CSCI 544- HOMEWORK 4
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NOTE: The jupyter notebooks have been executed on Google Colab, hence the path is w.r.t Colab. But the script called which uses the saved model to determine the output files uses data locally, so the dev, train and test data should be in the same folder as the scripts.

References:

https://yoseflaw.medium.com/step-by-step-ner-model-for-bahasa-indonesia-with-pytorch-and-torchtext-6f94fca08406
https://github.com/yoseflaw/nerindo

Task1: What are the precision, recall and F1 score on the dev data?
Answer:
accuracy: 96.04%; precision: 85.36%; recall: 76.62%; FB1: 80.76

Task2: What are the precision, recall and F1 score on the dev data?
Answer:
accuracy: 97.30%; precision: 84.33%; recall: 83.32%; FB1: 83.82

What are the precision, recall and F1 score on the dev data? (hint: the reasonable F1 score on dev is 88%.

Common Process (same for both tasks):

Data Preprocessing:

Training data:

1. The data is read, a new list is created which is basically a list of sentences (stored as list), and each element in the sentence is a tuple-including the word as well as the NER gold tag.
2. A VOCAB was created, which is a dictionary which stores the word and number of occurrences. Threshold was fixed as 3, so any word occurring less than 3 times was considered as <UNK>.
3. A word2idx file was created, which mapped each word to an index, 0 being for <PAD>(for padding) and 1 being for

<UNK>(unknown words. Rest of the indexes were done by iterating on a sorted VOCAB file.

4. A tag2idx was created, mapping the different tags with indexes. Like word2idx, 0 was allotted to <PAD> and then the tags were given the remaining 9 indexes.

Dev data:

1. The data is read, a new list is created which is basically a list of sentences (stored as list), and each element in the sentence is a tuple-including the word as well as the NER gold tag.

Test data:

1. The data is read, a new list is created which is basically a list of sentences (stored as list), and each element in the sentence is the word.

Training the Model:

A separate class NER is created for the training and evaluation purpose. The flow is :

train(): inside train, training accuracy and loss is calculated using the epoch() function, and dev loss and accuracy is calculated using evaluation() function. To determine the epoch timing, a separate function epoch_time() is called, which inputs the start and end time and gives the total time taken in seconds.

epoch(): This is the function to train the model. The only difference in the training of the model from previous homework flow is that the dimensions of the predicted tags and actual tags is changed a bit using view() to make it easier to pass through the loss and accuracy() function.

accuracy(): This functions inputs the predicted tags and actual tags in the same form as the loss function, uses argmax to find the index of maximum probability, not considering <PAD> indexes and then compares the tag value at that index with corresponding actual tag value to determine number of correct predictions.

evaluate(): This function is for evaluating the dev data, hence does not include the backward() and optimizer steps. Similar to training, the dimensions of predicted and actual tags are changed to pass to loss and accuracy function.

TASK 1:

Note: In the saved notebook, dev output format was for the conlleval file, so the dev file submitted was created by loading the saved model.

Data Set Creation:

1. Separate lists were created for labels and words, dividing the initial list for both DEV and TRAIN data.
2. A function[st_code()] was created to convert the words to numbers using word2idx created. It searches for the word and determines the corresponding word2idx value for the index. If the word is not found it uses 1 i.e index of <UNK>
3. An iterator was created to iterate through the list of lists and give the current sentence and label.
4. For the DataLoader, a collate function was created which does the following functions:
    a. Adds padding to the sentences using pad_sequence, so that the sentences are padded based on the maximum length of sentence batch wise.
    b. Similarly, adds padding to the labels
    c. Creates a list of length of the sentences in that batch.
5. The Shuffle is turned as False for dev and test so that the evaluation can be done.

Model:

The architecture is:

Embedding layer-> pack_padded_sequence->LSTM->
pad_packed_sequence->ELU->Linear->Classification

Input:

Sentence and sentence length(used for packing and unpacking the sequence)- this is obtained by the dataloader function- so whatever

the collate function returns, that is the input to the forward() function in the model.

Loss function: CrossEntropyLoss including ignore_index that ignores the index for<PAD>

Optimizer: SGD, learning rate=0.5

Scheduler: StepLR, step_size=3 and gamma=0.1

Hyperparameters:-

input_dim=len(word2idx): parameter for embedding layer
embedding_dim=100: parameter for embedding layer, LSTM layer
hidden_dim=256 : parameter for LSTM layer
num_labels = len(tag2idx) : parameter for final classifier (output dim)
output_dim=128: parameter for final classifier (input dim)
lstm_layers=1,
lstm_dropout=0.33,
word_pad_idx=word_pad_idx : padding index for embedding layer- 0

To maintain the desired dimension, the embedded sentences are packed based on the sentence lengths, and after obtaining the output of LSTM layer with the packed sequence, the sequence is unpacked and then sent to the ELU and then the linear layer following with the classifier.

Since the tags are imbalanced, weight is allotted to all the tags, and the respective weight for <PAD> is specified as zero.

After every epoch is finished, the model is evaluated on the dev and test data to obtain the tags to create the .out files. For this the list of list of words is considered, and is made into a tensor of list of list of indexes using word2idx. This list of tensor of sentences is padded batch wise and is then passed to the model, and then the index of best predicted tags are obtained, which with the help of idx2tag gives us the tag name. The tag name gets stored in a text file.

Now since data loader was not considered for creating prediction files, the length of the sentence also include padding. Therefore a new list of list was created for

DEV and TEST, which includes a tuple of (index in sentence, word, actual tag) as an element for each sentence. The lists for sentences in the predicted file are truncated based on the lengths of the sentences in the before mentioned DEV and TEST lists.

Using the actual list of tuples(with 3 elements each) and the predicted output, a file is created which includes the 3 elements form the tuple in case of DEV and the predicted file. This is used to check the F1 score with conll03eval.

TASK 2:

Data Set Creation:

1. Separate lists were created for labels and words, dividing the initial list for both DEV and TRAIN data.

2. An iterator was created which performs the following tasks:
    a. Create a list of Boolean masks for each sentence, where if the corresponding element in sentence(word) is capitalized, the value appended is 0 and if it is in lower 1 is appended.
    b. Get the sentence at a specific index, convert the sentence from list of strings to list of indexes using word2idx. It looks up the word and determines the corresponding word2idx value for the index. If the word is not found it uses 1 i.e index of <UNK>
    c. Get the list of labels at specific index and convert the sentence from list of strings to list of indexes using tag2idx.
3. For the DataLoader, a collate function was created which does the following functions:

a. Adds padding to the sentences using pad_sequence, so that the sentences are padded based on the maximum length of sentence batch wise.
b. Similarly, adds padding to the labels and the flags
c. Creates a list of length of the sentences in that batch.

4. The Shuffle is turned as False for dev and test so that the evaluation can be done.

The Gloveembeddings are read and an embedded matrix is created to send to embedding layer, which basically maps the word in word2idx with the glove embeddings. To deal with unknowns the mean array obtained from determining the mean of values of all words in glove at individual indexes is considered, and for pad it is an array of zeroes.

Model:

The architecture is:

Embedding layer-> concatenate embedded input with Boolean mask ->pack_padded_sequence->LSTM->pad_packed_sequence->ELU ->Linear->Classification

Input:

Sentence , sentence flags(Boolean mask added to embedded output) and sentence length(used for packing and unpacking the sequence)- this is obtained by the data loader function- so whatever the collate function returns, that is the input to the forward() function in the model.

Loss function: CrossEntropyLoss including ignore_index that ignores the index for<PAD>

Optimizer: SGD, learning rate=0.5

Scheduler: StepLR, step_size=1 and gamma=0.1

Hyperparameters:-

input_dim=len(word2idx): parameter for embedding layer
embedding_dim=101: parameter for embedding layer, LSTM layer
hidden_dim=256 : parameter for LSTM layer
num_labels = len(tag2idx) : parameter for final classifier (output dim)

output_dim=128: parameter for final classifier (input dim)
lstm_layers=1,
lstm_dropout=0.33,
word_pad_idx=word_pad_idx : padding index for embedding layer- 0

The working is similar to task 1, except the fact that instead of list of list of words, evaluation is done on outputs of loaders. Separate loaders for DEV and TEST are considered, predictions are obtained and then converted to string using dictionary. In this scenario, truncating output to remove padding is not required and it can be read directly.

HOMEWORK 4-Task1

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In [ ]:
```
import torch
import torch.nn as nn
import torch.optim as optim
import operator
from torch.utils.data import DataLoader
from torch.utils.data.dataset import Dataset
from torch.nn.utils.rnn import pad_sequence, pack_padded_sequence,pad_packed_se
import numpy as np
```

In [5]:
```
from google.colab import drive
drive.mount('/content/drive')
```

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

Train Data

In [6]:
```
# reading training data
training_data=[]
with open('/content/drive/MyDrive/Colab Notebooks/data/train', 'r') as readFile
        for inputs in readFile:
            inputs = inputs.rstrip()
            training_data.append(inputs.split(' '))

# create list of train tagged words
train_list=[]
for x in training_data:
    if len(x)>2:
        train_list.append([x[1],x[2]])
```

Find number of sentence

In [8]:
```
ct=0
for x in training_data:
    if len(x)>1:
        if x[0]=='1':
            ct=ct+1
ct
```

Out[8]:
```
14987
```

In [9]:
```
train_sentence_list=[]
st=[]
flag=0
for x in training_data:
    if len(x)>1:
            if x[0]=='1':
```

```
                flag=flag+1
                if flag == 1:
                    st=[]
                    st.append((x[1],x[2]))
                elif flag==14987:
                    print(flag)
                    train_sentence_list.append(st)
                    st=[]
                    st.append((x[1],x[2]))
                    train_sentence_list.append(st)
                    break
                else:
                    train_sentence_list.append(st)
                    st=[]
                    st.append((x[1],x[2]))
            else:
                st.append((x[1],x[2]))
```

```
14987
```

In [10]:
```
len(train_sentence_list)
```

Out[10]:
```
14987
```

In [11]:
```
train_sentence_list[-2:]
```

Out[11]:
```
[[('Swansea', 'B-ORG'), ('1', 'O'), ('Lincoln', 'B-ORG'), ('2', 'O')],
 [('-DOCSTART-', 'O')]]
```

Dev Data

In [12]:
```
# reading dev data
dev_data=[]
with open('/content/drive/MyDrive/Colab Notebooks/data/dev', 'r') as readFile:
        for inputs in readFile:
            inputs = inputs.rstrip()
            dev_data.append(inputs.split(' '))

dev_list=[]
for x in dev_data:
    if len(x)>1:
        dev_list.append((x[1],x[2]))
```

Find number of sentence

In [13]:
```
dev_ct=0
for x in dev_data:
    if len(x)>1:
        if x[0]=='1':
            dev_ct=dev_ct+1
dev_ct
```

Out[13]:
```
3466
```

In [14]:
```
dev_sentence_list=[]
dev_st=[]
dev_flag=0
```

```
for x in dev_data:
    if len(x)>1:
            if x[0]=='1':
                dev_flag=dev_flag+1
                if dev_flag == 1:
                    dev_st=[]
                    dev_st.append((x[1],x[2]))
                elif dev_flag==3466:
                    print(dev_flag)
                    dev_sentence_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[1],x[2]))
                    dev_sentence_list.append(dev_st)
                    break
                else:
                    dev_sentence_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[1],x[2]))
            else:
                dev_st.append((x[1],x[2]))
```

```
3466
```

In [15]:
```
len(dev_sentence_list)
```

Out[15]:
```
3466
```

Vocab creation

In [16]:
```
vocab_dict={}
count=0
for x in training_data:
    if len(x)>1:
        if x[1] in vocab_dict:
            temp=vocab_dict[x[1]]
            vocab_dict[x[1]]=temp+1
        else:
            vocab_dict[x[1]]=1

unk_c=0
unk_list=[]
for key in vocab_dict:
    if vocab_dict[key]<=2:
        unk_c=unk_c+vocab_dict[key]
        unk_list.append(key)
    else:
        continue
```

In [17]:
```
sorted_d1 = sorted(vocab_dict.items(), key=operator.itemgetter(1),reverse=True)

vocab_txt_file={}
ind2=1
vocab_txt_file[ind2]=('<UNK>',unk_c)

for i in sorted_d1:
    ind2=ind2+1
    if i[0] not in unk_list:
      x= i[0]
```

```
      y= i[1]
      vocab_txt_file[ind2]= (x,y)
    else:
      continue
```

Word2Idx Mapping

In [18]:
```
vocab_txt_file2={}
ind2=1
for i in sorted_d1:
    ind2=ind2+1
    x= i[0]
    y= i[1]
    vocab_txt_file2[ind2]= (x,y)
```

In [ ]:
```
# create a mapping from words to integers
word2idx= {word[0] : idx for idx, word in vocab_txt_file2.items()}
word2idx['<PAD>']= 0
word2idx['<UNK>']= 1
word2idx
```

In [21]:
```
len(word2idx)
```

Out[21]:
```
23626
```

Tag2Idx Mapping

In [22]:
```
tag_dict={}
count=0
for x in training_data:
    if len(x)>1:
        if x[2] in tag_dict:
            temp=tag_dict[x[2]]
            tag_dict[x[2]]=temp+1
        else:
            tag_dict[x[2]]=1
```

In [23]:
```
# create a mapping from tags to integers
tag2idx ={}
tag_ind=0
tag2idx['<PAD>']= tag_ind
for key, value in tag_dict.items():
        tag_ind=tag_ind+1
        tag2idx[key]=tag_ind
```

In [24]:
```
tag2idx
```

Out[24]:
```
{'<PAD>': 0,
 'B-ORG': 1,
 'O': 2,
 'B-MISC': 3,
 'B-PER': 4,
 'I-PER': 5,
 'B-LOC': 6,
 'I-ORG': 7,
 'I-MISC': 8,
 'I-LOC': 9}
```

Test data

In [25]:
```
idx2tag={}
for key, value in tag2idx.items():
    idx2tag[value]=key
```

In [26]:
```
# reading test data
test_data=[]
with open('/content/drive/MyDrive/Colab Notebooks/data/test', 'r') as readFile:
        for inputs in readFile:
            inputs = inputs.rstrip()
            test_data.append(inputs.split(' '))

test_list=[]
for x in test_data:
    if len(x)>1:
        test_list.append((x[0],x[1]))
```

In [27]:
```
tct=0
for x in test_data:
    if len(x)>1:
        if x[0]=='1':
            tct=tct+1
tct
```

Out[27]:
```
3684
```

In [28]:
```
test_sentence_list=[]
st_test=[]
flag_test=0
for x in test_data:
    if len(x)>1:
            if x[0]=='1':
                flag_test=flag_test+1
                if flag_test == 1:
                    st_test=[]
                    st_test.append((x[1]))
                elif flag_test==3684:
                    print(flag_test)
                    test_sentence_list.append(st_test)
                    st_test=[]
                    st_test.append((x[1]) )
                    test_sentence_list.append(st_test)
                    break
                else:
                    test_sentence_list.append(st_test)
                    st_test=[]
```

```
                    st_test.append((x[1]))
            else:
                st_test.append((x[1]))
```

```
3684
```

Data set creation

In [29]:
```
# sentences and labels
sentences_train = [[t[0] for t in sublst] for sublst in train_sentence_list]
labels_train = [[t[1] for t in sublst] for sublst in train_sentence_list]

sentences_dev = [[t[0] for t in sublst] for sublst in dev_sentence_list]
labels_dev = [[t[1] for t in sublst] for sublst in dev_sentence_list]
```

In [31]:
```
class creating_iterator(torch.utils.data.Dataset):

    def __init__(self,sentences, labels):
        self.sentences = sentences
        self.labels = labels

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

    def __getitem__(self, index):
        dataset = self.sentences[index]
        class_label  = self.labels[index]

        return dataset, class_label
```

In [32]:
```
def st_code(sentences, char2idx,flag=True):
    st_code_lt=[]
    for sentence in sentences:
        st=[]
        for char in sentence:
            if char in char2idx:
                st.append(char2idx[char])
            else:
                if flag:
                  st.append(1)
        st_code_lt.append(st)
    return st_code_lt
```

In [33]:
```
word2idx['<PAD>'],tag2idx['<PAD>']
```

Out[33]:
```
(0, 0)
```

In [34]:
```
converted_sentences_train = st_code(sentences_train, word2idx, flag=True)
converted_labels_train = st_code(labels_train, tag2idx, flag=False)
converted_sentences_dev = st_code(sentences_dev, word2idx, flag=True)
converted_labels_dev = st_code(labels_dev, tag2idx, flag=False)
```

In [35]:
```
train_dataset_fnn = creating_iterator(converted_sentences_train, converted_labe
test_dataset_fnn = creating_iterator(converted_sentences_dev, converted_labels_
```

In [36]:
```
batch_size=16
```

In [37]:
```
def collate_fn(batch):
    # Separate the sentences and labels in the batch
    sentences, labels = zip(*batch)

    # Pad the sentences with zeros using pad_sequence
    padded_sentences = pad_sequence([torch.LongTensor(sentence) for sentence ir

    # Pad the labels with zeros using pad_sequence
    padded_labels = pad_sequence([torch.LongTensor(label) for label in labels],

    # Calculate the sentence lengths
    sentence_lengths = torch.LongTensor([len(s) for s in sentences])

    return padded_sentences, padded_labels, sentence_lengths
```

In [38]:
```
# create PyTorch DataLoader objects for batching the data
train_loader = DataLoader(train_dataset_fnn, batch_size=batch_size, shuffle=Tru
dev_loader = DataLoader(test_dataset_fnn, batch_size=batch_size, shuffle=False,
```

Model

In [181…
```
tag_pad_idx=tag2idx['<PAD>']
word_pad_idx=word2idx['<PAD>']
```

In [182…
```
word_pad_idx
```

Out[182]:
```
0
```

In [183…
```
class BiLSTM(nn.Module):

  def __init__(self, input_dim, embedding_dim, hidden_dim, num_labels, lstm_lay
               emb_dropout, lstm_dropout, fc_dropout, word_pad_idx):
    super().__init__()
    self.embedding_dim = embedding_dim
    # LAYER 1: Embedding
    self.embedding = nn.Embedding(
        num_embeddings=input_dim,
        embedding_dim=embedding_dim,
        padding_idx=word_pad_idx
    )
    self.emb_dropout = nn.Dropout(emb_dropout)
    # LAYER 2: BiLSTM
    self.lstm = nn.LSTM(
        input_size=embedding_dim,
        hidden_size=hidden_dim,
        num_layers=lstm_layers,
        bidirectional=True,
        dropout=lstm_dropout if lstm_layers > 1 else 0
    )
    # LAYER 3: Fully-connected
    self.dropout3=nn.Dropout(lstm_dropout)
    self.elu = nn.ELU()
    self.fc = nn.Linear(hidden_dim * 2, output_dim)
    self.linear2=nn.Linear(output_dim,num_labels)

  def forward(self, sentence,sentence_lengths):
```

```
    embedded=self.embedding(sentence)

    # pack the sequences
    packed_embedded = pack_padded_sequence(embedded, sentence_lengths, batch_fi

    packed_output, (hidden, cell) = self.lstm(packed_embedded)

    # unpack the sequences
    output, output_lengths = pad_packed_sequence(packed_output, batch_first=Tru

    ner_out = self.fc(self.elu(output))
    out=self.linear2(ner_out)
    return out

  def init_weights(self):
    # to initialize all parameters from normal distribution
    # helps with converging during training
    for name, param in self.named_parameters():
      nn.init.normal_(param.data, mean=0, std=0.1)

  def init_embeddings(self, word_pad_idx):
    # initialize embedding for padding as zero
    self.embedding.weight.data[word_pad_idx] = torch.zeros(self.embedding_dim)

  def count_parameters(self):
    return sum(p.numel() for p in self.parameters() if p.requires_grad)
```

In [184…

```
bilstm = BiLSTM(
    input_dim=len(word2idx),
    embedding_dim=100,
    hidden_dim=256,
    num_labels = len(tag2idx),
    output_dim=128,
    lstm_layers=1,
    lstm_dropout=0.33,
    fc_dropout=0.25,
    emb_dropout=0.5,
    word_pad_idx=word_pad_idx
)
bilstm.init_weights()
bilstm.init_embeddings(word_pad_idx=word_pad_idx)
print(f"The model has {bilstm.count_parameters():,} trainable parameters.")
print(bilstm)
```

```
The model has 3,162,738 trainable parameters.
BiLSTM(
  (embedding): Embedding(23626, 100, padding_idx=0)
  (emb_dropout): Dropout(p=0.5, inplace=False)
  (lstm): LSTM(100, 256, bidirectional=True)
  (dropout3): Dropout(p=0.33, inplace=False)
  (elu): ELU(alpha=1.0)
  (fc): Linear(in_features=512, out_features=128, bias=True)
  (linear2): Linear(in_features=128, out_features=10, bias=True)
)
```

Determining dev and test lengths to past in evaluation of model to obtain predicted tags.

In [186…
```
dev_lengths=[]
for sent in dev_sentence_list:
    dev_lengths.append(len(sent))
```

In [187…
```
test_lengths=[]
for sent in test_sentence_list:
    test_lengths.append(len(sent))
```

Running

In [188…
```
from torch.optim.lr_scheduler import StepLR
```

In [189…
```
class NER(object):

  def __init__(self, model, train_loader, dev_loader,test_sentence_list,dev_ser
    self.model = model
    self.data_train = train_loader
    self.data_dev=dev_loader
    self.optimizer = optimizer_cls(model.parameters(),lr=0.5)
    #print('ignore', tag_pad_idx)
    self.loss_fn = loss_fn_cls(ignore_index=tag_pad_idx)
    self.scheduler = StepLR(self.optimizer, step_size=1, gamma=0.1)
    print(self.scheduler)


  @staticmethod
  def epoch_time(start_time, end_time):
    elapsed_time = end_time - start_time
    elapsed_mins = int(elapsed_time / 60)
    elapsed_secs = int(elapsed_time - (elapsed_mins * 60))
    return elapsed_mins, elapsed_secs

  def accuracy(self, preds, y):
    max_preds = preds.argmax(dim=1, keepdim=True)  # get the index of the max p
    # print("max_preds",max_preds)
    non_pad_elements = (y != tag_pad_idx).nonzero()  # prepare masking for padd
    # print("non_pad_elements",non_pad_elements)
    correct = max_preds[non_pad_elements].squeeze(1).eq(y[non_pad_elements])
    return correct.sum() / torch.FloatTensor([y[non_pad_elements].shape[0]])



  def epoch(self):
      epoch_loss = 0
      epoch_acc = 0
      self.model.train()
      for text, true_tags,sentence_lengths in self.data_train:
        #print(true_tags.shape) [torch.Size([64, 41])
        self.optimizer.zero_grad()
        pred_tags = self.model(text,sentence_lengths)
        #print(pred_tags.shape) [torch.Size([64, 41, 10])]
        pred_tags = pred_tags.view(-1, pred_tags.shape[-1])
        #print(pred_tags.shape) [torch.Size([2624, 10])]
        true_tags = true_tags.view(-1)
        # print(true_tags.shape) [torch.Size([2624])]
        batch_loss = self.loss_fn(pred_tags, true_tags)
        batch_acc = self.accuracy(pred_tags, true_tags)
```

```
        batch_loss.backward()
        self.optimizer.step()
        epoch_loss += batch_loss.item()
        epoch_acc += batch_acc.item()

        self.scheduler.step( epoch_loss / len(self.data_train))
        # print("Last LR", self.scheduler.get_last_lr())
    return epoch_loss / len(self.data_train), epoch_acc / len(self.data_trair

def evaluate(self):
    epoch_loss = 0
    epoch_acc = 0
    self.model.eval()
    with torch.no_grad():
        for text, true_tags,sentence_lengths in  self.data_dev:
            pred_tags = self.model(text,sentence_lengths)
            pred_tags = pred_tags.view(-1, pred_tags.shape[-1])
            true_tags = true_tags.view(-1)
            batch_loss = self.loss_fn(pred_tags, true_tags)
            batch_acc = self.accuracy(pred_tags, true_tags)
            epoch_loss += batch_loss.item()
            epoch_acc += batch_acc.item()
            self.scheduler.step(epoch_loss / len(self.data_dev))
    return epoch_loss / len( self.data_dev), epoch_acc / len( self.data_dev)

def train(self, n_epochs):
  valid_loss_min2 = np.Inf
  for epoch in range(n_epochs):
      start_time = time.time()
      train_loss, train_acc = self.epoch()
      end_time = time.time()
      epoch_mins, epoch_secs = NER.epoch_time(start_time, end_time)
      print(f"Epoch: {epoch + 1:02} | Epoch Time: {epoch_mins}m {epoch_secs}s
      print(f"\tTrn Loss: {train_loss:.3f} | Trn Acc: {train_acc * 100:.2f}%'
      val_loss, val_acc = self.evaluate()
      print(f"\tVal Loss: {val_loss:.3f} | Val Acc: {val_acc * 100:.2f}%")
      if val_loss<valid_loss_min2:
          torch.save(self.model, 'colab_collate_20_Copy10.pt')
          valid_loss_min2=val_loss

  dev_inputs = []
  for sentence in dev_sentence_list:
      input_ids = [word2idx.get(word[0], word2idx['<UNK>']) for word in sente
      dev_inputs.append(torch.tensor(input_ids)) # Add batch dimension

  dev_inputs = nn.utils.rnn.pad_sequence(dev_inputs, batch_first=True)

  # Run the inputs through the model to get predicted tag sequences
  ner.model.eval()
  with torch.no_grad():
      outputs_dev = ner.model(dev_inputs,dev_lengths)
  _, dev_predicted_tags = torch.max(outputs_dev, dim=2)


  # Convert the predicted tag sequences to string representations
  predictions_dev = []
  for sentence_tags in dev_predicted_tags:
      predicted_tags_list = [idx2tag[idx.item()] for idx in sentence_tags]
      predictions_dev.append(predicted_tags_list)
```

```
    # Save the predictions to a file
    with open('dev_pred1.txt', 'w') as f:
        for predicted_tags in predictions_dev:
            f.write(' '.join(predicted_tags) + '\n')


    inputs = []
    for sentence in test_sentence_list:
        input_ids = [word2idx.get(word, word2idx['<UNK>']) for word in sentence
        inputs.append(torch.tensor(input_ids)) # Add batch dimension

    inputs = nn.utils.rnn.pad_sequence(inputs, batch_first=True)

    # Run the inputs through the model to get predicted tag sequences
    ner.model.eval()
    with torch.no_grad():
        outputs = ner.model(inputs,test_lengths)
    _, predicted_tags = torch.max(outputs, dim=2)

    # Convert the predicted tag sequences to string representations
    predictions_test = []
    for sentence_tags in predicted_tags:
        predicted_tags_list = [idx2tag[idx.item()] for idx in sentence_tags]
        predictions_test.append(predicted_tags_list)

    # Save the predictions to a file
    with open('test_pred1.txt', 'w') as f:
        for predicted_tags in predictions_test:
            f.write(' '.join(predicted_tags) + '\n')
```

In [190…

```
import time
```

In [191…

```
%%time
# this will continue training if the model has been trained before.
# to restart training, run the bilstm creation cell (2 cells above) once again.
ner = NER(
  model=bilstm,
  train_loader=train_loader,
  dev_loader=dev_loader,
  optimizer_cls=optim.SGD,
  loss_fn_cls=nn.CrossEntropyLoss,
  test_sentence_list=test_sentence_list,
  dev_sentence_list=dev_sentence_list
)
ner.train(10)
```

```
<torch.optim.lr_scheduler.StepLR object at 0x7f5bf4f4f490>
Epoch: 01 | Epoch Time: 1m 32s
        Trn Loss: 0.574 | Trn Acc: 85.45%
        Val Loss: 0.398 | Val Acc: 88.68%
Epoch: 02 | Epoch Time: 1m 32s
        Trn Loss: 0.271 | Trn Acc: 92.14%
        Val Loss: 0.240 | Val Acc: 93.13%
Epoch: 03 | Epoch Time: 1m 30s
        Trn Loss: 0.155 | Trn Acc: 95.41%
        Val Loss: 0.197 | Val Acc: 94.64%
Epoch: 04 | Epoch Time: 1m 31s
        Trn Loss: 0.096 | Trn Acc: 97.27%
        Val Loss: 0.179 | Val Acc: 95.29%
Epoch: 05 | Epoch Time: 1m 31s
        Trn Loss: 0.060 | Trn Acc: 98.34%
        Val Loss: 0.178 | Val Acc: 95.68%
Epoch: 06 | Epoch Time: 1m 29s
        Trn Loss: 0.039 | Trn Acc: 98.95%
        Val Loss: 0.175 | Val Acc: 95.73%
Epoch: 07 | Epoch Time: 1m 30s
        Trn Loss: 0.028 | Trn Acc: 99.29%
        Val Loss: 0.195 | Val Acc: 95.16%
Epoch: 08 | Epoch Time: 1m 29s
        Trn Loss: 0.017 | Trn Acc: 99.56%
        Val Loss: 0.205 | Val Acc: 96.11%
Epoch: 09 | Epoch Time: 1m 31s
        Trn Loss: 0.012 | Trn Acc: 99.70%
        Val Loss: 0.223 | Val Acc: 96.06%
Epoch: 10 | Epoch Time: 1m 31s
        Trn Loss: 0.008 | Trn Acc: 99.82%
        Val Loss: 0.233 | Val Acc: 96.19%
CPU times: user 15min 53s, sys: 4.87 s, total: 15min 58s
Wall time: 16min 2s
```

Processing Dev Predictions to form .out file for submission and Score Check

The dev_pred file create above is called, and the data is appended in a list

In [192…
```
pred_dev=[]
with open('dev_pred1.txt', 'r') as readFile:
        for inputs in readFile:
            pred_dev.append(inputs.split(' '))
```

In [193…
```
len(pred_dev[2])
```

Out[193]:
```
109
```

A list of sentences is created using the dev data such that each sentence is a list whose individual elements store the index of the word in the sentence, the word and the tag from the dev file (basically all the info present in the file)

In [194…
```
dev_res_list=[]
dev_st=[]
dev_flag=0
for x in dev_data:
```

```
    if len(x)>1:
            if x[0]=='1':
                dev_flag=dev_flag+1
                if dev_flag == 1:
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                elif dev_flag==3466:
                    print(dev_flag)
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                    dev_res_list.append(dev_st)
                    break
                else:
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
            else:
                dev_st.append((x[0],x[1],x[2]))
```

```
3466
```

To create output file, the paddings are truncated from the output read from the DEV PRED file

In [195…

```
ik=0
tg=[]
for sent in pred_dev:
    th=[]
    lenk=0
    for jk in sent:
        if lenk<dev_lengths[ik]:
            th.append(jk)
            lenk=lenk+1
    tg.append(th)
    ik=ik+1
```

To calculate the F1 score, a file is created which includes the dev file data along with predicted tag per word.

In [ ]:

```
result_dict = {}
idx = 0
for i in range(len(dev_res_list)):
    for j in range(len(dev_res_list[i])):
        result_dict[idx] = (dev_res_list[i][j][0], dev_res_list[i][j][1],dev_re
        idx += 1

print(result_dict)
```

In [197…
```
start_i=0
with open("dev_pred_output.txt", 'w') as f:
    for key,i in result_dict.items() :
        if i[0] == '1' and start_i!=0:
            f.write('\n')
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
        else:
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
            start_i=start_i+1
```

In [198…
```
start_i=0
with open("dev_pred_output.out", 'w') as f:
    for key,i in result_dict.items() :
        if i[0] == '1' and start_i!=0:
            f.write('\n')
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
        else:
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
            start_i=start_i+1
```

Score Check using conll03eval

In [199…
```
!perl conll03eval < {'dev_pred_output.txt'}
```

```
processed 51578 tokens with 5942 phrases; found: 5334 phrases; correct: 4553.
accuracy:  96.04%; precision:  85.36%; recall:  76.62%; FB1:  80.76
              LOC: precision:  90.42%; recall:  83.23%; FB1:  86.68  1691
             MISC: precision:  86.00%; recall:  75.92%; FB1:  80.65  814
              ORG: precision:  80.14%; recall:  70.10%; FB1:  74.78  1173
              PER: precision:  83.57%; recall:  75.14%; FB1:  79.13  1656
```

Processing Test Predictions to form .out file for submission

A list of sentences is created using the test data such that each sentence is a list whose individual elements store the index of the word in the sentence and the word a (basically all the info present in the file)

In [200…
```
test_res_list=[]
st_test=[]
flag_test=0
for x in test_data:
    if len(x)>1:
            if x[0]=='1':
                flag_test=flag_test+1
                if flag_test == 1:
                    st_test=[]
                    st_test.append((x[0],x[1]))
                elif flag_test==3684:
                    print(flag_test)
                    test_res_list.append(st_test)
                    st_test=[]
                    st_test.append((x[0],x[1]) )
                    test_res_list.append(st_test)
                    break
                else:
                    test_res_list.append(st_test)
```

```
                    st_test=[]
                    st_test.append((x[0],x[1]))
            else:
                st_test.append((x[0],x[1]))
```

```
3684
```

The test_pred file create above is called, and the data is appended in a list

In [201…
```
pred_test=[]
with open('test_pred1.txt', 'r') as readFile:
        for inputs in readFile:
            pred_test.append(inputs.split(' '))
```

In [202…
```
len(pred_test[2])
```

Out[202]:
```
124
```

To create output file, the paddings are truncated from the output read from the TEST PRED file

In [203…
```
test_ik=0
test_tg=[]
for sent in pred_test:
    test_th=[]
    test_lenk=0
    for jk in sent:
        if test_lenk<test_lengths[test_ik]:
            test_th.append(jk)
            test_lenk=test_lenk+1
    test_tg.append(test_th)
    test_ik=test_ik+1
```

Output file is created which includes the dev file data along with predicted tag per word.

In [ ]:
```
test_dict = {}
test_idx = 0
for i in range(len(test_res_list)):
    for j in range(len(test_res_list[i])):
        test_dict[test_idx] = (test_res_list[i][j][0], test_res_list[i][j][1],
        test_idx += 1

print(test_dict)
```

In [205…
```
start_ie=0
with open("test1.txt", 'w') as f:
    for key,i in test_dict.items() :
        if i[0] == '1' and start_ie!=0:
            f.write('\n')
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
        else:
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
            start_ie=start_ie+1
```

In [206…
```
start_ie=0
with open("test1.out", 'w') as f:
    for key,i in test_dict.items() :
        if i[0] == '1' and start_ie!=0:
            f.write('\n')
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
        else:
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
            start_ie=start_ie+1
```

SAVING MODEL FOR SUBMISSION

In [208…
```
torch.save(ner.model,'blstm1.pt')
```

Reloading Saved Model to verify that the correct model is saved and it reciprocates the actual result

In [209…
```
### SAVED MODEL
```

In [210…
```
# Load the model
modelw = torch.load("blstm1.pt")

dev_inputs = []
for sentence in dev_sentence_list:
    input_ids = [word2idx.get(word[0], word2idx['<UNK>']) for word in sentence]
    dev_inputs.append(torch.tensor(input_ids)) # Add batch dimension

dev_inputs = nn.utils.rnn.pad_sequence(dev_inputs, batch_first=True)

# Run the inputs through the model to get predicted tag sequences
modelw.eval()
with torch.no_grad():
    outputs_dev = modelw(dev_inputs,dev_lengths)
_, dev_predicted_tags = torch.max(outputs_dev, dim=2)


# Convert the predicted tag sequences to string representations
predictions_dev = []
for sentence_tags in dev_predicted_tags:
    predicted_tags_list = [idx2tag[idx.item()] for idx in sentence_tags]
    predictions_dev.append(predicted_tags_list)

# Save the predictions to a file
with open('dev_check1.txt', 'w') as f:
    for predicted_tags in predictions_dev:
        f.write(' '.join(predicted_tags) + '\n')


inputs = []
for sentence in test_sentence_list:
    input_ids = [word2idx.get(word, word2idx['<UNK>']) for word in sentence]
    inputs.append(torch.tensor(input_ids)) # Add batch dimension

inputs = nn.utils.rnn.pad_sequence(inputs, batch_first=True)

# Run the inputs through the model to get predicted tag sequences
```

```
modelw.eval()
with torch.no_grad():
    outputs = modelw(inputs,test_lengths)
_, predicted_tags = torch.max(outputs, dim=2)

# Convert the predicted tag sequences to string representations
predictions_test = []
for sentence_tags in predicted_tags:
    predicted_tags_list = [idx2tag[idx.item()] for idx in sentence_tags]
    predictions_test.append(predicted_tags_list)

# Save the predictions to a file
with open('test_check1.txt', 'w') as f:
    for predicted_tags in predictions_test:
        f.write(' '.join(predicted_tags) + '\n')
```

Processing Dev Predictions using LOADED MODEL to form .out file for submission and Score Check

In [211…
```
pred_dev_trial=[]
with open('dev_check1.txt', 'r') as readFile:
        for inputs in readFile:
            pred_dev_trial.append(inputs.split(' '))
```

In [212…
```
len(pred_dev_trial[2])
```

Out[212]:
```
109
```

In [213…
```
dev_res_list=[]
dev_st=[]
dev_flag=0
for x in dev_data:
    if len(x)>1:
            if x[0]=='1':
                dev_flag=dev_flag+1
                if dev_flag == 1:
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                elif dev_flag==3466:
                    print(dev_flag)
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                    dev_res_list.append(dev_st)
                    break
                else:
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
            else:
                dev_st.append((x[0],x[1],x[2]))
```

```
3466
```

In [214…
```
ikdev_trial=0
tgdev_trial=[]
for sent in pred_dev_trial:
    th=[]
```

```
    lenk=0
    for jk in sent:
        if lenk<dev_lengths[ikdev_trial]:
            th.append(jk)
            lenk=lenk+1
    tgdev_trial.append(th)
    ikdev_trial=ikdev_trial+1
```

In [ ]:
```
result_dictdev_trial = {}
idxdev_trial = 0
for i in range(len(dev_res_list)):
    for j in range(len(dev_res_list[i])):
        result_dictdev_trial[idxdev_trial] = (dev_res_list[i][j][0], dev_res_li
        idxdev_trial += 1

print(result_dictdev_trial)
```

In [216…
```
start_idev_trial=0
with open("dev_check1_output.txt", 'w') as f:
    for key,i in result_dictdev_trial.items() :
        if i[0] == '1' and start_idev_trial!=0:
            f.write('\n')
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
        else:
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
            start_idev_trial=start_idev_trial+1
```

In [217…
```
!perl conll03eval < {'dev_check1_output.txt'}
```

```
processed 51578 tokens with 5942 phrases; found: 5334 phrases; correct: 4553.
accuracy:  96.04%; precision:  85.36%; recall:  76.62%; FB1:  80.76
              LOC: precision:  90.42%; recall:  83.23%; FB1:  86.68  1691
             MISC: precision:  86.00%; recall:  75.92%; FB1:  80.65  814
              ORG: precision:  80.14%; recall:  70.10%; FB1:  74.78  1173
              PER: precision:  83.57%; recall:  75.14%; FB1:  79.13  1656
```

In [75]:
```
```

HOMEWORK 4-Task2

NAME: Asmita Chotani
USC ID: 3961468036

In [1]:
```
import torch
import torch.nn as nn
import torch.optim as optim
import operator
from torch.utils.data import DataLoader
from torch.utils.data.dataset import Dataset
from torch.nn.utils.rnn import pad_sequence, pack_padded_sequence,pad_packed_se
import numpy as np
```

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

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

In [3]:
```
import time
```

Train Data

In [4]:
```
# reading training data
training_data=[]
with open('/content/drive/MyDrive/Colab Notebooks/data/train', 'r') as readFile
        for inputs in readFile:
            inputs = inputs.rstrip()
            training_data.append(inputs.split(' '))

# create list of train tagged words
train_list=[]
for x in training_data:
    if len(x)>2:
        train_list.append([x[1],x[2]])
```

Find number of sentence

In [6]:
```
ct=0
for x in training_data:
    if len(x)>1:
        if x[0]=='1':
            ct=ct+1
ct
```

Out[6]:
```
14987
```

In [7]:
```
train_sentence_list=[]
st=[]
flag=0
```

```
for x in training_data:
    if len(x)>1:
            if x[0]=='1':
                flag=flag+1
                if flag == 1:
                    st=[]
                    st.append((x[1],x[2]))
                elif flag==14987:
                    print(flag)
                    train_sentence_list.append(st)
                    st=[]
                    st.append((x[1],x[2]))
                    train_sentence_list.append(st)
                    break
                else:
                    train_sentence_list.append(st)
                    st=[]
                    st.append((x[1],x[2]))
            else:
                st.append((x[1],x[2]))
```

```
14987
```

In [8]:
```
len(train_sentence_list)
```

Out[8]:
```
14987
```

In [9]:
```
train_sentence_list[-2:]
```

Out[9]:
```
[[('Swansea', 'B-ORG'), ('1', 'O'), ('Lincoln', 'B-ORG'), ('2', 'O')],
 [('-DOCSTART-', 'O')]]
```

Dev Data

In [10]:
```
# reading dev data
dev_data=[]
with open('/content/drive/MyDrive/Colab Notebooks/data/dev', 'r') as readFile:
        for inputs in readFile:
            inputs = inputs.rstrip()
            dev_data.append(inputs.split(' '))

dev_list=[]
for x in dev_data:
    if len(x)>1:
        dev_list.append((x[1],x[2]))
```

Find number of sentence

In [11]:
```
dev_ct=0
for x in dev_data:
    if len(x)>1:
        if x[0]=='1':
            dev_ct=dev_ct+1
dev_ct
```

Out[11]:
```
3466
```

In [12]:
```
dev_sentence_list=[]
dev_st=[]
dev_flag=0
for x in dev_data:
    if len(x)>1:
            if x[0]=='1':
                dev_flag=dev_flag+1
                if dev_flag == 1:
                    dev_st=[]
                    dev_st.append((x[1],x[2]))
                elif dev_flag==3466:
                    print(dev_flag)
                    dev_sentence_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[1],x[2]))
                    dev_sentence_list.append(dev_st)
                    break
                else:
                    dev_sentence_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[1],x[2]))
            else:
                dev_st.append((x[1],x[2]))
```

```
3466
```

In [13]:
```
len(dev_sentence_list)
```

Out[13]:
```
3466
```

Vocab creation

In [14]:
```
vocab_dict={}
count=0
for x in training_data:
    if len(x)>1:
        if x[1] in vocab_dict:
            temp=vocab_dict[x[1]]
            vocab_dict[x[1]]=temp+1
        else:
            vocab_dict[x[1]]=1

unk_c=0
unk_list=[]
for key in vocab_dict:
    if vocab_dict[key]<=2:
        unk_c=unk_c+vocab_dict[key]
        unk_list.append(key)
    else:
        continue
```

In [15]:
```
sorted_d1 = sorted(vocab_dict.items(), key=operator.itemgetter(1),reverse=True)

vocab_txt_file={}
ind2=1
vocab_txt_file[ind2]=('<UNK>',unk_c)

for i in sorted_d1:
```

```
    ind2=ind2+1
    if i[0] not in unk_list:
      x= i[0]
      y= i[1]
      vocab_txt_file[ind2]= (x,y)
    else:
      continue
```

Word2Idx Mapping

In [16]:
```
vocab_txt_file2={}
ind2=1
for i in sorted_d1:
    ind2=ind2+1
    x= i[0]
    y= i[1]
    vocab_txt_file2[ind2]= (x,y)
```

In [ ]:
```
# create a mapping from words to integers
word2idx= {word[0] : idx for idx, word in vocab_txt_file2.items()}
word2idx['<PAD>']= 0
word2idx['<UNK>']= 1
```

In [19]:
```
len(word2idx)
```

Out[19]:
```
23626
```

Tag2Idx Mapping

In [20]:
```
tag_dict={}
count=0
for x in training_data:
    if len(x)>1:
        if x[2] in tag_dict:
            temp=tag_dict[x[2]]
            tag_dict[x[2]]=temp+1
        else:
            tag_dict[x[2]]=1
```

In [21]:
```
# create a mapping from tags to integers
tag2idx ={}
tag_ind=0
tag2idx['<PAD>']= tag_ind
for key, value in tag_dict.items():
        tag_ind=tag_ind+1
        tag2idx[key]=tag_ind
```

In [22]:
```
tag2idx
```

Out[22]:
```
{'<PAD>': 0,
 'B-ORG': 1,
 'O': 2,
 'B-MISC': 3,
 'B-PER': 4,
 'I-PER': 5,
 'B-LOC': 6,
 'I-ORG': 7,
 'I-MISC': 8,
 'I-LOC': 9}
```

Test data

In [23]:
```
idx2tag={}
for key, value in tag2idx.items():
    idx2tag[value]=key
```

In [24]:
```
# reading test data
test_data=[]
with open('/content/drive/MyDrive/Colab Notebooks/data/test', 'r') as readFile:
        for inputs in readFile:
            inputs = inputs.rstrip()
            test_data.append(inputs.split(' '))

test_list=[]
for x in test_data:
    if len(x)>1:
        test_list.append((x[0],x[1]))
```

In [25]:
```
tct=0
for x in test_data:
    if len(x)>1:
        if x[0]=='1':
            tct=tct+1
tct
```

Out[25]:
```
3684
```

In [26]:
```
test_sentence_list=[]
st_test=[]
flag_test=0
for x in test_data:
    if len(x)>1:
            if x[0]=='1':
                flag_test=flag_test+1
                if flag_test == 1:
                    st_test=[]
                    st_test.append((x[1]))
                elif flag_test==3684:
                    print(flag_test)
                    test_sentence_list.append(st_test)
                    st_test=[]
                    st_test.append((x[1]) )
                    test_sentence_list.append(st_test)
                    break
                else:
                    test_sentence_list.append(st_test)
                    st_test=[]
```

```
                    st_test.append((x[1]))
            else:
                st_test.append((x[1]))
```

```
3684
```

In [26]:

GloVE Embeddings

In [27]:
```
# Load the GloVe word embeddings
gloveembeddings_index = {}
with open("/content/drive/MyDrive/Colab Notebooks/data/glove.6B.100d", 'r', enc
    for line in f:
        values = line.split()
        word = values[0]
        coefs = np.asarray(values[1:],dtype='float32')
        gloveembeddings_index[word] = coefs
```

Finding a mean array- array with mean of values at that index(considering all words)

In [28]:
```
a = np.array(list(gloveembeddings_index.values()))
# calculate the mean of the array along axis 0 (i.e., column-wise)
mean_array = np.mean(a, axis=0)
mean_array
```

Out[28]:
```
array([ 0.05209883, -0.09711445, -0.1380765 ,  0.11075345, -0.02722748,
       -0.00326409,  0.03176443, -0.05076874,  0.15321693, -0.02367382,
       -0.0078552 ,  0.08436131, -0.08042031, -0.08836847, -0.01713637,
        0.07352565, -0.16472325,  0.05473585,  0.15367231, -0.05284015,
       -0.16474274, -0.00894895, -0.13604094, -0.03889371, -0.09204532,
        0.02874651,  0.02445944,  0.19419461, -0.03297978,  0.00509352,
        0.0146906 , -0.1554301 ,  0.03542742, -0.02936257,  0.01372886,
       -0.0606757 ,  0.02025392, -0.14560148,  0.05823914,  0.01729455,
        0.16282158,  0.18634756, -0.06337869,  0.1306742 , -0.11122588,
        0.0272168 ,  0.03868013,  0.15675613,  0.01344932,  0.1942456 ,
       -0.01218801,  0.03659216, -0.08235365, -0.24420363,  0.07523726,
        0.46423653,  0.06318451,  0.0508127 , -0.38147202, -0.20739552,
        0.03489431, -0.18234783,  0.09021272, -0.02504168, -0.22256528,
        0.03382994, -0.13379364, -0.14375682, -0.11264054, -0.03744001,
        0.06188852,  0.09650661,  0.08384212,  0.1964642 , -0.07446123,
        0.00921882,  0.03034359, -0.02482695,  0.27563572,  0.02422197,
       -0.23416583, -0.0523523 ,  0.10200828, -0.03673672,  0.2940292 ,
        0.05685116,  0.01759575,  0.07998175, -0.07554322,  0.14788596,
        0.01690632,  0.07576851,  0.07596124, -0.10800065,  0.20829839,
       -0.07841395,  0.08663727,  0.12381283, -0.23434106, -0.00925518],
      dtype=float32)
```

In [29]:
```
word2idx['<PAD>']
```

Out[29]:
```
0
```

In [30]:
```
gloveembeddings_index['<UNK>']=mean_array
gloveembeddings_index['<PAD>']=np.zeros(100)
```

In [31]:
```
embedding_dim = 100
embedding_matrix = torch.zeros(len(word2idx), embedding_dim)

for word, i in word2idx.items():

    if word.lower() in gloveembeddings_index:
        gl_arr=gloveembeddings_index.get(word.lower())
    else:
        # use a separate vector for unknown words
        gl_arr=mean_array

    embedding_vector = torch.tensor([float(val) for val in gl_arr])
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector
```

In [32]:
```
embedding_matrix[-1]
```

Out[32]:
```
tensor([ 1.6726e-01,  1.4320e-01, -1.2082e-01, -7.8781e-02, -1.7077e-01,
        -9.3653e-01,  5.8246e-01, -6.2791e-01, -1.9830e-01, -7.5090e-02,
         2.5395e-01, -4.6827e-01, -3.2224e-01,  5.9827e-02, -1.4065e-01,
        -9.3421e-01,  5.2194e-01,  5.6817e-01, -4.3139e-02,  5.4231e-01,
         1.1159e-01, -9.4118e-02,  3.3264e-01,  4.5098e-02,  1.1834e-02,
         2.1319e-01, -2.7672e-01,  2.5103e-01, -3.0275e-01,  2.8093e-01,
        -1.0180e-01,  8.2269e-01, -1.1770e-01, -4.7092e-01,  6.5125e-03,
         1.0679e-01, -1.6053e-03,  6.6219e-01, -5.1579e-01,  1.0093e-02,
        -1.4211e-01,  1.2317e-01, -2.5549e-01,  3.2337e-01, -5.6766e-02,
         4.5298e-01, -3.0577e-01, -3.5621e-01,  6.0563e-01, -4.2232e-01,
         7.7133e-01, -1.4756e-01,  5.3443e-01,  3.1634e-02,  4.0789e-01,
        -1.7314e+00, -2.7442e-01,  3.9674e-02,  1.0830e-01,  5.9719e-01,
         4.5612e-01,  1.0674e-01,  4.0332e-01,  2.5917e-01, -1.3672e-01,
        -1.1555e-01,  8.3351e-01,  1.1184e+00, -6.1635e-01,  8.3756e-01,
        -4.1139e-01,  5.7142e-01, -2.2588e-01, -2.3991e-01,  3.6087e-02,
        -2.1587e-01,  2.1814e-01,  5.2343e-01, -6.5846e-01, -2.3907e-02,
         2.0842e-01,  1.9192e-01,  3.2933e-02, -1.5500e-01, -6.0777e-01,
        -3.8761e-01,  7.2386e-02,  3.0557e-01,  4.8542e-01, -2.2670e-01,
         2.0055e-01,  1.6957e-02,  3.2667e-01,  1.1048e-01, -4.0344e-01,
         1.8371e-01, -8.5615e-02,  3.3737e-01, -7.3411e-01, -1.2241e-01])
```

In [33]:
```
embedding_matrix.shape
```

Out[33]:
```
torch.Size([23626, 100])
```

Data set creation

In [35]:
```
# sentences and labels
sentences_train = [[t[0] for t in sublst] for sublst in train_sentence_list]
labels_train = [[t[1] for t in sublst] for sublst in train_sentence_list]

sentences_dev = [[t[0] for t in sublst] for sublst in dev_sentence_list]
labels_dev = [[t[1] for t in sublst] for sublst in dev_sentence_list]
```

In [36]:
```
sentences_test = [[t[0] for t in sublst] for sublst in test_sentence_list]
```

In [37]:
```
sentences_train[:4]
```

Out[37]:
```
[['EU', 'rejects', 'German', 'call', 'to', 'boycott', 'British', 'lamb', '.'],
 ['Peter', 'Blackburn'],
 ['BRUSSELS', '1996-08-22'],
 ['The',
  'European',
  'Commission',
  'said',
  'on',
  'Thursday',
  'it',
  'disagreed',
  'with',
  'German',
  'advice',
  'to',
  'consumers',
  'to',
  'shun',
  'British',
  'lamb',
  'until',
  'scientists',
  'determine',
  'whether',
  'mad',
  'cow',
  'disease',
  'can',
  'be',
  'transmitted',
  'to',
  'sheep',
  '.']]
```

In [38]:
```
tag2idx
```

Out[38]:
```
{'<PAD>': 0,
 'B-ORG': 1,
 'O': 2,
 'B-MISC': 3,
 'B-PER': 4,
 'I-PER': 5,
 'B-LOC': 6,
 'I-ORG': 7,
 'I-MISC': 8,
 'I-LOC': 9}
```

Iterator for Train and Dev data- converts words to numbers, converts tags to numbers using index dictionaries created and creates a list of booolean mask per word in the sentences

In [39]:
```
class creating_iterator(torch.utils.data.Dataset):
    def __init__(self, sentences, labels, word2idx, tag2idx):
        self.sentences = sentences
        self.labels = labels
        self.word2idx = word2idx
        self.tag2idx = tag2idx

    def __len__(self):
```

```
        return len(self.sentences)

    def __getitem__(self, idx):
        sentence = self.sentences[idx]
        class_label  = self.labels[idx]

        # Create a list of boolean flags where 1 corresponds to lowercase and (
        sentence_flags = []
        for word in sentence:
          if word.lower()==word:
            sentence_flags.append(1)
          else:
            sentence_flags.append(0)

        # Convert the words to their corresponding indices using word2idx

        converted_sentence = [self.word2idx.get(word, self.word2idx['<UNK>']) f

        # Convert the labels to their corresponding indices using word2idx
        converted_labels = [self.tag2idx.get(tag, 0) for tag in class_label]


        return converted_sentence, converted_labels, sentence_flags
```

In [40]:
```
train_dataset_fnn = creating_iterator(sentences_train, labels_train, word2idx,
dev_dataset_fnn = creating_iterator(sentences_dev, labels_dev, word2idx, tag2ic
```

In [41]:
```
batch_size=16
```

collate function used to pad the sentences, corresponding labels and boolean masks. I also calculates length of the sentences to be used in pack_padded in future.

In [42]:
```
def collate_fn(batch):
    # Separate the sentences and labels in the batch
    sentences, labels, flags = zip(*batch)

    # Pad the sentences with zeros using pad_sequence
    padded_sentences = pad_sequence([torch.LongTensor(sentence) for sentence in

    # Pad the labels with zeros using pad_sequence
    padded_labels = pad_sequence([torch.LongTensor(label) for label in labels],

    # Calculate the sentence lengths
    sentence_lengths = torch.LongTensor([len(s) for s in sentences])

    sent_flags=pad_sequence([torch.LongTensor(flag) for flag in flags], batch_f


    return padded_sentences, padded_labels, sentence_lengths, sent_flags
```

In [43]:
```
# create PyTorch DataLoader objects for batching the data
train_loader = DataLoader(train_dataset_fnn, batch_size=batch_size, shuffle=Tru
dev_loader = DataLoader(dev_dataset_fnn, batch_size=batch_size, shuffle=False,
```

Similar iterator and collate functions for test, which does not include label related tasks and data

In [44]:
```
class test_creating_iterator(torch.utils.data.Dataset):
    def __init__(self, sentences,word2idx):
        self.sentences = sentences
        self.word2idx = word2idx

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

    def __getitem__(self, idx):
        sentence = self.sentences[idx]

        # Create a list of boolean flags where 1 corresponds to lowercase and (
        sentence_flags = []
        for word in sentence:
          if word.lower()==word:
            sentence_flags.append(1)
          else:
            sentence_flags.append(0)

        # Convert the words to their corresponding indices using word2idx
        converted_sentence = [self.word2idx.get(word, self.word2idx['<UNK>']) f

        return converted_sentence,sentence_flags
```

In [45]:
```
def test_collate_fn(batch):
    # Separate the sentences and labels in the batch
    sentences, flags = zip(*batch)

    # Pad the sentences with zeros using pad_sequence
    padded_sentences = pad_sequence([torch.LongTensor(sentence) for sentence in

    # Calculate the sentence lengths
    sentence_lengths = torch.LongTensor([len(s) for s in sentences])

    sent_flags=pad_sequence([torch.LongTensor(flag) for flag in flags], batch_f


    return padded_sentences, sentence_lengths, sent_flags
```

In [46]:
```
test_dataset_fnn=test_creating_iterator(sentences_test,word2idx)
test_loader = DataLoader(test_dataset_fnn, batch_size=batch_size, shuffle=False
```

In [47]:
```
len(test_dataset_fnn)
```

Out[47]:
```
3684
```

Model

In [84]:
```
tag_pad_idx=tag2idx['<PAD>']
word_pad_idx=word2idx['<PAD>']
```

In [85]:
```
word_pad_idx
```

Out[85]:
```
0
```

In [86]:
```
class Glove_EmbedLSTM(nn.Module):

  def __init__(self, input_dim, embedding_dim, hidden_dim, num_labels, lstm_lay
               emb_dropout, lstm_dropout, fc_dropout, word_pad_idx,pretrained_e
    super().__init__()
    self.embedding_dim = embedding_dim
    # LAYER 1: Embedding
    self.embedding=nn.Embedding.from_pretrained(pretrained_embed, freeze = Fals

    self.emb_dropout = nn.Dropout(emb_dropout)
    # LAYER 2: BiLSTM
    self.lstm = nn.LSTM(
        input_size=101,
        hidden_size=hidden_dim,
        num_layers=lstm_layers,
        bidirectional=True,
        dropout=lstm_dropout if lstm_layers > 1 else 0
    )
    # LAYER 3: Fully-connected

    self.dropout3=nn.Dropout(lstm_dropout)
    self.elu = nn.ELU()
    self.fc = nn.Linear(hidden_dim * 2, output_dim)
    self.linear2=nn.Linear(output_dim,num_labels)

  def forward(self, sentence, sentence_lengths, sentence_flags):
    # Get the embeddings for the sentence
    embedded = self.embedding(sentence)
    # print(embedded.shape)
    concatenated_tensor = torch.cat((embedded, sentence_flags.unsqueeze(-1)), c
    # print(concatenated_tensor.shape)
    # Pack the sequences
    packed_embedded = pack_padded_sequence(concatenated_tensor, sentence_length
    # print(packed_embedded.data.shape)
    packed_output, (hidden, cell) = self.lstm(packed_embedded)
    # print(packed_output.data.shape)
    # Unpack the sequences
    output, output_lengths = pad_packed_sequence(packed_output, batch_first=Tru
    # print(packed_output.data.shape)
    ner_out = self.fc(self.elu(output))
    out = self.linear2(ner_out)

    return out

  def init_weights(self):
    # to initialize all parameters from normal distribution
    # helps with converging during training
    for name, param in self.named_parameters():
      nn.init.normal_(param.data, mean=0, std=0.1)

  # def init_embeddings(self, word_pad_idx):
  #   # initialize embedding for padding as zero
  #   self.embedding.weight.data[word_pad_idx] = torch.zeros(self.embedding_dim

  def count_parameters(self):
    return sum(p.numel() for p in self.parameters() if p.requires_grad)
```

In [87]:
```
Gbilstm = Glove_EmbedLSTM(
    input_dim=len(word2idx),
```

```
    embedding_dim=100,
    hidden_dim=256,
    num_labels = len(tag2idx),
    output_dim=128,
    lstm_layers=1,
    lstm_dropout=0.33,
    fc_dropout=0.25,
    emb_dropout=0.5,
    word_pad_idx=word_pad_idx,
    pretrained_embed = embedding_matrix
)
Gbilstm.init_weights()
# Gbilstm.init_embeddings(word_pad_idx=word_pad_idx)
print(f"The model has {Gbilstm.count_parameters():,} trainable parameters.")
print(Gbilstm)
```

```
The model has 3,164,786 trainable parameters.
Glove_EmbedLSTM(
  (embedding): Embedding(23626, 100)
  (emb_dropout): Dropout(p=0.5, inplace=False)
  (lstm): LSTM(101, 256, bidirectional=True)
  (dropout3): Dropout(p=0.33, inplace=False)
  (elu): ELU(alpha=1.0)
  (fc): Linear(in_features=512, out_features=128, bias=True)
  (linear2): Linear(in_features=128, out_features=10, bias=True)
)
```

In [88]:
```
dev_lengths=[]
for sent in dev_sentence_list:
    dev_lengths.append(len(sent))
```

In [89]:
```
test_lengths=[]
for sent in test_sentence_list:
    test_lengths.append(len(sent))
```

Running

In [90]:
```
from torch.optim.lr_scheduler import StepLR
```

In [91]:
```
class NER(object):

  def __init__(self, model, train_loader,test_loader, dev_loader,test_sentence_
    self.model = model
    self.data_train = train_loader
    self.data_dev=dev_loader
    self.data_test=test_loader
    self.optimizer = optimizer_cls(model.parameters(),lr=0.5)
    #print('ignore', tag_pad_idx)
    self.loss_fn = nn.CrossEntropyLoss(ignore_index=0)
    self.scheduler = StepLR(self.optimizer, step_size=3, gamma=0.1)
    print(self.scheduler)


  @staticmethod
  def epoch_time(start_time, end_time):
    elapsed_time = end_time - start_time
    elapsed_mins = int(elapsed_time / 60)
    elapsed_secs = int(elapsed_time - (elapsed_mins * 60))
```

```
    return elapsed_mins, elapsed_secs

  def accuracy(self, preds, y):
    max_preds = preds.argmax(dim=1, keepdim=True)  # get the index of the max p
    # print("max_preds",max_preds)
    non_pad_elements = (y != tag_pad_idx).nonzero()  # prepare masking for padd
    # print("non_pad_elements",non_pad_elements)
    correct = max_preds[non_pad_elements].squeeze(1).eq(y[non_pad_elements])
    return correct.sum() / torch.FloatTensor([y[non_pad_elements].shape[0]])



  def epoch(self):
      epoch_loss = 0
      epoch_acc = 0
      self.model.train()
      for text, true_tags,sentence_lengths,sentence_flags in self.data_train:
        # print(type(sentence_flags)).  tensor of list of lists
        # print("t1",true_tags.shape) #[torch.Size([64, 41])
        self.optimizer.zero_grad()
        pred_tags = self.model(text,sentence_lengths,sentence_flags) ##send bma
        # print("p1",pred_tags.shape) #[torch.Size([64, 41, 10])]
        pred_tags = pred_tags.view(-1, pred_tags.shape[-1])
        # print(pred_tags)
        # print("p2",pred_tags.shape) #[torch.Size([2624, 10])]
        true_tags = true_tags.view(-1)
        # print(true_tags)
        # print("t2",true_tags.shape) #[torch.Size([2624])]
        batch_loss = self.loss_fn(pred_tags, true_tags)
        # print("batch_loss",batch_loss)
        batch_acc = self.accuracy(pred_tags, true_tags)
        batch_loss.backward()
        self.optimizer.step()
        epoch_loss += batch_loss.item()
        # print("epoch_loss",epoch_loss)
        epoch_acc += batch_acc.item()

        self.scheduler.step( epoch_loss / len(self.data_train))
        # print("Last LR", self.scheduler.get_last_lr())
      return epoch_loss / len(self.data_train), epoch_acc / len(self.data_trair

  def evaluate(self):
      epoch_loss = 0
      epoch_acc = 0
      self.model.eval()
      with torch.no_grad():
          for text, true_tags,sentence_lengths,sentence_flags in  self.data_dev
              pred_tags = self.model(text,sentence_lengths,sentence_flags)
              pred_tags = pred_tags.view(-1, pred_tags.shape[-1])
              true_tags = true_tags.view(-1)
              batch_loss = self.loss_fn(pred_tags, true_tags)
              batch_acc = self.accuracy(pred_tags, true_tags)
              epoch_loss += batch_loss.item()
              epoch_acc += batch_acc.item()
              self.scheduler.step(epoch_loss / len(self.data_dev))
      return epoch_loss / len( self.data_dev), epoch_acc / len( self.data_dev)

  def train(self, n_epochs):
    valid_loss_min2 = np.Inf
    for epoch in range(n_epochs):
```

```
        start_time = time.time()
        train_loss, train_acc = self.epoch()
        end_time = time.time()
        epoch_mins, epoch_secs = NER.epoch_time(start_time, end_time)
        print(f"Epoch: {epoch + 1:02} | Epoch Time: {epoch_mins}m {epoch_secs}s
        print(f"\tTrn Loss: {train_loss:.3f} | Trn Acc: {train_acc * 100:.2f}%"
        val_loss, val_acc = self.evaluate()
        print(f"\tVal Loss: {val_loss:.3f} | Val Acc: {val_acc * 100:.2f}%")
        if val_loss<valid_loss_min2:
            torch.save(self.model, 'GloveEmbed_trial2.pt')
            valid_loss_min2=val_loss

    ##########################################
    # Creating prediction file with the predicted tags for dev
    self.model.eval()
    predictions = []
    true_labels = []
    with torch.no_grad():
        for inputs, targets,sent_len,sent_fl in self.data_dev:
            outputs = self.model(inputs,sent_len,sent_fl)
            _, preds = torch.max(outputs, dim=2)
            predictions.extend(preds.tolist())
            true_labels.extend(targets.tolist())

    print(predictions)
    # Convert the predicted tag sequences to string representations
    predictions_dev = []
    for sentence_tags in predictions:
        predicted_tags_list = [idx2tag[idx] for idx in sentence_tags]
        predictions_dev.append(predicted_tags_list)


    # Save the predictions to a file
    with open('GloveEmbed_trial2_dev_pred.txt', 'w') as f:
        for predicted_tags in predictions_dev:
            f.write(' '.join(predicted_tags) + '\n')

    ##########################################
    # Creating prediction file with the predicted tags for test
    self.model.eval()
    predictions_test = []
    with torch.no_grad():
        for inputs, sent_len,sent_fl in self.data_test:
            outputs = self.model(inputs,sent_len,sent_fl)
            _, preds = torch.max(outputs, dim=2)
            predictions_test.extend(preds.tolist())

    # Convert the predicted tag sequences to string representations
    test_preds = []
    for sentence_tags in predictions_test:
        predicted_tags_list = [idx2tag[idx] for idx in sentence_tags]
        test_preds.append(predicted_tags_list)


    # Save the predictions to a file
    with open('GloveEmbed_trial2_test_pred.txt', 'w') as f:
        for predicted_tags in test_preds:
            f.write(' '.join(predicted_tags) + '\n')
```

In [92]:

```
%%time
# this will continue training if the model has been trained before.
# to restart training, run the bilstm creation cell (2 cells above) once again.
ner = NER(
  model=Gbilstm,
  train_loader=train_loader,
  dev_loader=dev_loader,
  test_loader=test_loader,
  optimizer_cls=optim.SGD,
  loss_fn_cls=nn.CrossEntropyLoss,
  test_sentence_list=test_sentence_list,
  dev_sentence_list=dev_sentence_list
)
ner.train(10)
```

```
<torch.optim.lr_scheduler.StepLR object at 0x7f810a8611f0>
/usr/local/lib/python3.9/dist-packages/torch/optim/lr_scheduler.py:163: UserWa
rning: The epoch parameter in `scheduler.step()` was not necessary and is bein
g deprecated where possible. Please use `scheduler.step()` to step the schedul
er. During the deprecation, if epoch is different from None, the closed form i
s used instead of the new chainable form, where available. Please open an issu
e if you are unable to replicate your use case: https://github.com/pytorch/pyt
orch/issues/new/choose.
  warnings.warn(EPOCH_DEPRECATION_WARNING, UserWarning)
```

```
Epoch: 01 | Epoch Time: 1m 43s
        Trn Loss: 0.335 | Trn Acc: 88.73%
        Val Loss: 0.246 | Val Acc: 92.27%
Epoch: 02 | Epoch Time: 1m 42s
        Trn Loss: 0.186 | Trn Acc: 93.94%
        Val Loss: 0.178 | Val Acc: 94.74%
Epoch: 03 | Epoch Time: 1m 41s
        Trn Loss: 0.121 | Trn Acc: 96.20%
        Val Loss: 0.130 | Val Acc: 96.02%
Epoch: 04 | Epoch Time: 1m 42s
        Trn Loss: 0.083 | Trn Acc: 97.49%
        Val Loss: 0.121 | Val Acc: 96.57%
Epoch: 05 | Epoch Time: 1m 41s
        Trn Loss: 0.057 | Trn Acc: 98.30%
        Val Loss: 0.109 | Val Acc: 96.97%
Epoch: 06 | Epoch Time: 1m 44s
        Trn Loss: 0.039 | Trn Acc: 98.90%
        Val Loss: 0.110 | Val Acc: 97.21%
Epoch: 07 | Epoch Time: 1m 41s
        Trn Loss: 0.027 | Trn Acc: 99.26%
        Val Loss: 0.128 | Val Acc: 96.68%
Epoch: 08 | Epoch Time: 1m 43s
        Trn Loss: 0.018 | Trn Acc: 99.53%
        Val Loss: 0.117 | Val Acc: 97.15%
Epoch: 09 | Epoch Time: 1m 42s
        Trn Loss: 0.012 | Trn Acc: 99.69%
        Val Loss: 0.124 | Val Acc: 97.23%
Epoch: 10 | Epoch Time: 1m 42s
        Trn Loss: 0.008 | Trn Acc: 99.80%
        Val Loss: 0.132 | Val Acc: 97.36%
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2, 2], [2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 9, 2, 6, 2, 6,
9, 2, 6, 2, 2, 6, 2, 2, 2, 2, 2, 2, 2, 2, 2], [2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
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2, 2, 2], [2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2], [6, 2, 2, 1, 7, 2, 2, 2,
2, 2, 2, 3, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2, 2, 2,
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2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
```

```
2], [2, 1, 7, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2], [2, 2, 2, 2, 2,
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2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2]]
CPU times: user 17min 57s, sys: 1.96 s, total: 17min 59s
Wall time: 18min 3s
```

Processing Dev Predictions to form .out file for submission and Score Check

The dev_pred file create above is called, and the data is appended in a list

In [93]:
```
pred_dev=[]
with open('GloveEmbed_trial2_dev_pred.txt', 'r') as readFile:
        for inputs in readFile:
            pred_dev.append(inputs.split(' '))
```

A list of sentences is created using the dev data such that each sentence is a list whose individual elements store the index of the word in the sentence, the word and the tag from the dev file (basically all the info present in the file)

In [94]:
```
dev_res_list=[]
dev_st=[]
dev_flag=0
for x in dev_data:
    if len(x)>1:
            if x[0]=='1':
                dev_flag=dev_flag+1
                if dev_flag == 1:
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                elif dev_flag==3466:
                    print(dev_flag)
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                    dev_res_list.append(dev_st)
                    break
                else:
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
            else:
                dev_st.append((x[0],x[1],x[2]))
```

```
3466
```

To calculate the F1 score, a file is created which includes the dev file data along with predicted tag per word.

In [ ]:
```
result_dict = {}
idx = 0
for i in range(len(dev_res_list)):
    for j in range(len(dev_res_list[i])):
        result_dict[idx] = (dev_res_list[i][j][0], dev_res_list[i][j][1],dev_re
        idx += 1
```

In [96]:
```
start_i=0
with open("GloveEmbed_trial2_dev_pred_out.txt", 'w') as f:
    for key,i in result_dict.items() :
        if i[0] == '1' and start_i!=0:
            f.write('\n')
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
        else:
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
            start_i=start_i+1
```

In [97]:
```
start_i=0
with open("gl_dev2_trial2.out", 'w') as f:
    for key,i in result_dict.items() :
        if i[0] == '1' and start_i!=0:
            f.write('\n')
            f.write('%s %s %s\n' % (i[0], i[1], i[3]))
        else:
            f.write('%s %s %s\n' % (i[0], i[1], i[3]))
            start_i=start_i+1
```

In [98]:
```
start_i=0
with open("GloveEmbed_trial2_dev_pred_out.out", 'w') as f:
    for key,i in result_dict.items() :
        if i[0] == '1' and start_i!=0:
            f.write('\n')
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
        else:
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
            start_i=start_i+1
```

Score Check using conll03eval

In [99]:
```
!perl conll03eval < {'GloveEmbed_trial2_dev_pred_out.txt'}
```

```
processed 51578 tokens with 5942 phrases; found: 5871 phrases; correct: 4951.
accuracy:  97.30%; precision:  84.33%; recall:  83.32%; FB1:  83.82
              LOC: precision:  86.99%; recall:  89.87%; FB1:  88.41  1898
             MISC: precision:  83.29%; recall:  76.79%; FB1:  79.91  850
              ORG: precision:  77.74%; recall:  76.06%; FB1:  76.89  1312
              PER: precision:  86.80%; recall:  85.34%; FB1:  86.07  1811
```

Processing Test Predictions to form .out file for submission

A list of sentences is created using the test data such that each sentence is a list whose individual elements store the index of the word in the sentence and the word a (basically all the info present in the file)

In [101…
```
test_res_list=[]
st_test=[]
flag_test=0
for x in test_data:
    if len(x)>1:
            if x[0]=='1':
                flag_test=flag_test+1
                if flag_test == 1:
```

```
                    st_test=[]
                    st_test.append((x[0],x[1]))
                elif flag_test==3684:
                    print(flag_test)
                    test_res_list.append(st_test)
                    st_test=[]
                    st_test.append((x[0],x[1]) )
                    test_res_list.append(st_test)
                    break
                else:
                    test_res_list.append(st_test)
                    st_test=[]
                    st_test.append((x[0],x[1]))
            else:
                st_test.append((x[0],x[1]))
```

```
3684
```

The test_pred file create above is called, and the data is appended in a list

In [102…
```
pred_test=[]
with open('GloveEmbed_trial2_test_pred.txt', 'r') as readFile:
        for inputs in readFile:
            pred_test.append(inputs.split(' '))
```

Output file is created which includes the test file data along with predicted tag per word.

In [106…
```
test_dict = {}
test_idx = 0
for i in range(len(test_res_list)):
    for j in range(len(test_res_list[i])):
        test_dict[test_idx] = (test_res_list[i][j][0], test_res_list[i][j][1],
        test_idx += 1
```

In [107…
```
start_ie=0
with open("GloveEmbed_trial2_test_pred_out.txt", 'w') as f:
    for key,i in test_dict.items() :
        if i[0] == '1' and start_ie!=0:
            f.write('\n')
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
        else:
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
            start_ie=start_ie+1
```

In [108…
```
start_ie=0
with open("GloveEmbed_trial2_test_pred_out.out", 'w') as f:
    for key,i in test_dict.items() :
        if i[0] == '1' and start_ie!=0:
            f.write('\n')
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
        else:
            f.write('%s %s %s\n' % (i[0], i[1], i[2]))
            start_ie=start_ie+1
```

SAVING MODEL FOR SUBMISSION

In [109…
```
torch.save(ner.model,'GloveEmbed_trial2_m2.pt')
```

In [110…
```
### SAVED MODEL
```

Reloading Saved Model to verify that the correct model is saved and it reciprocates the actual result

In [111…
```
# Load the model
modelw = torch.load("GloveEmbed_trial2_m2.pt")

##########################################
# Creating prediction file with the predicted tags for dev
modelw.eval()
predictions = []
true_labels = []
with torch.no_grad():
    for inputs, targets,sent_len,sent_fl in dev_loader:
        outputs = modelw(inputs,sent_len,sent_fl)
        _, preds = torch.max(outputs, dim=2)
        predictions.extend(preds.tolist())
        true_labels.extend(targets.tolist())

# Convert the predicted tag sequences to string representations
predictions_dev = []
for sentence_tags in predictions:
    predicted_tags_list = [idx2tag[idx] for idx in sentence_tags]
    predictions_dev.append(predicted_tags_list)

# Save the predictions to a file
with open('GloveEmbed_trial2_devcheck_pred.txt', 'w') as f:
    for predicted_tags in predictions_dev:
        f.write(' '.join(predicted_tags) + '\n')

########################################
# Creating prediction file with the predicted tags for test
modelw.eval()
predictions_test = []
with torch.no_grad():
    for inputs, sent_len,sent_fl in test_loader:
        outputs = modelw(inputs,sent_len,sent_fl)
        _, preds = torch.max(outputs, dim=2)
        predictions_test.extend(preds.tolist())

# Convert the predicted tag sequences to string representations
test_preds = []
for sentence_tags in predictions_test:
    predicted_tags_list = [idx2tag[idx] for idx in sentence_tags]
    test_preds.append(predicted_tags_list)

# Save the predictions to a file
with open('GloveEmbed_trial2_testcheck_pred.txt', 'w') as f:
    for predicted_tags in test_preds:
        f.write(' '.join(predicted_tags) + '\n')
```

Processing Dev Predictions using LOADED MODEL to form .out file for submission and Score Check

In [112…
```
pred_dev_trial=[]
with open('GloveEmbed_trial2_devcheck_pred.txt', 'r') as readFile:
        for inputs in readFile:
            pred_dev_trial.append(inputs.split(' '))
```

In [113…
```
len(pred_dev_trial[2])
```

Out[113]: 41

In [114…
```
dev_res_list=[]
dev_st=[]
dev_flag=0
for x in dev_data:
    if len(x)>1:
            if x[0]=='1':
                dev_flag=dev_flag+1
                if dev_flag == 1:
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                elif dev_flag==3466:
                    print(dev_flag)
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
                    dev_res_list.append(dev_st)
                    break
                else:
                    dev_res_list.append(dev_st)
                    dev_st=[]
                    dev_st.append((x[0],x[1],x[2]))
            else:
                dev_st.append((x[0],x[1],x[2]))
```

3466

In [ ]:
```
result_dictdev_trial = {}
idxdev_trial = 0
for i in range(len(dev_res_list)):
    for j in range(len(dev_res_list[i])):
        result_dictdev_trial[idxdev_trial] = (dev_res_list[i][j][0], dev_res_li
        idxdev_trial += 1
```

In [117…
```
start_idev_trial=0
with open("GloveEmbed_trial2_devcheck_pred_out.txt", 'w') as f:
    for key,i in result_dictdev_trial.items() :
        if i[0] == '1' and start_idev_trial!=0:
            f.write('\n')
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
        else:
            f.write('%s %s %s %s\n' % (i[0], i[1], i[2], i[3]))
            start_idev_trial=start_idev_trial+1
```

In [118…
```
!perl conll03eval < {'GloveEmbed_trial2_devcheck_pred_out.txt'}
```

```
processed 51578 tokens with 5942 phrases; found: 5871 phrases; correct: 4951.
accuracy:  97.30%; precision:  84.33%; recall:  83.32%; FB1:  83.82
              LOC: precision:  86.99%; recall:  89.87%; FB1:  88.41  1898
             MISC: precision:  83.29%; recall:  76.79%; FB1:  79.91  850
              ORG: precision:  77.74%; recall:  76.06%; FB1:  76.89  1312
              PER: precision:  86.80%; recall:  85.34%; FB1:  86.07  1811
```

In [120…