

Multiclass Text Classification with

Logistic Regression Implemented with PyTorch and CE Loss

First, we will do some initialization.

```
In [1]: 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: cuda
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.

```
In [2]: train_df = pd.read_csv('https://raw.githubusercontent.com/mhjabreel/CharCnn_
train_df.columns = ['class index', 'title', 'description']
train_df
```

Out [2]:

	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 acknowl...
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 x 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.

```
In [3]: labels = open('/kaggle/input/classes/classes.txt').read().splitlines()
classes = train_df['class index'].map(lambda i: labels[i-1])Se leen etiqueta

train_df.insert(1, 'class', classes)
train_df
```

Out [3]:

	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\...
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 acknowle...
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 x 4 columns

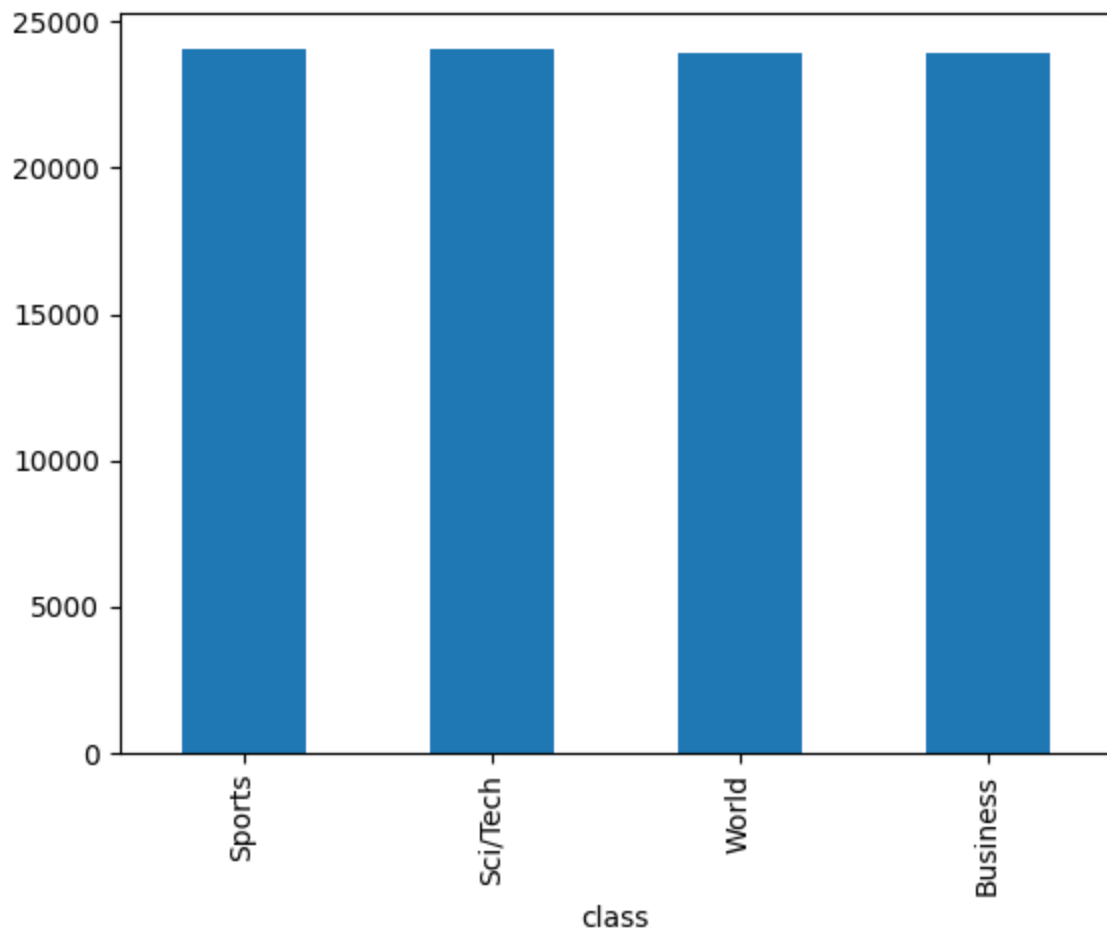
Let's inspect how balanced our examples are by using a bar plot.

In [4]: `train_df = train_df.sample(frac=0.8, random_state= 42)`**Dividirlos los datos en entrenamiento/prueba de forma aleatoria**In [5]: `pd.value_counts(train_df['class']).plot.bar()`

/tmp/ipykernel_30/1245903889.py:1: FutureWarning: pandas.value_counts is deprecated and will be removed in a future version. Use pd.Series(obj).value_counts() instead.

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

Out [5]: `<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".

```
In [6]: print(train_df.loc[0, 'description'])
```

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

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

```
In [7]: 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
```

Out [7]:

	class index	class	title	description	text
71787	3	Business	BBC set for major shake-up, claims newspaper	London - The British Broadcasting Corporation,...	bbc set for major shake-up, claims newspaper l...
67218	3	Business	Marsh averts cash crunch	Embattled insurance broker #39;s banks agree t...	marsh averts cash crunch embattled insurance b...
54066	2	Sports	Jeter, Yankees Look to Take Control (AP)	AP - Derek Jeter turned a season that started ...	jeter, yankees look to take control (ap) ap - ...
7168	4	Sci/Tech	Flying the Sun to Safety	When the Genesis capsule comes back to Earth w...	flying the sun to safety when the genesis caps...
29618	3	Business	Stocks Seen Flat as Nortel and Oil Weigh	NEW YORK (Reuters) - U.S. stocks were set to ...	stocks seen flat as nortel and oil weigh new ...
...
59228	4	Sci/Tech	Investors Flock to Web Networking Sites	Internet whiz kids Marc Andreessen, Josh Kopel...	investors flock to web networking sites intern...
61417	3	Business	Samsung Electric Quarterly Profit Up	Samsung Electronics Co. Ltd. #39;s (005930.KS:...	samsung electric quarterly profit up samsung e...
20703	3	Business	Coeur Still Committed to Wheaton Deal	Coeur d #39;Alene Mines Corp. said Tuesday tha...	coeur still committed to wheaton deal coeur d ...
40626	3	Business	Clouds on horizon for low-cost airlines	NEW YORK -- As larger US airlines suffer growi...	clouds on horizon for low-cost airlines new yo...
25059	2	Sports	Furcal issues apology for DUI arrest, returns ...	NAMES Atlanta Braves shortstop Rafael Furcal r...	furcal issues apology for dui arrest, returns ...

96000 rows x 5 columns

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.

In [8]:

```
from nltk.tokenize import word_tokenize

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

```
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```

Out [8]:

	class index	class	title	description	text	tokens
71787	3	Business	BBC set for major shake- up, claims newspaper	London - The British Broadcasting Corporation,...	bbc set for major shake- up, claims newspaper l...	[bbc, set, for, major, shake- up, ,, claims, ne...
67218	3	Business	Marsh averts cash crunch	Embattled insurance broker #39;s banks agree t...	marsh averts cash crunch embattled insurance b...	[marsh, averts, cash, crunch, embattled, insur...
54066	2	Sports	Jeter, Yankees Look to Take Control (AP)	AP - Derek Jeter turned a season that started ...	jeter, yankees look to take control (ap) ap - ...	[jeter, ,, yankees, look, to, take, control, (...
7168	4	Sci/Tech	Flying the Sun to Safety	When the Genesis capsule comes back to Earth w...	flying the sun to safety when the genesis caps...	[flying, the, sun, to, safety, when, the, gene...
29618	3	Business	Stocks Seen Flat as Nortel and Oil Weigh	NEW YORK (Reuters) - U.S. stocks were set to ...	stocks seen flat as nortel and oil weigh new ...	[stocks, seen, flat, as, nortel, and, oil, wei...
...
59228	4	Sci/Tech	Investors Flock to Web Networking Sites	Internet whiz kids Marc Andreessen, Josh Kopel...	investors flock to web networking sites intern...	[investors, flock, to, web, networking, sites,...
61417	3	Business	Samsung Electric Quarterly Profit Up	Samsung Electronics Co. Ltd. #39;s (005930.KS:...	samsung electric quarterly profit up samsung e...	[samsung, electric, quarterly, profit, up, sam...
20703	3	Business	Coeur Still Committed to Wheaton Deal	Coeur d #39;Alene Mines Corp. said Tuesday tha...	coeur still committed to wheaton deal coeur d ...	[coeur, still, committed, to, wheaton, deal, c...
40626	3	Business	Clouds on horizon for low-cost airlines	NEW YORK -- As larger US airlines suffer growi...	clouds on horizon for low-cost airlines new yo...	[clouds, on, horizon, for, low-cost, airlines,...
25059	2	Sports	Furcal issues apology for DUI arrest, returns ...	NAMES Atlanta Braves shortstop Rafael Furcal r...	furcal issues apology for dui arrest, returns ...	[furcal, issues, apology, for, dui, arrest,

class index	class	title	description	text	tokens
.....					

96000 rows × 6 columns

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

```
In [9]: 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: 17,430

```
In [10]: 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
```

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Out[10]:

	class index	class	title	description	text	tokens	features
71787	3	Business	BBC set for major shake-up, claims newspaper	London - The British Broadcasting Corporation,...	bbc set for major shake-up, claims newspaper l...	[bbc, set, for, major, shake-up, ,, claims, ne...	{2451: 1, 167: 1, 11: 1, 201: 1, 6778: 2, 2: 5...
67218	3	Business	Marsh averts cash crunch	Embattled insurance broker #39;s banks agree t...	marsh averts cash crunch embattled insurance b...	[marsh, averts, cash, crunch, embattled, insur...	{1945: 2, 0: 2, 723: 1, 5100: 1, 2891: 1, 752:...
54066	2	Sports	Jeter, Yankees Look to Take Control (AP)	AP - Derek Jeter turned a season that started ...	jeter, yankees look to take control (ap) ap - ...	[jeter, ,, yankees, look, to, take, control, (...	{6670: 2, 2: 1, 508: 1, 599: 1, 4: 1, 193: 1, ...
7168	4	Sci/Tech	Flying the Sun to Safety	When the Genesis capsule comes back to Earth w...	flying the sun to safety when the genesis caps...	[flying, the, sun, to, safety, when, the, gene...	{2601: 1, 1: 4, 416: 2, 4: 3, 1061: 1, 96: 1, ...
29618	3	Business	Stocks Seen Flat as Nortel and Oil Weigh	NEW YORK (Reuters) - U.S. stocks were set to ...	stocks seen flat as nortel and oil weigh new ...	[stocks, seen, flat, as, nortel, and, oil, wei...	{158: 2, 646: 1, 1523: 1, 21: 1, 2035: 2, 9: 1...
...
59228	4	Sci/Tech	Investors Flock to Web Networking Sites	Internet whiz kids Marc Andreessen, Josh Kopel...	investors flock to web networking sites intern...	[investors, flock, to, web, networking, sites,...	{366: 1, 8544: 1, 4: 1, 227: 1, 2620: 1, 992: ...
61417	3	Business	Samsung Electric Quarterly Profit Up	Samsung Electronics Co. Ltd. #39;s (005930.KS:...	samsung electric quarterly profit up samsung e...	[samsung, electric, quarterly, profit, up, sam...	{1745: 2, 2597: 1, 536: 2, 154: 2, 51: 1, 926:...

	class index	class	title	description	text	tokens	features
20703	3	Business	Coeur Still Committed to Wheaton Deal	Coeur d #39;Alene Mines Corp. said Tuesday tha...	coeur still committed to wheaton deal coeur d ...	[coeur, still, committed, to, wheaton, deal, c...	{0: 3, 239: 1, 3351: 2, 4: 2, 9726: 2, 130: 1,...
40626	3	Business	Clouds on horizon for low-cost airlines	NEW YORK -- As larger US airlines suffer growi...	clouds on horizon for low-cost airlines new yo...	[clouds, on, horizon, for, low- cost, airlines,...	{5532: 1, 10: 1, 7500: 1, 11: 1, 2949: 2, 683:...
25059	2	Sports	Furcal issues apology for DUI arrest, returns ...	NAMES Atlanta Braves shortstop Rafael Furcal r...	furcal issues apology for dui arrest, returns ...	[furcal, issues, apology, for, dui, arrest, ,...	{9372: 3, 951: 1, 6078: 2, 11: 2, 11962: 2, 15...

96000 rows x 7 columns

Este código transforma listas de tokens en vectores de características que representan la frecuencia de cada token.

```
In [11]: 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)
```

```
0%|          | 0/96000 [00:00<?, ?it/s]
```

Para que puedan ser utilizados como entradas en modelos de aprendizaje profundo de PyTorch, convertimos los vectores de características dispersos a vectores densos. Más adelante, entrenamos un modelo de red neuronal lineal para la clasificación multiclase usando el optimizador SGD y la función de pérdida de entropía cruzada.

```
In [12]: 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()
        # 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%|          | 0/96000 [00:00<?, ?it/s]
epoch 2: 0%|          | 0/96000 [00:00<?, ?it/s]
epoch 3: 0%|          | 0/96000 [00:00<?, ?it/s]
epoch 4: 0%|          | 0/96000 [00:00<?, ?it/s]
epoch 5: 0%|          | 0/96000 [00:00<?, ?it/s]

```

Next, we evaluate on the test dataset

```

In [13]: # repeat all preprocessing done above, this time on the test set
test_df = pd.read_csv('https://raw.githubusercontent.com/mhjabreel/CharCnn_K
test_df.columns = ['class index', 'title', 'description']
test_df['text'] = test_df['title'].str.lower() + " " + test_df['description']
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]

```

Convertimos el texto en vectores de características y luego en tensores de PyTorch

```
In [14]: 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	0.89	0.90	0.90	1900
Sports	0.94	0.97	0.95	1900
Business	0.88	0.81	0.84	1900
Sci/Tech	0.84	0.87	0.85	1900
accuracy			0.89	7600
macro avg	0.89	0.89	0.89	7600
weighted avg	0.89	0.89	0.89	7600

El modelo es bueno, tiene una precisión promedio de 89%, sumandole que las clases tienen valores altos en precisión (recall y f1-score) y significa que hace buen trabajo como clasificador multiclase