

Multiclass Text Classification with

Logistic Regression Implemented with PyTorch and CE Loss

First, we will do some initialization.

```
In [ ]: 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.

```
In [ ]: train_df = pd.read_csv('./train.csv', header=None) # leemos el archivo csv
train_df.columns = ['class index', 'title', 'description'] # le asignamos nombres a las columnas
train_df # mostramos el dataframe
```

Out []:

	class index		title	description
0	Class Index		Title	Description
1	3	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...	
2	3	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...	
3	3	Oil and Economy Cloud Stocks' Outlook (Reuters)	Reuters - Soaring crude prices plus worries\ab...	
4	3	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\...	
...
119996	1	Pakistan's Musharraf Says Won't Quit as Army C...	KARACHI (Reuters) - Pakistani President Perve...	
119997	2	Renteria signing a top-shelf deal	Red Sox general manager Theo Epstein acknowled...	
119998	2	Saban not going to Dolphins yet	The Miami Dolphins will put their courtship of...	
119999	2	Today's NFL games	PITTSBURGH at NY GIANTS Time: 1:30 p.m. Line: ...	
120000	2	Nets get Carter from Raptors	INDIANAPOLIS -- All-Star Vince Carter was trad...	

120001 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.

```
In [ ]: labels = open('./classes.txt').read().splitlines() # leemos las etiquetas de
train_df = train_df.drop(0).reset_index(drop=True) # eliminamos la primera
train_df['class index'] = train_df['class index'].astype(int) # convertimos
classes = train_df['class index'].map(lambda i: labels[i-1]) # mapeamos los
train_df.insert(1, 'class', classes) # insertamos la columna 'class' en la p
train_df # mostramos el dataframe
```

Out []:

	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.

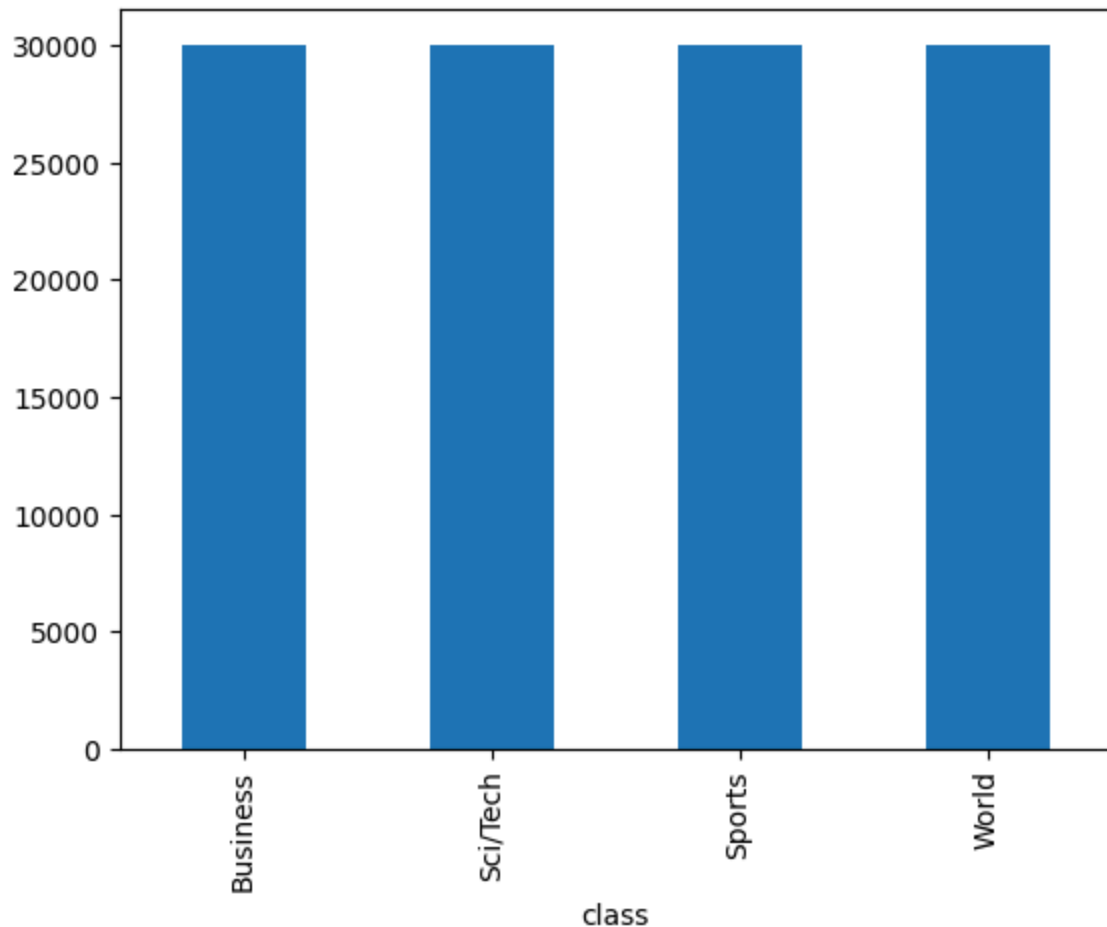
In []: `pd.value_counts(train_df['class']).plot.bar() # graficamos la distribución c`

```

/var/folders/7b/g3f6kzfd1b99b918vd8tvd100000gn/T/ipykernel_25959/1245903889.
py:1: FutureWarning: pandas.value_counts is deprecated and will be removed i
n a future version. Use pd.Series(obj).value_counts() instead.
pd.value_counts(train_df['class']).plot.bar()

```

Out []: `<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 [ ]: print(train_df.loc[0, 'description']) # mostramos la descripción de la prime
```

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.

```
In [ ]: title = train_df['title'].str.lower() # convertimos el título a minúsculas
descr = train_df['description'].str.lower() # convertimos la descripción a minúsculas
text = title + " " + descr # concatenamos el título y la descripción
train_df['text'] = text.str.replace('\\', ' ', regex=False) # reemplazamos los backslashes por espacios
train_df # mostramos el dataframe
```

Out []:

	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 acknowl...	renteria signing a top-shelf deal red sox gene...
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 dorp...
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...
119999	2	Sports	Nets get Carter from Raptors	INDIANAPOLIS -- All-Star Vince Carter was trad...	nets get carter from raptors indianapolis -- a...

120000 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 [ ]: import nltk # importamos la librería nltk
nltk.download('punkt_tab') # descargamos el tokenizador 'punkt', que tiene u
```

```
[nltk_data] Downloading package punkt_tab to
[nltk_data] /Users/hibrantapia/nltk_data...
[nltk_data] Unzipping tokenizers/punkt_tab.zip.
```

Out[]: True

```
In [ ]: from nltk.tokenize import word_tokenize # importamos la función word_tokenize
train_df['tokens'] = train_df['text'].progress_map(word_tokenize) # tokeniza
train_df # mostramos el dataframe
```

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Out[]:

	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 acknowle...	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 dorp...	[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...
119999	2	Sports	Nets get Carter from	INDIANAPOLIS -- All-Star	nets get carter from	[nets, get, carter, from,

class index	class	title	description	text	tokens
		Raptors	Vince Carter was trad...	raptors indianapolis -- a...	raptors, indianapoli...

120000 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 [ ]: threshold = 10 # umbral de frecuencia de las palabras
tokens = train_df['tokens'].explode().value_counts() # contamos la frecuencia
tokens = tokens[tokens > threshold] # seleccionamos las palabras que superan
id_to_token = ['[UNK]'] + tokens.index.tolist() # creamos una lista con las
token_to_id = {w:i for i,w in enumerate(id_to_token)} # creamos un diccionario
vocabulary_size = len(id_to_token) # obtenemos el tamaño del vocabulario
print(f'vocabulary size: {vocabulary_size:,}') # mostramos el tamaño del voc
```

vocabulary size: 19,668

```
In [ ]: from collections import defaultdict # importamos la clase defaultdict de la
def make_feature_vector(tokens, unk_id=0): # esta es la función que convierte
    vector = defaultdict(int) # inicializamos un diccionario con valores enteros
    for t in tokens: # iteramos sobre los tokens
        i = token_to_id.get(t, unk_id) # obtenemos el índice de la palabra en el diccionario
        vector[i] += 1 # incrementamos el valor del índice en el diccionario
    return vector # retornamos el diccionario

train_df['features'] = train_df['tokens'].progress_map(make_feature_vector)
train_df # mostramos el dataframe
```

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Out[]:

	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, 566: 1, 1609: 1, 15347: 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...	{16371: 2, 1077: 1, 854: 1, 1287: 1, 4243: 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, 4575: 1, 158: 1, 116: 1,...
3	3	Business	Iraq Halts Oil Exports from Main Southern Pipe...	Reuters - Authorities have halted oil export\...	iraq halts oil exports from main southern pipe...	[iraq, halts, oil, exports, from, main, southe...	{77: 2, 7404: 1, 66: 3, 1785: 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, 4376: 1, 4: 2, 3590: 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...	{8468: 2, 2634: 1, 5: 4, 0: 3, 127: 1, 203: 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...	{7747: 2, 68: 1, 660: 1, 4: 2, 1440: 2, 704: 1...

	class index	class	title	description	text	tokens	features
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...	{106: 1, 23: 1, 728: 1, 225: 1, 1588: 1, 22: 1...
119999	2	Sports	Nets get Carter from Raptors	INDIANAPOLIS -- All-Star Vince Carter was trad...	nets get carter from raptors indianapolis -- a...	[nets, get, carter, from, raptors, indianapoli...	{2163: 2, 226: 1, 2403: 2, 32: 1, 2994: 2, 219...

120000 rows × 7 columns

```
In [ ]: def make_dense(feats): # esta función convierte el vector de características
        x = np.zeros(vocabulary_size) # inicializamos un vector de ceros
        for k,v in feats.items(): # iteramos sobre los elementos del vector de c
            x[k] = v # asignamos el valor del elemento al vector denso
        return x # retornamos el vector denso

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

X_train = torch.tensor(X_train, dtype=torch.float32) # convertimos la matriz
y_train = torch.tensor(y_train) # convertimos el arreglo de etiquetas a un t

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```

```
In [ ]: from torch import nn # importamos el módulo nn de torch
        from torch import optim # importamos el módulo optim de torch

        # hyperparameters
        lr = 1.0 # learning rate
        n_epochs = 5 # number of epochs
        n_examples = X_train.shape[0] # number of examples
        n_feats = X_train.shape[1] # number of features
        n_classes = len(labels) # number of classes

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

        # train the model
        indices = np.arange(n_examples) # create an array of indices
        for epoch in range(n_epochs): # iterate over the epochs
            np.random.shuffle(indices) # shuffle the indices
            for i in tqdm(indices, desc=f'epoch {epoch+1}'): # iterate over the exam
                # clear gradients
                model.zero_grad() # clear gradients
                # send datum to right device
```

```

x = X_train[i].unsqueeze(0).to(device) # send the feature vector to
y_true = y_train[i].unsqueeze(0).to(device) # send the label to the
# predict label scores
y_pred = model(x) # predict the label scores
# compute loss
loss = loss_func(y_pred, y_true) #
# backpropagate
loss.backward() # backpropagate the loss
# optimize model parameters
optimizer.step() # optimize the model parameters

```

```

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]

```

Next, we evaluate on the test dataset

```

In [ ]: # repeat all preprocessing done above, this time on the test set
test_df = pd.read_csv('./test.csv', header=None) # leemos el archivo csv
test_df.columns = ['class index', 'title', 'description'] # le asignamos non
test_df['text'] = test_df['title'].str.lower() + " " + test_df['description']
test_df['text'] = test_df['text'].str.replace('\\', ' ', regex=False) # reen
test_df['tokens'] = test_df['text'].progress_map(word_tokenize) # tokenizamo
test_df['features'] = test_df['tokens'].progress_map(make_feature_vector) #

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0%|          | 0/7601 [00:00<?, ?it/s]

```

Out[]:

	class index	title	description	text	tokens	features
0	Class Index	Title	Description	title description	[title, description]	{394: 1, 3701: 1}
1	3	Fears for T N pension after talks	Unions representing workers at Turner Newall...	fears for t n pension after talks unions repre...	[fears, for, t, n, pension, after, talks, unio...	{862: 1, 11: 1, 151: 1, 5349: 1, 1471: 1, 38: ...
2	4	The Race is On: Second Private Team Sets Launc...	SPACE.com - TORONTO, Canada -- A second\team o...	the race is on: second private team sets launc...	[the, race, is, on, :, second, private, team, ...	{1: 3, 493: 1, 24: 1, 10: 1, 28: 1, 133: 2, 92...
3	4	Ky. Company Wins Grant to Study Peptides (AP)	AP - A company founded by a chemistry research...	ky. company wins grant to study peptides (ap) ...	[ky., company, wins, grant, to, study, peptide...	{11738: 1, 60: 2, 407: 1, 4362: 2, 4: 2, 514: ...
4	4	Prediction Unit Helps Forecast Wildfires (AP)	AP - It's barely dawn when Mike Fitzpatrick st...	prediction unit helps forecast wildfires (ap) ...	[prediction, unit, helps, forecast, wildfires,...	{9154: 1, 612: 1, 2049: 1, 705: 1, 0: 4, 14: 1...
...
7596	1	Around the world	Ukrainian presidential candidate Viktor Yushch...	around the world ukrainian presidential candid...	[around, the, world, ukrainian, presidential, ...	{437: 1, 1: 2, 58: 1, 4477: 1, 389: 1, 1398: 1...
7597	2	Void is filled with Clement	With the supply of attractive pitching options...	void is filled with clement with the supply of...	[void, is, filled, with, clement, with, the, s...	{9010: 1, 24: 1, 4890: 1, 19: 3, 9831: 2, 1: 5...
7598	2	Martinez leaves bitter	Like Roger Clemens did almost exactly eight ye...	martinez leaves bitter like roger clemens did ...	[martinez, leaves, bitter, like, roger, clemen...	{2131: 2, 1790: 1, 2951: 2, 317: 1, 1698: 1, 2...
7599	3	5 of arthritis patients in Singapore take Bext...	SINGAPORE : Doctors in the United States have ...	5 of arthritis patients in singapore take bext...	[5, of, arthritis, patients, in, singapore, ta...	{627: 1, 6: 1, 2701: 1, 2439: 1, 7: 2, 1019: 2...
7600	3	EBay gets into rentals	EBay plans to buy the	ebay gets into rentals ebay	[ebay, gets, into, rentals,	{1563: 2, 537: 1, 73:

class index	title	description	text	tokens	features
		apartment and home renta...	plans to buy the a...	ebay, plans, to, b...	1, 11111: 1, 160: 1, 4: ...

7601 rows × 6 columns

```
In [ ]: test_df = test_df.drop(index=0).reset_index(drop=True) # eliminamos la primera fila
test_df # mostramos el dataframe
```

Out[]:

	class index	title	description	text	tokens	features
0	3	Fears for T N pension after talks	Unions representing workers at Turner Newall...	fears for t n pension after talks unions repre...	[fears, for, t, n, pension, after, talks, unio...	{862: 1, 11: 1, 151: 1, 5349: 1, 1471: 1, 38: ...
1	4	The Race is On: Second Private Team Sets Launc...	SPACE.com - TORONTO, Canada -- A second\team o...	the race is on: second private team sets launc...	[the, race, is, on, :, second, private, team, ...	{1: 3, 493: 1, 24: 1, 10: 1, 28: 1, 133: 2, 92...
2	4	Ky. Company Wins Grant to Study Peptides (AP)	AP - A company founded by a chemistry research...	ky. company wins grant to study peptides (ap) ...	[ky., company, wins, grant, to, study, peptide...	{11738: 1, 60: 2, 407: 1, 4362: 2, 4: 2, 514: ...
3	4	Prediction Unit Helps Forecast Wildfires (AP)	AP - It's barely dawn when Mike Fitzpatrick st...	prediction unit helps forecast wildfires (ap) ...	[prediction, unit, helps, forecast, wildfires,...	{9154: 1, 612: 1, 2049: 1, 705: 1, 0: 4, 14: 1...
4	4	Calif. Aims to Limit Farm- Related Smog (AP)	AP - Southern California's smog-fighting agenc...	calif. aims to limit farm- related smog (ap) ap...	[calif., aims, to, limit, farm- related, smog, ...	{1076: 1, 1713: 1, 4: 2, 3282: 1, 0: 4, 13226:...
...
7595	1	Around the world	Ukrainian presidential candidate Viktor Yushch...	around the world ukrainian presidential candid...	[around, the, world, ukrainian, presidential, ...	{437: 1, 1: 2, 58: 1, 4477: 1, 389: 1, 1398: 1...
7596	2	Void is filled with Clement	With the supply of attractive pitching options...	void is filled with clement with the supply of...	[void, is, filled, with, clement, with, the, s...	{9010: 1, 24: 1, 4890: 1, 19: 3, 9831: 2, 1: 5...
7597	2	Martinez leaves bitter	Like Roger Clemens did almost exactly eight ye...	martinez leaves bitter like roger clemens did ...	[martinez, leaves, bitter, like, roger, clemen...	{2131: 2, 1790: 1, 2951: 2, 317: 1, 1698: 1, 2...
7598	3	5 of arthritis patients in Singapore take Bext...	SINGAPORE : Doctors in the United States have ...	5 of arthritis patients in singapore take bext...	[5, of, arthritis, patients, in, singapore, ta...	{627: 1, 6: 1, 2701: 1, 2439: 1, 7: 2, 1019: 2...

	class index	title	description	text	tokens	features
7599	3	EBay gets into rentals	EBay plans to buy the apartment and home renta...	ebay gets into rentals ebay plans to buy the a...	[ebay, gets, into, rentals, ebay, plans, to, b...	{1563: 2, 537: 1, 73: 1, 11111: 1, 160: 1, 4: ...

7600 rows × 6 columns

```
In [ ]: test_df['class_index'] = pd.to_numeric(test_df['class_index'], errors='coerc
```

```
In [ ]: X_test = np.stack(test_df['features'].progress_map(make_dense)) # convertimos
y_test = test_df['class_index'].to_numpy() - 1 # convertimos las etiquetas a
X_test = torch.tensor(X_test, dtype=torch.float32) # convertimos la matriz c
y_test = torch.tensor(y_test) # convertimos el arreglo de etiquetas a un ter
```

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

```
In [ ]: from sklearn.metrics import classification_report # importamos la función cl

# set model to evaluation mode
model.eval()

# don't store gradients
with torch.no_grad(): # no almacenar gradientes
    X_test = X_test.to(device) # enviar la matriz de características al disp
    y_pred = torch.argmax(model(X_test), dim=1) # predecir las etiquetas
    y_pred = y_pred.cpu().numpy() # convertir las etiquetas a un arreglo de
    print(classification_report(y_test, y_pred, target_names=labels)) # most
```

	precision	recall	f1-score	support
World	0.95	0.82	0.88	1900
Sports	0.93	0.98	0.95	1900
Business	0.85	0.86	0.85	1900
Sci/Tech	0.82	0.89	0.85	1900
accuracy			0.89	7600
macro avg	0.89	0.89	0.88	7600
weighted avg	0.89	0.89	0.88	7600