Multiclass Text Classification with

Feed-forward Neural Networks and Word Embeddings

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 '
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 [2]:

```
train_df = pd.read_csv('/kaggle/input/ag-news-classification-dataset/train.c
train_df.columns = ['class index', 'title', 'description']
train_df
```

Out[2]:

	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\f...
...	...	...	...
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 [3]:

```
non_numeric = train_df[~train_df['class index'].str.isnumeric()]
print(non_numeric)
```

```
  class index  title  description
0  Class Index  Title  Description
```

In [4]:

```
train_df = train_df.drop(0).reset_index(drop=True)
```

In [5]:

```
non_numeric = train_df[~train_df['class index'].str.isnumeric()]
print(non_numeric)
```

```
Empty DataFrame
Columns: [class index, title, description]
Index: []
```

In [6]:
```
train_df['class index'] = train_df['class index'].astype(int)
```

In [7]:
```
labels = ['World', 'Sports', 'Business', 'Sci/Tech']
classes = train_df['class index'].map(lambda i: labels[i-1])
train_df.insert(1, 'class', classes)
train_df.head()
```

Out[7]:

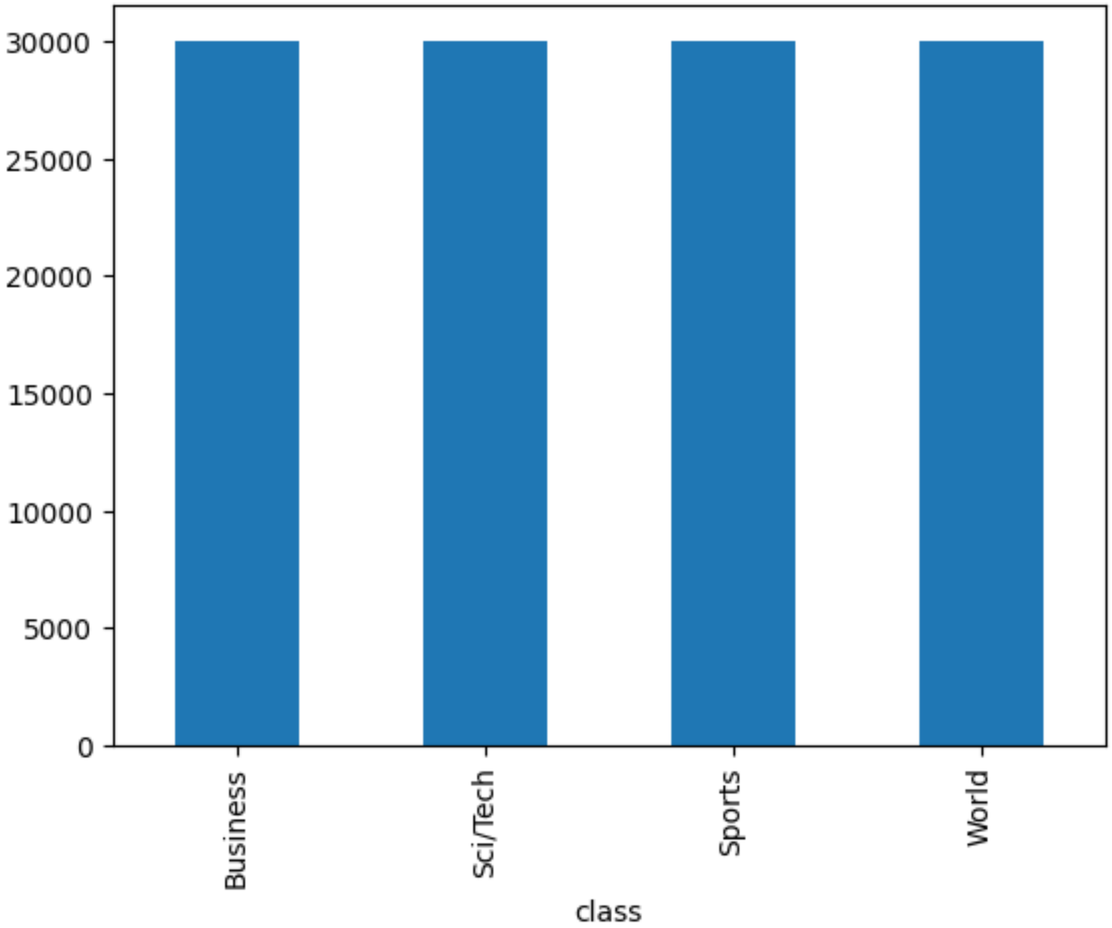
	class index	class	title	description
0	3	Business	Wall St. Bears Claw Back Into the Black (Reuters)	Reuters - Short-sellers, Wall Street's dwindli...
1	3	Business	Carlyle Looks Toward Commercial Aerospace (Reu...	Reuters - Private investment firm Carlyle Grou...
2	3	Business	Oil and Economy Cloud Stocks' 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...

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

In [8]:
```
pd.value_counts(train_df['class']).plot.bar()
```

```
/tmp/ipykernel_30/1245903889.py:1: FutureWarning: pandas.value_counts is dep
recated and will be removed in a future version. Use pd.Series(obj).value_co
unts() instead.
  pd.value_counts(train_df['class']).plot.bar()
```

Out[8]:
```
<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 [9]:
```
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 [10]:
```
train_df['text'] = train_df['title'].str.lower() + " " + train_df['descripti
train_df['text'] = train_df['text'].str.replace('\\', ' ', regex=False)
train_df
```

Out[10]:

	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...
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...
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 × 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 [11]:

```python
from nltk.tokenize import word_tokenize

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

```
 0%|          | 0/120000 [00:00<?, ?it/s]
```

Out[11]:

	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...

	class index	class	title	description	text	tokens
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...

120000 rows × 6 columns

Now we will load the GloVe word embeddings.

In [12]:

```
from gensim.models import KeyedVectors
glove = KeyedVectors.load_word2vec_format("/kaggle/input/glove6b300dtxt/glov
glove.vectors.shape
```

Out[12]:

```
(400000, 300)
```

The word embeddings have been pretrained in a different corpus, so it would be a good idea to estimate how good our tokenization matches the GloVe vocabulary.

In [13]:

```
from collections import Counter

def count_unknown_words(data, vocabulary):
    counter = Counter()
    for row in tqdm(data):
        counter.update(tok for tok in row if tok not in vocabulary)
    return counter

# find out how many times each unknown token occurrs in the corpus
c = count_unknown_words(train_df['tokens'], glove.key_to_index)

# find the total number of tokens in the corpus
total_tokens = train_df['tokens'].map(len).sum()

# find some statistics about occurrences of unknown tokens
unk_tokens = sum(c.values())
percent_unk = unk_tokens / total_tokens
distinct_tokens = len(list(c))

print(f'total number of tokens: {total_tokens:,}')
print(f'number of unknown tokens: {unk_tokens:,}')
print(f'number of distinct unknown tokens: {distinct_tokens:,}')
print(f'percentage of unkown tokens: {percent_unk:.2%}')
print('top 50 unknown words:')
for token, n in c.most_common(10):
    print(f'\t{n}\t{token}')
```

```
  0%|          | 0/120000 [00:00<?, ?it/s]
```

```
total number of tokens: 5,273,096
number of unknown tokens: 66,008
number of distinct unknown tokens: 24,792
percentage of unkown tokens: 1.25%
top 50 unknown words:
        2984    /b
        2119    href=
        2117    /a
        1813    //www.investor.reuters.com/fullquote.aspx
        1813    target=/stocks/quickinfo/fullquote
        537     /p
        510     newsfactor
        471     cbs.mw
        431     color=
        417     /font
```

Glove embeddings seem to have a good coverage on this dataset -- only 1.25% of the tokens in the dataset are unknown, i.e., don't appear in the GloVe vocabulary.

Still, we will need a way to handle these unknown tokens. Our approach will be to add a new embedding to GloVe that will be used to represent them. This new embedding will be initialized as the average of all the GloVe embeddings.

We will also add another embedding, this one initialized to zeros, that will be used to pad the sequences of tokens so that they all have the same length. This will be useful when we train with mini-batches.

In [14]:

```python
# string values corresponding to the new embeddings
unk_tok = '[UNK]'
pad_tok = '[PAD]'

# initialize the new embedding values
unk_emb = glove.vectors.mean(axis=0)
pad_emb = np.zeros(300)

# add new embeddings to glove
glove.add_vectors([unk_tok, pad_tok], [unk_emb, pad_emb])

# get token ids corresponding to the new embeddings
unk_id = glove.key_to_index[unk_tok]
pad_id = glove.key_to_index[pad_tok]

unk_id, pad_id
```

Out[14]:

```
(400000, 400001)
```

Extendemos el modelo de embeddings preentrenado glove al agregar representaciones para tokens especiales de palabras desconocidas

In [15]:

```python
from sklearn.model_selection import train_test_split

train_df, dev_df = train_test_split(train_df, train_size=0.8)
train_df.reset_index(inplace=True)
```

```
dev_df.reset_index(inplace=True)
```

We will now add a new column to our dataframe that will contain the padded sequences of token ids.

In [16]:

```
threshold = 10
tokens = train_df['tokens'].explode().value_counts()
vocabulary = set(tokens[tokens > threshold].index.tolist())
print(f'vocabulary size: {len(vocabulary):,}')
```

```
vocabulary size: 17,441
```

In [17]:

```
# find the length of the longest list of tokens
max_tokens = train_df['tokens'].map(len).max()

# return unk_id for infrequent tokens too
def get_id(tok):
    if tok in vocabulary:
        return glove.key_to_index.get(tok, unk_id)
    else:
        return unk_id

# function that gets a list of tokens and returns a list of token ids,
# with padding added accordingly
def token_ids(tokens):
    tok_ids = [get_id(tok) for tok in tokens]
    pad_len = max_tokens - len(tok_ids)
    return tok_ids + [pad_id] * pad_len

# add new column to the dataframe
train_df['token ids'] = train_df['tokens'].progress_map(token_ids)
train_df
```

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

Out[17]:

	index	class index	class	title	description	text	tokens
0	9116	1	World	Najaf's Residents Feel Trapped in Battle (AP)	AP - For nearly three weeks, Amer al-Jamali ha...	najaf's residents feel trapped in battle (ap) ...	[najaf, 's, residents, feel, trapped, in, batt...
1	99831	3	Business	U.S. FDA Adds Restrictions to Acne Drug	WASHINGTON (Reuters) - Roche's acne drug Accu...	u.s. fda adds restrictions to acne drug washi...	[u.s., fda, adds, restrictions, to, acne, drug...
2	10663	3	Business	Smithfield Foods Profit More Than Doubles	Smithfield Foods Inc. (SFD.N: Quote, Profile, ...	smithfield foods profit more than doubles smit...	[smithfield, foods, profit, more, than, double...
3	73175	4	Sci/Tech	PluggedIn: The OQO Is Not Just Another Handhel...	SAN FRANCISCO (Reuters) - A full-fledged Wind...	pluggedin: the oqo is not just another handhel...	[pluggedin, :, the, oqo, is, not, just, anothe...
4	104494	4	Sci/Tech	IBM invigorates LTO tape storage	LTO (linear tape open)-based drives are invigo...	ibm invigorates lto tape storage lto (linear t...	[ibm, invigorates, lto, tape, storage, lto, (,...
...	...	...	...	...	...	...	...
95995	89460	1	World	Bush, Blair See Hope for Palestinian State (AP)	AP - As Yasser Arafat was buried, President Bu...	bush, blair see hope for palestinian state (ap...	[bush, ,, blair, see, hope, for, palestinian, ...
95996	60620	1	World	Ex-Soldiers Vow to Bring Order to Haiti Capital	Ex-soldiers who helped topple former President...	ex-soldiers vow to bring order to haiti capita...	[ex-soldiers, vow, to, bring, order, to, haiti...

	index	class index	class	title	description	text	tokens	
95997	34086	1	World	Musharraf says U.S. must address root of terro...	Reuters - The United States could lose its war...	musharraf says u.s. must address root of terro...	[musharraf, says, u.s., must, address, root, o...	! 1
95998	58067	1	World	Nuclear materials #39;vanish #39; in Iraq	Equipment and materials that could be used to ...	nuclear materials #39;vanish #39; in iraq equ...	[nuclear, materials, #, 39, ;, vanish, #, 39, ...	
95999	92975	4	Sci/Tech	In Brief: Bowstreet unveils pre-packaged porta...	Bowstreet this week launched its Enterprise Po...	in brief: bowstreet unveils pre-packaged porta...	[in, brief, :, bowstreet, unveils, pre-package...	[4 4

96000 rows × 8 columns

Que todas las secuencias sean de la misma longitud. Las listas de tokens ahora van a ser IDs de tokens.

In [18]:

```
max_tokens = dev_df['tokens'].map(len).max()
dev_df['token ids'] = dev_df['tokens'].progress_map(token_ids)
dev_df
```

```
 0%|          | 0/24000 [00:00<?, ?it/s]
```

Out[18]:

	index	class index	class	title	description	text	tokens
0	60974	1	World	Sharon Accepts Plan to Reduce Gaza Army Operat...	Israeli Prime Minister Ariel Sharon accepted a...	sharon accepts plan to reduce gaza army operat...	[sharon, accepts, plan, to, reduce, gaza, army...
1	50391	4	Sci/Tech	Internet Key Battleground in Wildlife Crime Fight	Why trawl through a sweaty illegal\wildlife ma...	internet key battleground in wildlife crime fi...	[internet, key, battleground, in, wildlife, cr...
2	9307	3	Business	July Durable Good Orders Rise 1.7 Percent	America's factories saw orders for costly manu...	july durable good orders rise 1.7 percent amer...	[july, durable, good, orders, rise, 1.7, perce...
3	35221	3	Business	Growing Signs of a Slowing on Wall Street	all Street #39;s earnings growth, fueled by tw...	growing signs of a slowing on wall street all ...	[growing, signs, of, a, slowing, on, wall, str...
4	40081	1	World	The New Faces of Reality TV	The introduction of children to the genre was ...	the new faces of reality tv the introduction o...	[the, new, faces, of, reality, tv, the, introd...
...	...	...	...	...	...	...	...
23995	49572	1	World	Iraqi Kidnappers Release 2 Indonesian Women	Two Indonesian women held hostage for several ...	iraqi kidnappers release 2 indonesian women tw...	[iraqi, kidnappers, release, 2, indonesian, wo...

	index	class index	class	title	description	text	tokens
23996	40409	4	Sci/Tech	Big Wi-Fi Project for Philadelphia	What would Benjamin Franklin say? Philadelphia...	big wi-fi project for philadelphia what would ...	[big, wi-fi, project, for, philadelphia, what,...
23997	70470	2	Sports	Owen scores again	Michael Owen scored the winner for Real Madrid...	owen scores again michael owen scored the winn...	[owen, scores, again, michael, owen, scored, t...
23998	7941	4	Sci/Tech	US Online Retail Sales Expected To Double In S...	Online retail sales in the US are expected to ...	us online retail sales expected to double in s...	[us, online, retail, sales, expected, to, doub...
23999	42303	1	World	Egyptian holding company says it has heard fou...	Egypt said Tuesday that Iraqi kidnappers had f...	egyptian holding company says it has heard fou...	[egyptian, holding, company, says, it, has, he...

24000 rows × 8 columns

Now we will get a numpy 2-dimensional array corresponding to the token ids, and a 1-dimensional array with the gold classes. Note that the classes are one-based (i.e., they start at one), but we need them to be zero-based, so we need to subtract one from this array.

In [19]:

```
from torch.utils.data import Dataset

class MyDataset(Dataset):
    def __init__(self, x, y):
        self.x = x
        self.y = y
    def __len__(self):
        return len(self.y)

    def __getitem__(self, index):
        x = torch.tensor(self.x[index])
        y = torch.tensor(self.y[index])
        return x, y
```

Definimos la función *getitem*. Hace que los datos se pueda utilizar para el entrenamiento por lotes.

Next, we construct our PyTorch model, which is a feed-forward neural network with two layers:

In [20]:

```
from torch import nn
import torch.nn.functional as F

class Model(nn.Module):
    def __init__(self, vectors, pad_id, hidden_dim, output_dim, dropout):
        super().__init__()
        # embeddings must be a tensor
        if not torch.is_tensor(vectors):
            vectors = torch.tensor(vectors)
        # keep padding id
        self.padding_idx = pad_id
        # embedding layer
        self.embs = nn.Embedding.from_pretrained(vectors, padding_idx=pad_id
        # feedforward layers
        self.layers = nn.Sequential(
            nn.Dropout(dropout),
            nn.Linear(vectors.shape[1], hidden_dim),
            nn.ReLU(),
            nn.Dropout(dropout),
            nn.Linear(hidden_dim, output_dim),
        )

    def forward(self, x):
        # get boolean array with padding elements set to false
        not_padding = torch.isin(x, self.padding_idx, invert=True)
        # get lengths of examples (excluding padding)
        lengths = torch.count_nonzero(not_padding, axis=1)
        # get embeddings
        x = self.embs(x)
        # calculate means
        x = x.sum(dim=1) / lengths.unsqueeze(dim=1)
        # pass to rest of the model
        output = self.layers(x)
        # calculate softmax if we're not in training mode
        #if not self.training:
        #    output = F.softmax(output, dim=1)
        return output
```

Se convierte los tokens en embeddings y se calcula la media de los embeddings de cada secuencia (excluyendo el padding), y pasa el resultado por una red

completamente conectada para obtener la salida.

Next, we implement the training procedure. We compute the loss and accuracy on the development partition after each epoch.

In [ ]:

```
from torch import optim
from torch.utils.data import DataLoader
from sklearn.metrics import accuracy_score

# hyperparameters
lr = 1e-3
weight_decay = 0
batch_size = 500
shuffle = True
n_epochs = 5
hidden_dim = 50
output_dim = len(labels)
dropout = 0.1
vectors = glove.vectors

# initialize the model, loss function, optimizer, and data-loader
model = Model(vectors, pad_id, hidden_dim, output_dim, dropout).to(device)
loss_func = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=lr, weight_decay=weight_decay)
train_ds = MyDataset(train_df['token ids'], train_df['class index'] - 1)
train_dl = DataLoader(train_ds, batch_size=batch_size, shuffle=shuffle)
dev_ds = MyDataset(dev_df['token ids'], dev_df['class index'] - 1)
dev_dl = DataLoader(dev_ds, batch_size=batch_size, shuffle=shuffle)

train_loss = []
train_acc = []

dev_loss = []
dev_acc = []

# train the model
for epoch in range(n_epochs):
    losses = []
    gold = []
    pred = []
    model.train()
    for X, y_true in tqdm(train_dl, desc=f'epoch {epoch+1} (train)'):
        # clear gradients
        model.zero_grad()
        # send batch to right device
        X = X.to(device)
        y_true = y_true.to(device)
        # predict label scores
        y_pred = model(X)
        # compute loss
        loss = loss_func(y_pred, y_true)
        # accumulate for plotting
        losses.append(loss.detach().cpu().item())
        gold.append(y_true.detach().cpu().numpy())
        pred.append(np.argmax(y_pred.detach().cpu().numpy(), axis=1))
        # backpropagate
        loss.backward()
        # optimize model parameters
        optimizer.step()
    train_loss.append(np.mean(losses))
    train_acc.append(accuracy_score(np.concatenate(gold), np.concatenate(pre

    model.eval()
    with torch.no_grad():
        losses = []
        gold = []
        pred = []
        for X, y_true in tqdm(dev_dl, desc=f'epoch {epoch+1} (dev)'):
            X = X.to(device)
            y_true = y_true.to(device)
            y_pred = model(X)
            loss = loss_func(y_pred, y_true)
            losses.append(loss.cpu().item())
            gold.append(y_true.cpu().numpy())
            pred.append(np.argmax(y_pred.cpu().numpy(), axis=1))
        dev_loss.append(np.mean(losses))
        dev_acc.append(accuracy_score(np.concatenate(gold), np.concatenate(p
```

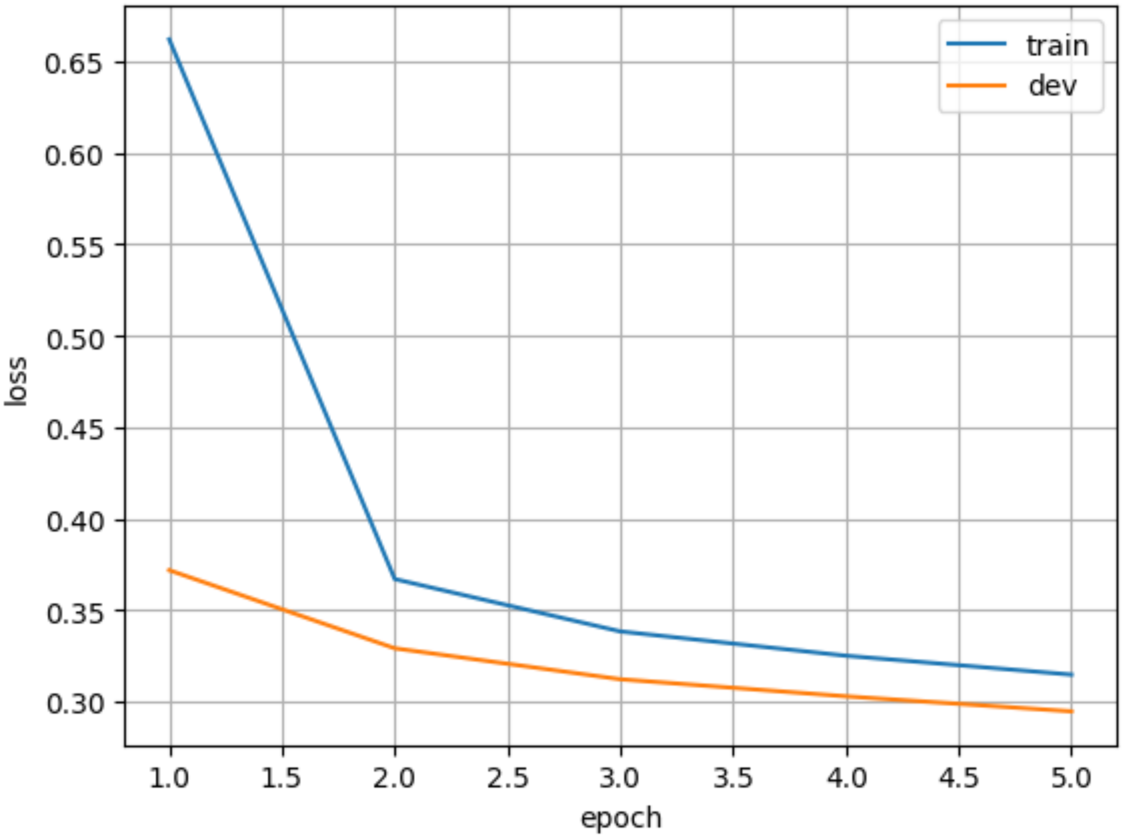
```
epoch 1 (train):   0%|          | 0/192 [00:00<?, ?it/s]
epoch 1 (dev):   0%|          | 0/48 [00:00<?, ?it/s]
epoch 2 (train):   0%|          | 0/192 [00:00<?, ?it/s]
epoch 2 (dev):   0%|          | 0/48 [00:00<?, ?it/s]
epoch 3 (train):   0%|          | 0/192 [00:00<?, ?it/s]
epoch 3 (dev):   0%|          | 0/48 [00:00<?, ?it/s]
epoch 4 (train):   0%|          | 0/192 [00:00<?, ?it/s]
epoch 4 (dev):   0%|          | 0/48 [00:00<?, ?it/s]
epoch 5 (train):   0%|          | 0/192 [00:00<?, ?it/s]
epoch 5 (dev):   0%|          | 0/48 [00:00<?, ?it/s]
```

Con optimización mediante Adam se entrena un modelo de clasificación multiclase

Let's plot the loss and accuracy on dev:

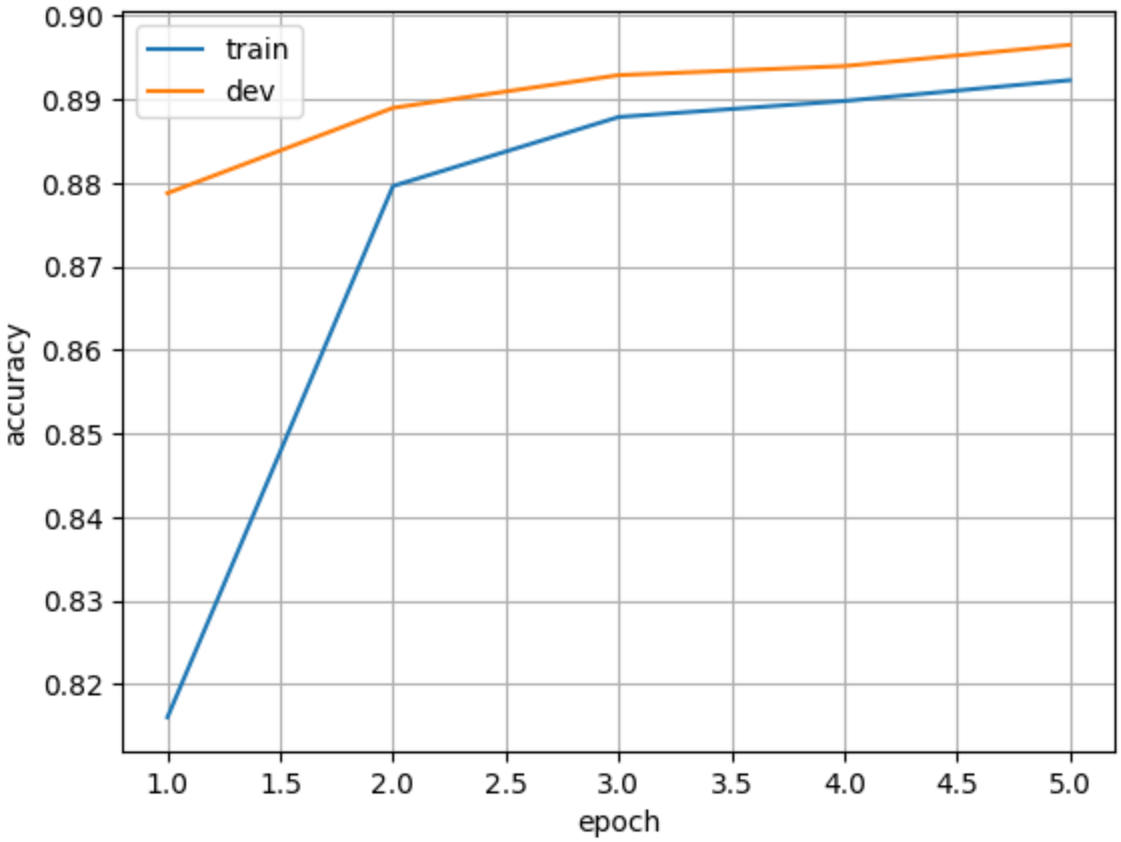
In [22]:

```
import matplotlib.pyplot as plt
%matplotlib inline

x = np.arange(n_epochs) + 1

plt.plot(x, train_loss)
plt.plot(x, dev_loss)
plt.legend(['train', 'dev'])
plt.xlabel('epoch')
plt.ylabel('loss')
plt.grid(True)
```



In [23]:

```
plt.plot(x, train_acc)
plt.plot(x, dev_acc)
plt.legend(['train', 'dev'])
plt.xlabel('epoch')
plt.ylabel('accuracy')
plt.grid(True)
```



Next, we evaluate on the testing partition:

In [24]:

```
# repeat all preprocessing done above, this time on the test set
test_df = pd.read_csv('/kaggle/input/ag-news-classification-dataset/test.csv
test_df.columns = ['class index', 'title', 'description']

test_df = test_df.drop(0).reset_index(drop=True)
test_df['class index'] = test_df['class index'].astype(int)

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)
max_tokens = dev_df['tokens'].map(len).max()
test_df['token ids'] = test_df['tokens'].progress_map(token_ids)
```

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

convertimos el texto en secuencias de tokens, asignar IDs a los tokens y normalizar la longitud de las secuencias.

In [25]:

```
from sklearn.metrics import classification_report

# set model to evaluation mode
model.eval()

dataset = MyDataset(test_df['token ids'], test_df['class index'] - 1)
data_loader = DataLoader(dataset, batch_size=batch_size)
y_pred = []
```

```
# don't store gradients
with torch.no_grad():
    for X, _ in tqdm(data_loader):
        X = X.to(device)
        # predict one class per example
        y = torch.argmax(model(X), dim=1)
        # convert tensor to numpy array (sending it back to the cpu if neede
        y_pred.append(y.cpu().numpy())
        # print results
    print(classification_report(dataset.y, np.concatenate(y_pred), target_na
```

```
  0%|          | 0/16 [00:00<?, ?it/s]
              precision    recall  f1-score   support

       World       0.92      0.89      0.90      1900
      Sports       0.95      0.98      0.96      1900
    Business       0.86      0.84      0.85      1900
    Sci/Tech       0.86      0.88      0.87      1900

    accuracy                           0.90      7600
   macro avg       0.90      0.90      0.90      7600
weighted avg       0.90      0.90      0.90      7600
```

El modelo tiene un buen rendimiento, tiene una precición de 90%