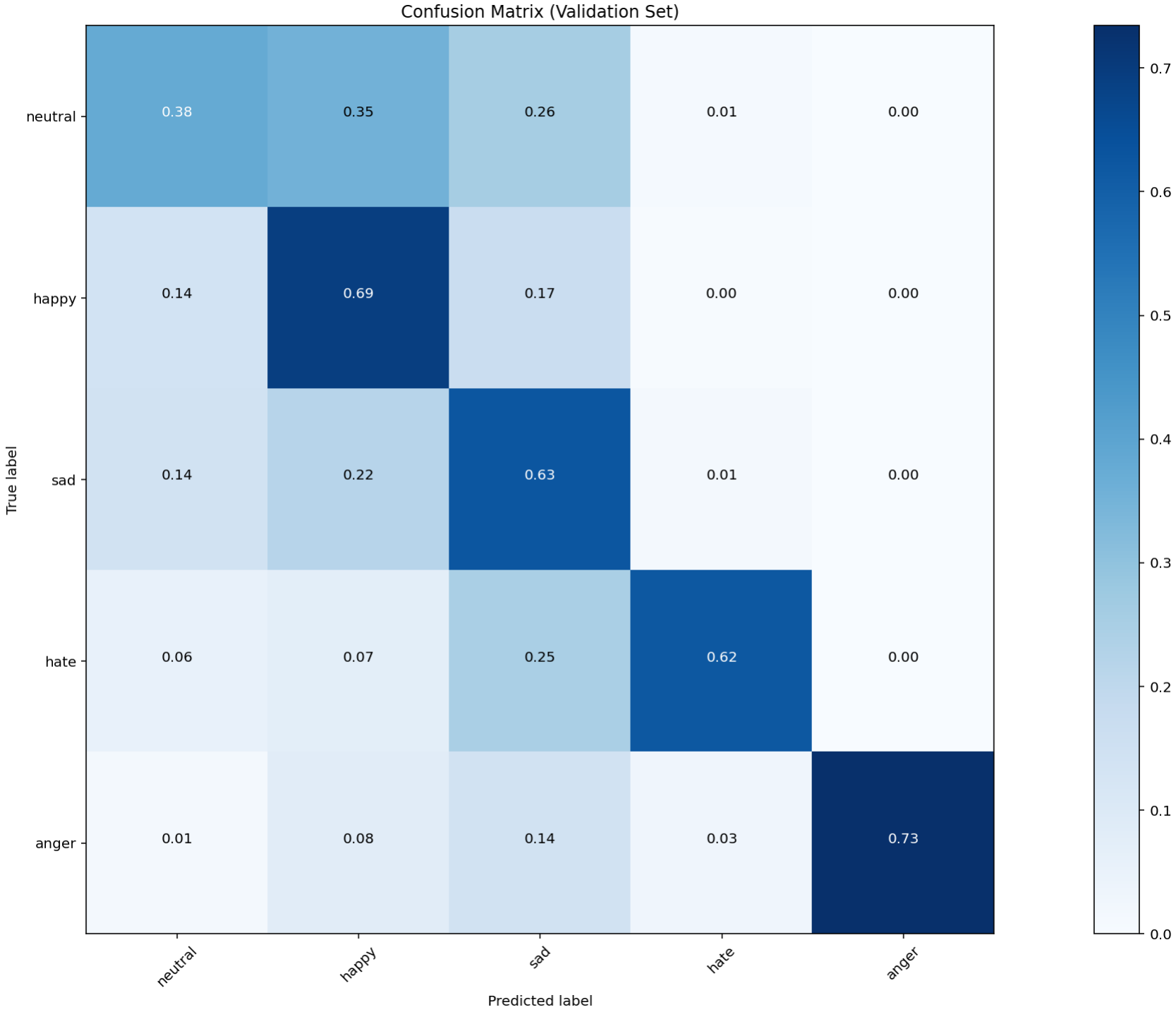
```
#model_test = load_model('checkpoint-0.866.h5')
#model_test = load_model('best_weights.h5')
Y_test = np.argmax(y_val, axis=1) # Convert one-hot to index
#y_pred = model_test.predict(x_val)
y_pred = model.predict(x_val)
y_pred_class = np.argmax(y_pred,axis=1)
cnf_matrix = confusion_matrix(Y_test, y_pred_class)
```

```
print(classification_report(Y_test, y_pred_class, target_names=classes))
```

```
              precision    recall  f1-score   support

     neutral       0.42      0.38      0.40      1844
       happy       0.61      0.69      0.65      3268
         sad       0.62      0.63      0.62      3245
        hate       0.88      0.62      0.73       878
       anger       0.95      0.73      0.83       222

    accuracy                           0.60      9457
   macro avg       0.69      0.61      0.65      9457
weighted avg       0.61      0.60      0.60      9457
```

```
def plot_confusion_matrix(cm, labels,
                          normalize=True,
                          title='Confusion Matrix (Validation Set)',
```

```
                          cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        #print("Normalized confusion matrix")
    else:
        #print('Confusion matrix, without normalization')
        pass

    #print(cm)

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(labels))
    plt.xticks(tick_marks, labels, rotation=45)
    plt.yticks(tick_marks, labels)

    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")

    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')

plt.figure(figsize=(20,10))
plot_confusion_matrix(cnf_matrix, labels=classes)

# precision = true_pos / (true_pos + false_pos)
# recall = true_pos / (true_pos + false_neg)
```




```
text = ["I salute you for the bravery and sacrifice! A true hero indeed.",
```

```
text = [ "I salute you for the bravery and sacrifice! A true hero indeed.",
         "I am sorry but I trust HRW I damned sight more than the PAP and it's cronies! Off course the PAP will say that th
         "PAP are taking the piss again!",
         "Thought he sold his kidney to buy it; Instead, he bought a kidney then bought the car Filthy rich This is why we
         "Somebody needs to water Tharman's head, hair needs to be grown there",
         "what a nuisance fk. a proper clean and flat footpath,,now obstructed by sharedbikes..! which idiotic MP allowed t
         "What baby bonus scheme ??? To grow up a kid in Singapore you think is easy now bo ??? Both parent need to work to
        ]


sequences_test = tokenizer.texts_to_sequences(text)
data_int_t = pad_sequences(sequences_test, padding='pre', maxlen=(MAX_SEQUENCE_LENGTH-5))
data_test = pad_sequences(data_int_t, padding='post', maxlen=(MAX_SEQUENCE_LENGTH))
y_prob = model.predict(data_test)
for n, prediction in enumerate(y_prob):
    pred = y_prob.argmax(axis=-1)[n]
    print(text[n],"\nPrediction:",classes[pred],"\n")
```

```
I salute you for the bravery and sacrifice! A true hero indeed.
Prediction: happy

I am sorry but I trust HRW I damned sight more than the PAP and it's cronies! Off course the PAP will say that they (HRW) made things up.
Prediction: sad

PAP are taking the piss again!
Prediction: neutral

Thought he sold his kidney to buy it; Instead, he bought a kidney then bought the car Filthy rich This is why we need communism
Prediction: sad

Somebody needs to water Tharman's head, hair needs to be grown there
Prediction: neutral

what a nuisance fk. a proper clean and flat footpath,,now obstructed by sharedbikes..! which idiotic MP allowed this to happen?
Prediction: sad

What baby bonus scheme ??? To grow up a kid in Singapore you think is easy now bo ??? Both parent need to work to grow up a kid until 21
Prediction: happy
```

```
np.array(sequences_test[0])
```

```
array([   1, 6097,    5,   12,    3,    6, 4841,    4,  515, 1476, 1238])
```

```
text = ["never talk to me again",
        "do not get angry or frustrated or desperate or enraged or depressed or any such thing you are all educated",
        "i hate worthless insights",
        "it is the worst day of my life",
        "i love you mom",
        "stop saying bullshit",
        "congratulations on your acceptance",
        "your stupidity has no limt",
        "sounds like a fun plan",
        "i will celebrate soon",
        "the game just finished",
        "you are so mean"]


sequences_test = tokenizer.texts_to_sequences(text)
data_int_t = pad_sequences(sequences_test, padding='pre', maxlen=(MAX_SEQUENCE_LENGTH-5))
data_test = pad_sequences(data_int_t, padding='post', maxlen=(MAX_SEQUENCE_LENGTH))
y_prob = model.predict(data_test)
for n, prediction in enumerate(y_prob):
    pred = y_prob.argmax(axis=-1)[n]
    print(text[n],"\nPrediction:",classes[pred],"\n")
```

never talk to me again
Prediction: neutral

do not get angry or frustrated or desperate or enraged or depressed or any such thing you are all educated
Prediction: anger

i hate worthless insights
Prediction: hate

it is the worst day of my life
Prediction: sad

i love you mom
Prediction: happy

stop saying bullshit
Prediction: sad

congratulations on your acceptance
Prediction: happy

your stupidity has no limt
Prediction: sad

sounds like a fun plan
Prediction: happy

i will celebrate soon
Prediction: happy

the game just finished
Prediction: happy

you are so mean
Prediction: neutral