Multiclass Text Classification with

Logistic Regression Implemented with PyTorch and CE Loss

First, we will do some initialization.

```
from google.colab import drive
drive.mount('/content/drive')
!pwd
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=Tr
/content
```

```
%cd "drive"
%cd "MyDrive"
%cd "ag_new_csv"
!ls
```

```
/content/drive
/content/drive/MyDrive
/content/drive/MyDrive/ag_new_csv
classes.txt  test.csv  train.csv
```

```
import random
import torch
import numpy as np
import pandas as pd
from tqdm.notebook import tqdm

# enable tqdm in pandas
tqdm.pandas()

# set to True to use the gpu (if there is one available)
use_gpu = True

# select device
device = torch.device('cuda' if use_gpu and torch.cuda.is_available() else 'cpu')
print(f'device: {device.type}')

# random seed
seed = 1234

# set random seed
if seed is not None:
    print(f'random seed: {seed}')
    random.seed(seed)
    np.random.seed(seed)
    torch.manual_seed(seed)
```

```
device: cpu
random seed: 1234
```

We will be using the AG's News Topic Classification Dataset. It is stored in two CSV files: `train.csv` and `test.csv`, as well as a `classes.txt` that stores the labels of the classes to predict.

First, we will load the training dataset using pandas and take a quick look at how the data.

```
train_df = pd.read_csv('train.csv', header=None)
train_df.columns = ['class index', 'title', 'description']
train_df
```

	class index	title	description
0	3	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...
1	3	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...
2	3	Oil and Economy Cloud Stocks' Outlook (Reuters)	Reuters - Soaring crude prices plus worries\ab...
3	3	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\f...
4	3	Oil prices soar to all-time record, posing new...	AFP - Tearaway world oil prices, toppling reco...
...	...	...	...
119995	1	Pakistan's Musharraf Says Won't Quit as Army C...	KARACHI (Reuters) - Pakistani President Perve...
119996	2	Renteria signing a top-shelf deal	Red Sox general manager Theo Epstein acknowled...
119997	2	Saban not going to Dolphins yet	The Miami Dolphins will put their courtship of...
119998	2	Today's NFL games	PITTSBURGH at NY GIANTS Time: 1:30 p.m. Line: ...
119999	2	Nets get Carter from Raptors	INDIANAPOLIS -- All-Star Vince Carter was trad...

120000 rows × 3 columns

The dataset consists of 120,000 examples, each consisting of a class index, a title, and a description. The class labels are distributed in a separated file. We will add the labels to the dataset so that we can interpret the data more easily. Note that the label indexes are one-based, so we need to subtract one to retrieve them from the list.

```
labels = open('classes.txt').read().splitlines()
classes = train_df['class index'].map(lambda i: labels[i-1])
train_df.insert(1, 'class', classes)
train_df
```

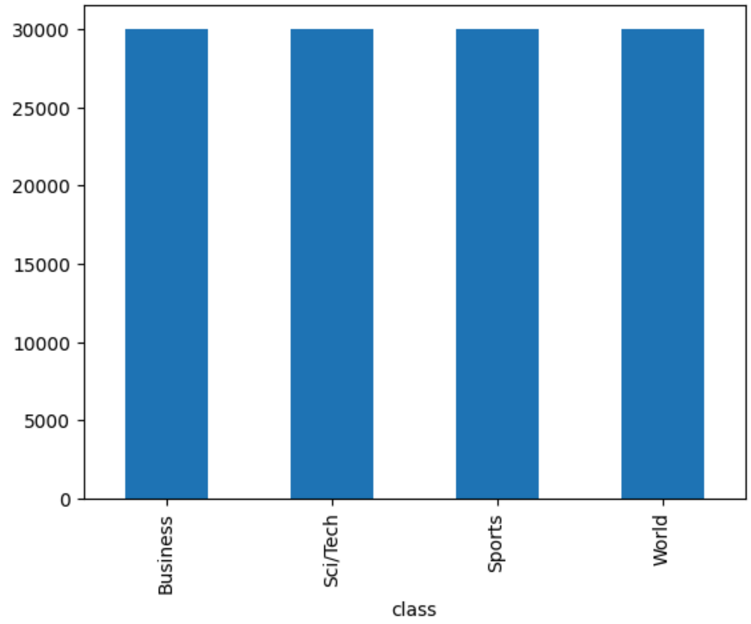
	class index	class	title	description
0	3	Business	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...
1	3	Business	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...
2	3	Business	Oil and Economy Cloud Stocks' Outlook (Reuters)	Reuters - Soaring crude prices plus worries\ab...
3	3	Business	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\f...
4	3	Business	Oil prices soar to all-time record, posing new...	AFP - Tearaway world oil prices, toppling reco...
...	...	...	...	...
119995	1	World	Pakistan's Musharraf Says Won't Quit as Army C...	KARACHI (Reuters) - Pakistani President Perve...
119996	2	Sports	Renteria signing a top-shelf deal	Red Sox general manager Theo Epstein acknowled...
119997	2	Sports	Saban not going to Dolphins yet	The Miami Dolphins will put their courtship of...
119998	2	Sports	Today's NFL games	PITTSBURGH at NY GIANTS Time: 1:30 p.m. Line: ...
119999	2	Sports	Nets get Carter from Raptors	INDIANAPOLIS -- All-Star Vince Carter was trad...

120000 rows × 4 columns

Let's inspect how balanced our examples are by using a bar plot.

```
pd.value_counts(train_df['class']).plot.bar()
```

```
<ipython-input-5-78d1f3cd1886>:1: FutureWarning: pandas.value_counts is deprecated and will be removed in a future version.
  pd.value_counts(train_df['class']).plot.bar()
<Axes: xlabel='class'>
```



The classes are evenly distributed. That's great!

However, the text contains some spurious backslashes in some parts of the text. They are meant to represent newlines in the original text. An example can be seen below, between the words "dwindling" and "band".

```
print(train_df.loc[0, 'description'])
```

```
Reuters - Short-sellers, Wall Street's dwindling\band of ultra-cynics, are seeing green again.
```

We will replace the backslashes with spaces on the whole column using pandas replace method.

```
title = train_df['title'].str.lower()
descr = train_df['description'].str.lower()
text = title + " " + descr
train_df['text'] = text.str.replace('\\', ' ', regex=False)
train_df
```

	class index	class	title	description	text
0	3	Business	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...	wall st. bears claw back into the black (reute...
1	3	Business	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...	carlyle looks toward commercial aerospace (reu...
2	3	Business	Oil and Economy Cloud Stocks' Outlook (Reuters)	Reuters - Soaring crude prices plus worries\ab...	oil and economy cloud stocks' outlook (reuters...
3	3	Business	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\f...	iraq halts oil exports from main southern pipe...
4	3	Business	Oil prices soar to all-time record, posing new...	AFP - Tearaway world oil prices, toppling reco...	oil prices soar to all-time record, posing new...
...	...	...	...	...	...
119995	1	World	Pakistan's Musharraf Says Won't Quit as Army C...	KARACHI (Reuters) - Pakistani President Perve...	pakistan's musharraf says won't quit as army c...
119996	2	Sports	Renteria signing a top-shelf deal	Red Sox general manager Theo Epstein acknowled...	renteria signing a top-shelf deal red sox gene...

Now we will proceed to tokenize the title and description columns using NLTK's word_tokenize(). We will add a new column to our dataframe with the list of tokens.

```
import nltk
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
True
```

```
from nltk.tokenize import word_tokenize

train_df['tokens'] = train_df['text'].progress_map(word_tokenize)
train_df
```

```
100%                                   120000/120000 [00:44<00:00, 3221.73it/s]
```

	class index	class	title	description	text	tokens
0	3	Business	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...	wall st. bears claw back into the black (reute...	[wall, st., bears, claw, back, into, the, blac...
1	3	Business	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...	carlyle looks toward commercial aerospace (reu...	[carlyle, looks, toward, commercial, aerospace...
2	3	Business	Oil and Economy Cloud Stocks' Outlook (Reuters)	Reuters - Soaring crude prices plus worries\ab...	oil and economy cloud stocks' outlook (reuters...	[oil, and, economy, cloud, stocks, ', outlook,...
3	3	Business	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\f...	iraq halts oil exports from main southern pipe...	[iraq, halts, oil, exports, from, main, southe...
4	3	Business	Oil prices soar to all-time record, posing new...	AFP - Tearaway world oil prices, toppling reco...	oil prices soar to all-time record, posing new...	[oil, prices, soar, to, all-time, record, ,, p...
...	...	...	...	...	...	...
119995	1	World	Pakistan's Musharraf Says Won't Quit as Army C...	KARACHI (Reuters) - Pakistani President Perve...	pakistan's musharraf says won't quit as army c...	[pakistan, 's, musharraf, says, wo, n't, quit,...
119996	2	Sports	Renteria signing a top-shelf deal	Red Sox general manager Theo Epstein acknowled...	renteria signing a top-shelf deal red sox gene...	[renteria, signing, a, top-shelf, deal, red, s...
119997	2	Sports	Saban not going to Dolphins yet	The Miami Dolphins will put their courtship of...	saban not going to dolphins yet the miami dolp...	[saban, not, going, to, dolphins, yet, the, mi...
119998	2	Sports	Today's NFL games	PITTSBURGH at NY GIANTS Time: 1:30 p.m. Line: ...	today's nfl games pittsburgh at ny giants time...	[today, 's, nfl, games, pittsburgh, at, ny, gi...
				INDIANAPOLIS -- All-Star Vince	nets get carter from raptors	[nets, get, carter, from,

Now we will create a vocabulary from the training data. We will only keep the terms that repeat beyond some threshold established below.

```
threshold = 10
tokens = train_df['tokens'].explode().value_counts()
tokens = tokens[tokens > threshold]
id_to_token = ['[UNK]'] + tokens.index.tolist()
token_to_id = {w:i for i,w in enumerate(id_to_token)}
vocabulary_size = len(id_to_token)
print(f'vocabulary size: {vocabulary_size:,}')
```

```
vocabulary size: 19,671
```

```
from collections import defaultdict

def make_feature_vector(tokens, unk_id=0):
    vector = defaultdict(int)
    for t in tokens:
        i = token_to_id.get(t, unk_id)
        vector[i] += 1
    return vector

train_df['features'] = train_df['tokens'].progress_map(make_feature_vector)
train_df
```

```
100%                    120000/120000 [00:05<00:00, 23774.27it/s]
```

	class index	class	title	description	text	tokens	features
0	3	Business	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...	wall st. bears claw back into the black (reute...	[wall, st., bears, claw, back, into, the, blac...	{427: 2, 563: 1, 1607: 1, 15337: 1, 120: 1, 73...
1	3	Business	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...	carlyle looks toward commercial aerospace (reu...	[carlyle, looks, toward, commercial, aerospace...	{16358: 2, 1078: 1, 855: 1, 1287: 1, 4248: 1, ...
2	3	Business	Oil and Economy Cloud Stocks' Outlook (Reuters)	Reuters - Soaring crude prices plus worries\ab...	oil and economy cloud stocks' outlook (reuters...	[oil, and, economy, cloud, stocks, ', outlook,...	{66: 1, 9: 2, 351: 2, 4564: 1, 158: 1, 116: 1,...
3	3	Business	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\f...	iraq halts oil exports from main southern pipe...	[iraq, halts, oil, exports, from, main, southe...	{77: 2, 7372: 1, 66: 3, 1783: 1, 32: 2, 900: 2...
4	3	Business	Oil prices soar to all-time record, posing new...	AFP - Tearaway world oil prices, toppling reco...	oil prices soar to all-time record, posing new...	[oil, prices, soar, to, all-time, record, ,, p...	{66: 2, 99: 2, 4387: 1, 4: 2, 3604: 1, 149: 1,...
...	...	...	...	...	...	...	...
119995	1	World	Pakistan's Musharraf Says Won't Quit as Army C...	KARACHI (Reuters) - Pakistani President Perve...	pakistan's musharraf says won't quit as army c...	[pakistan, 's, musharraf, says, wo, n't, quit,...	{383: 1, 23: 1, 1625: 2, 91: 1, 1804: 1, 285: ...
119996	2	Sports	Renteria signing a top-shelf deal	Red Sox general manager Theo Epstein acknowled...	renteria signing a top-shelf deal red sox gene...	[renteria, signing, a, top-shelf, deal, red, s...	{8510: 2, 2637: 1, 5: 4, 0: 3, 127: 1, 202: 3,...
119997	2	Sports	Saban not going to Dolphins yet	The Miami Dolphins will put their courtship of...	saban not going to dolphins yet the miami dolp...	[saban, not, going, to, dolphins, yet, the, mi...	{7758: 2, 68: 1, 661: 1, 4: 2, 1439: 2, 704: 1...

Se tokeniza el texto con word_tokenize de NLTK y se agrega como una nueva columna al DataFrame. Se crea un vocabulario a partir de los términos que aparecen con una frecuencia mayor a un umbral de 10.Cada texto se convierte en un vector de características donde cada posición representa la frecuencia de un token específico en el vocabulario.

```
def make_dense(feats):
    x = np.zeros(vocabulary_size)
    for k,v in feats.items():
        x[k] = v
    return x

X_train = np.stack(train_df['features'].progress_map(make_dense))
y_train = train_df['class index'].to_numpy() - 1

X_train = torch.tensor(X_train, dtype=torch.float32)
y_train = torch.tensor(y_train)
```

```
66%                    79253/120000 [00:10<00:08, 4758.11it/s]
```

```
from torch import nn
from torch import optim

# hyperparameters
lr = 1.0
n_epochs = 5
n_examples = X_train.shape[0]
n_feats = X_train.shape[1]
n_classes = len(labels)

# initialize the model, loss function, optimizer, and data-loader
model = nn.Linear(n_feats, n_classes).to(device)
loss_func = nn.CrossEntropyLoss()
optimizer = optim.SGD(model.parameters(), lr=lr)

# train the model
indices = np.arange(n_examples)
for epoch in range(n_epochs):
    np.random.shuffle(indices)
    for i in tqdm(indices, desc=f'epoch {epoch+1}'):
        # clear gradients
        model.zero_grad()
        model.zero_grad()
        # send datum to right device
        x = X_train[i].unsqueeze(0).to(device)
        y_true = y_train[i].unsqueeze(0).to(device)
        # predict label scores
        y_pred = model(x)
        # compute loss
        loss = loss_func(y_pred, y_true)
        # backpropagate
        loss.backward()
        # optimize model parameters
        optimizer.step()
```

```
epoch 1:   0%|          | 0/120000 [00:00<?, ?it/s]
epoch 2:   0%|          | 0/120000 [00:00<?, ?it/s]
epoch 3:   0%|          | 0/120000 [00:00<?, ?it/s]
epoch 4:   0%|          | 0/120000 [00:00<?, ?it/s]
epoch 5:   0%|          | 0/120000 [00:00<?, ?it/s]
```

Se convierte la matriz de características y las etiquetas a tensores de PyTorch para su uso en el modelo.Se define un modelo de regresión logística con PyTorch, que incluye una función de pérdida de entropía cruzada(CrossEntropyLoss) y el optimizador SGD. Luego se entrena el modelo en lotes, realizando predicciones, calculando el error, y ajustando los parámetros.

Next, we evaluate on the test dataset

Se aplica el mismo flujo de preprocesamiento de texto al conjunto de prueba y se convierte en tensores. Se utiliza classification_report de Scikit-learn para evaluar el rendimiento del modelo, generando métricas de clasificación, como precisión, recall, y F1, para cada clase.

+ Código + Texto

```
# repeat all preprocessing done above, this time on the test set
test_df = pd.read_csv('data/ag_news_csv/test.csv', header=None)
test_df.columns = ['class index', 'title', 'description']
test_df['text'] = test_df['title'].str.lower() + " " + test_df['description'].str.lower()
test_df['text'] = test_df['text'].str.replace('\\', ' ', regex=False)
test_df['tokens'] = test_df['text'].progress_map(word_tokenize)
test_df['features'] = test_df['tokens'].progress_map(make_feature_vector)

X_test = np.stack(test_df['features'].progress_map(make_dense))
y_test = test_df['class index'].to_numpy() - 1
X_test = torch.tensor(X_test, dtype=torch.float32)
y_test = torch.tensor(y_test)
```

```
  0%|          | 0/7600 [00:00<?, ?it/s]
  0%|          | 0/7600 [00:00<?, ?it/s]
  0%|          | 0/7600 [00:00<?, ?it/s]
```

```
from sklearn.metrics import classification_report

# set model to evaluation mode
model.eval()

# don't store gradients
with torch.no_grad():
    X_test = X_test.to(device)
    y_pred = torch.argmax(model(X_test), dim=1)
    y_pred = y_pred.cpu().numpy()
    print(classification_report(y_test, y_pred, target_names=labels))
```

```
              precision    recall  f1-score   support

       World       0.94      0.82      0.88      1900
      Sports       0.89      0.99      0.94      1900
    Business       0.81      0.88      0.85      1900
    Sci/Tech       0.89      0.83      0.86      1900
```