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Multiclass Text Classification with

Feed-forward Neural Networks and Word Embeddings

First, we will do some initialization.

In [9]:
```
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: cuda
random seed: 1234
```

Este bloque de código configura el entorno para un proyecto de aprendizaje profundo usando PyTorch, habilita el uso de GPU si está disponible, y establece semillas aleatorias para garantizar la reproducibilidad de los experimentos.

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 [10]:
```
train_df = pd.read_csv('/kaggle/input/ag-news/ag_news_csv/train.csv', header
train_df.columns = ['class index', 'title', 'description']
train_df
```

Out[10]:

	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

Este bloque prepara un subconjunto de datos de entrenamiento para análisis o modelado.

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 [11]:
```
labels = open('/kaggle/input/ag-news/ag_news_csv/classes.txt').read().splitl
classes = train_df['class index'].map(lambda i: labels[i-1])
train_df.insert(1, 'class', classes)
train_df
```

Out[11]:

	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

Este bloque de código transforma los índices de clase en etiquetas descriptivas, lo que hace que el conjunto de datos sea más fácil de interpretar y trabajar. Al agregar la nueva columna 'class', el DataFrame ahora contiene tanto los índices como los nombres de las clases, lo que facilitará el análisis y el entrenamiento de

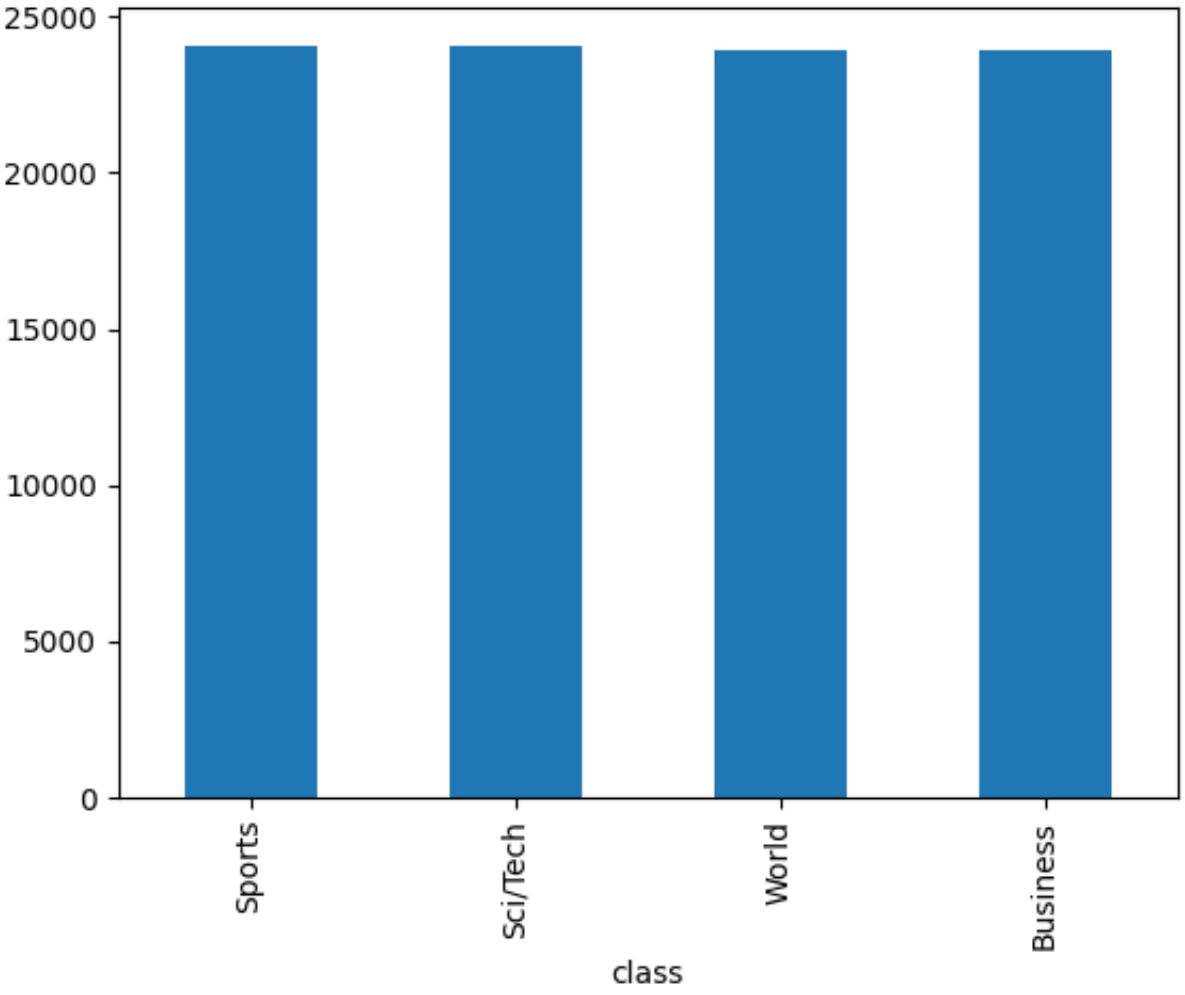
modelos de aprendizaje automático.

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

In [12]:
```
train_df=train_df.sample(frac=0.8, random_state=42)
pd.value_counts(train_df['class']).plot.bar()
```

```
/tmp/ipykernel_30/1641164020.py:2: 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[12]: <Axes: xlabel='class'>



Este bloque de código genera una gráfica de barras para una clase del Data Frame

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 [13]:
```
print(train_df.loc[0, 'description'])
```

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

Este bloque de código muestra la primera instancia de la clase "description" del DataFrame de entrenamiento.

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

In [14]:
```
train_df['text'] = train_df['title'].str.lower() + " " + train_df['descripti
train_df['text'] = train_df['text'].str.replace('\\', ' ', regex=False)
train_df
```

Out[14]:

	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 × 5 columns

Este bloque de código crea una nueva columna en el DataFrame de entrenamiento llamada "text" en el cual se encuentra una fusión de las columnas "title" y "description", con toda la información en minúsculas.

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 [15]:
```
from nltk.tokenize import word_tokenize

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

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

Out[15]:

	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...
			Coeur Still	Coeur d	coeur still	[coeur, still,

20703	3	Business	Committed to Wheaton Deal	#39;Alene Mines Corp. said Tuesday tha...	committed to wheaton deal coeur d ...	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, ,,...

96000 rows × 6 columns

Este bloque de código tokeniza el texto en la columna 'text' del DataFrame usando word_tokenize de la librería nltk y almacena los tokens en una nueva columna.

Now we will load the GloVe word embeddings.

In [16]:
```
from gensim.models import KeyedVectors
glove = KeyedVectors.load_word2vec_format("/kaggle/input/aaaaaaaaaa/glove.6E
glove.vectors.shape
```

Out[16]:
```
(400000, 300)
```

Este bloque de código carga un conjunto de vectores de palabras GloVe preentrenados y verifica la forma de los vectores cargados. La forma resultante confirmará que se han cargado correctamente los vectores y permitirá al usuario conocer cuántas palabras están representadas y la dimensionalidad de sus representaciones vectoriales.

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 [17]:
```
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
```

```python
# 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%|          | 0/96000 [00:00<?, ?it/s]
total number of tokens: 4,218,415
number of unknown tokens: 52,899
number of distinct unknown tokens: 20,979
percentage of unkown tokens: 1.25%
top 50 unknown words:
        2379    /b
        1708    href=
        1707    /a
        1461    //www.investor.reuters.com/fullquote.aspx
        1461    target=/stocks/quickinfo/fullquote
        450     /p
        396     newsfactor
        380     cbs.mw
        344     color=
        332     face=
```

Este bloque de código analiza un conjunto de datos para identificar y contar palabras que no se encuentran en un vocabulario predefinido (en este caso, los vectores GloVe). Proporciona estadísticas útiles sobre la calidad del vocabulario en relación con el corpus, como el total de tokens, la cantidad de palabras desconocidas y el porcentaje de tokens desconocidos.

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 [18]:
```
# 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[18]: (400000, 400001)

Este bloque de código agrega dos tokens especiales al modelo de embeddings GloVe para manejar palabras desconocidas y rellenar secuencias.

In [19]:
```
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)
```

Este bloque de código divide un conjunto de datos en un subconjunto de entrenamiento y otro de validación utilizando una proporción del 80/20. La división se realiza de manera aleatoria para asegurar que ambas partes sean representativas del conjunto de datos original. Después de la división, se restablecen los índices de ambos DataFrames para mantener un orden y facilitar su manipulación en pasos posteriores del análisis o modelado.

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

In [20]:
```
threshold = 10
tokens = train_df['tokens'].explode().value_counts()
vocabulary = set(tokens[tokens > threshold].index.tolist())
```

```
print(f'vocabulary size: {len(vocabulary):,}')
```

```
vocabulary size: 15,451
```

Este bloque de código construye un vocabulario a partir de los tokens en el conjunto de datos de entrenamiento, asegurando que solo se incluyan aquellos tokens que aparecen con suficiente frecuencia (más de 10 veces). Al final, se imprime el tamaño del vocabulario.

In [21]:
```
# 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%|          | 0/76800 [00:00<?, ?it/s]
```

Out[21]:

	index	class index	class	title	description	text	tokens	token ids
0	41480	3	Business	Unrest forces oil prices higher	Oil futures have jumped to their highest closi...	unrest forces oil prices higher oil futures ha...	[unrest, forces, oil, prices, higher, oil, fut...	[4615 340, 316 468 609, 316 3081, 33 3450..
1	112119	4	Sci/Tech	Old News.... REALLY Old News!	The video archives of Pathe News are online, c...	old news.... really old news! the video archiv...	[old, news, ..., ., really, old, news, !, the,...	[167, 172 434, 2 588, 167 172, 805 0, 974,..

2	75220	2	Sports	Ace in the Hole	General Manager Theo Epstein said the Red Sox ...	ace in the hole general manager theo epstein s...	[ace, in, the, hole, general, manager, theo, e...	[7588, 6 0, 2924 216, 865 15599 17434 16,..
3	111911	2	Sports	UNDATED: 14 points.	Tiffany Porter-Talbert scored 24 points, and W...	undated: 14 points. tiffany porter-talbert sco...	[undated, :, 14, points, ., tiffany, porter-ta...	[5833 45, 657 226, 2 15956 400000 878, 79..
4	80697	2	Sports	Flatley, Rogers on bench for Australia for rug...	Back from injury, Elton Flatley and Mat Rogers...	flatley, rogers on bench for australia for rug...	[flatley, ,, rogers, on, bench, for, australia...	[400000 1, 5638 13, 4530 10, 603 10 2707,..
...	...	...	...	...	...	...	...	..
76795	110136	2	Sports	Gerrard aiming high	Steven Gerrard insists he #39;ll not accept q...	gerrard aiming high steven gerrard insists he ...	[gerrard, aiming, high, steven, gerrard, insis...	[15773 7584 152 4411 15773 4971, 18 2749..
76796	112554	3	Business	Local gamer: Grand Theft Auto #39; steals the ...	Just how excited is Justin Field about the new...	local gamer: grand theft auto #39; steals the ...	[local, gamer, :, grand, theft, auto, #, 39, ;...	[250 400000 45, 1063 6539 2612 2749 3403..
76797	116840	3	Business	Sprint, Nextel Agree To Merge	The deal, valued at $35 billion, will create ...	sprint, nextel agree to merge the deal, valued...	[sprint, ,, nextel, agree, to, merge, the, dea...	[5514, 1 17774 2137, 4 9194, 0 435, 1 595..
76798	34067	3	Business	Export Cut to China Seen as	Yukos, the Russian oil giant, is	export cut to china seen as	[export, cut, to, china,	[2467 611, 4 132, 541

				Clever Strategy on...	playing a wea...	clever strategy on...	seen, as, clever, str...	19, 11114 1747, 13 ..
76799	34374	2	Sports	Clough: A genuine original	Although Brian Clough retired from management ...	clough: a genuine original although brian clou...	[clough, :, a, genuine, original, although, br...	[35035 45, 7 7231 929 376 2789 35035 16..

76800 rows × 8 columns

Este bloque de código convierte listas de tokens en listas de IDs de tokens, asegurando que todas las listas tengan la misma longitud mediante el uso de relleno. La función get_id maneja la asignación de IDs a tokens conocidos y desconocidos, mientras que la función token_ids se encarga de generar la lista de IDs y agregar el relleno necesario. Al final, se añade esta nueva información al DataFrame

In [22]:
```
max_tokens = dev_df['tokens'].map(len).max()
dev_df['token ids'] = dev_df['tokens'].progress_map(token_ids)
dev_df
```

```
0%|          | 0/19200 [00:00<?, ?it/s]
```

Out[22]:

	index	class index	class	title	description	text	toker
0	96457	1	World	House G.O.P. Leader Hails Ethics Panel's Rebuk...	Tom DeLay of Texas claimed vindication today a...	house g.o.p. leader hails ethics panel's rebuk...	[house, g.o. ., leader, hail ethics, panel
1	65284	2	Sports	Pittsburgh Steelers Notes	Bill Cowher is no longer 0-for-Texas. He beat ...	pittsburgh steelers notes bill cowher is no lo...	[pittsburg steeler notes, bi cowher, is
				US, Iraq	SAMARRA,	us, iraq control	[us, ,, ira

2	48958	1	World	control Samarra	Iraq - US and Iraqi forces in Samarra...	samarra samarra, iraq - us an...	contro samarr samarra, ,, ir
3	78606	4	Sci/Tech	Novel Approach Targets Alzheimer #39;s Develop...	A new technique may someday be able to stop Al...	novel approach targets alzheimer #39;s develop...	[nove approac target alzheimer, 39, ;
4	68705	1	World	EU #39;s Prodi ready to stay on if new Brussel...	European Commission head Romano Prodi would be...	eu #39;s prodi ready to stay on if new brussel...	[eu, #, 39, ;, prodi, read to, stay, on,
...	...	...	...	...	...	...	
19195	105060	4	Sci/Tech	Sun buys IT services company to help HP/IBM fight	Sun Microsystems is buying IT services company...	sun buys it services company to help hp/ibm fi...	[sun, buys, service company, t help, h
19196	93591	2	Sports	Raps down and out in LA	The Raptors have to be reminded sometimes that...	raps down and out in la the raptors have to be...	[raps, dow and, out, in, l the, raptor h
19197	97615	2	Sports	South Africa in strong position Kanpur Test	KANPUR: Andrew Halls unbeaten knock of 78 help...	south africa in strong position kanpur test ka...	[south, afric in, stron positio kanpur,
19198	11883	3	Business	Oil Rebounds After Iraq Pipeline	LONDON (Reuters) - Oil prices	oil rebounds after iraq pipeline	[oil, rebound after, ira pipelin

				Attack	rose on Friday ...	attack londo...	attack,
19199	7378	1	World	Impoverished families of Nepal hostages in Ira...	AFP - Relatives of 12 Nepalese workers missing...	impoverished families of nepal hostages in ira...	[impoverishe families, c nepa hostages,

19200 rows × 8 columns

Este bloque de código calcula la longitud máxima de las listas de tokens en el conjunto de desarrollo y utiliza esta información para convertir las listas de tokens en listas de IDs de tokens, asegurando que todas las listas tengan la misma longitud mediante el uso de relleno. La nueva columna token ids en el DataFrame dev_df contendrá esta información.

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 [23]:
```
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
```

La clase MyDataset proporciona una forma estructurada de manejar datos en PyTorch. Permite encapsular las características y etiquetas en un formato que puede ser fácilmente utilizado por los DataLoader de PyTorch para entrenar modelos de aprendizaje automático. Al definir métodos como len y getitem, se asegura que la clase cumpla con las expectativas de PyTorch para un objeto

Dataset, facilitando la iteración y el muestreo de datos durante el entrenamiento.

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

In [24]:
```
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
```

La clase Model define una red neuronal para clasificación de texto que utiliza embeddings preentrenados. Se encarga de convertir índices de tokens en embeddings, calcular la media de los embeddings (excluyendo los de relleno) y pasar esa representación a través de una serie de capas para producir una salida.

El uso de capas de dropout ayuda a mitigar el sobreajuste durante el entrenamiento.

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

In [25]:
```
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)
```

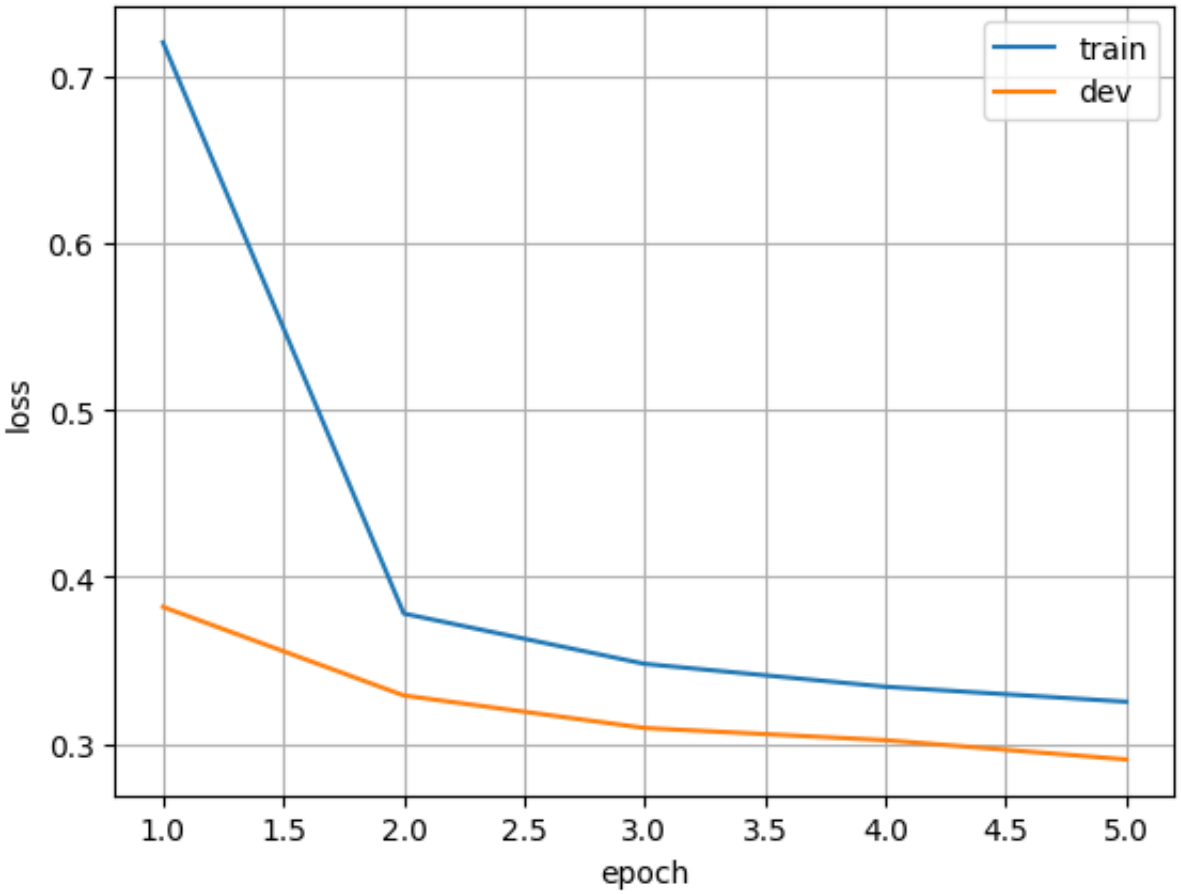
```
        # predict label scores
        y_pred = model(X)
        # compute loss
        loss = loss_func(y_pred, y_true)
        # accumulate for plotting
        losses.append(loss.detach().cpu().item())
        gold.append(y_true.detach().cpu().numpy())
        pred.append(np.argmax(y_pred.detach().cpu().numpy(), 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%|          | 0/154 [00:00<?, ?it/s]
epoch 1 (dev):   0%|          | 0/39 [00:00<?, ?it/s]
epoch 2 (train):   0%|          | 0/154 [00:00<?, ?it/s]
epoch 2 (dev):   0%|          | 0/39 [00:00<?, ?it/s]
epoch 3 (train):   0%|          | 0/154 [00:00<?, ?it/s]
epoch 3 (dev):   0%|          | 0/39 [00:00<?, ?it/s]
epoch 4 (train):   0%|          | 0/154 [00:00<?, ?it/s]
epoch 4 (dev):   0%|          | 0/39 [00:00<?, ?it/s]
epoch 5 (train):   0%|          | 0/154 [00:00<?, ?it/s]
epoch 5 (dev):   0%|          | 0/39 [00:00<?, ?it/s]
```

Este bloque de código configura y entrena un modelo de red neuronal para clasificación de texto utilizando PyTorch. Se definen los hiperparámetros, se inicializan el modelo, la función de pérdida y el optimizador. Luego, el modelo se entrena durante varias épocas, evaluando su rendimiento en un conjunto de validación después de cada época. Las pérdidas y precisiones se almacenan para su análisis posterior.

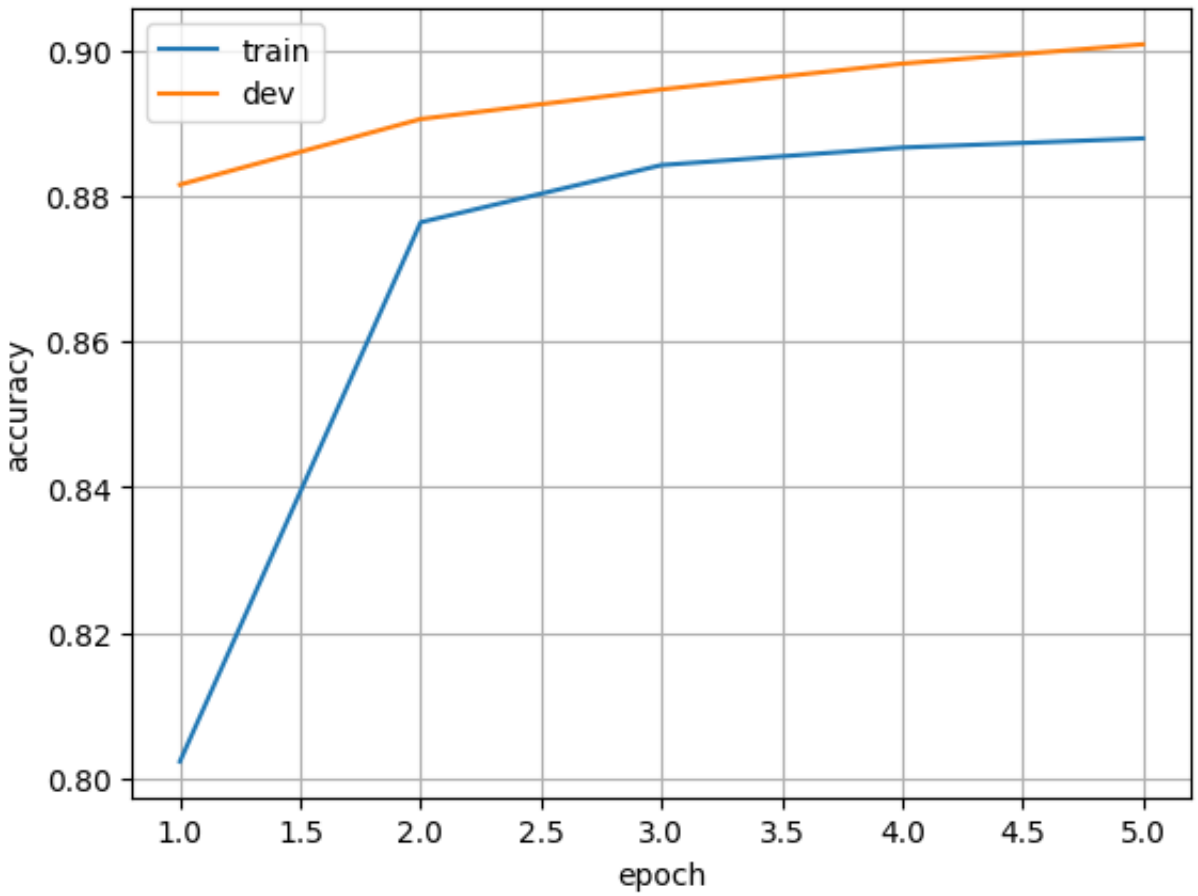
Let's plot the loss and accuracy on dev:

In [26]:
```
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)
```



Este bloque de código se encarga de visualizar la evolución de las pérdidas (losses) del modelo durante el entrenamiento y la evaluación en las épocas.

In [27]:
```
plt.plot(x, train_acc)
plt.plot(x, dev_acc)
plt.legend(['train', 'dev'])
plt.xlabel('epoch')
plt.ylabel('accuracy')
plt.grid(True)
```



Este bloque de código se centra en visualizar la precisión (accuracy) del modelo a lo largo de las épocas de entrenamiento y validación.

Next, we evaluate on the testing partition:

In [28]:
```
# repeat all preprocessing done above, this time on the test set
test_df = pd.read_csv('/kaggle/input/ag-news/ag_news_csv/test.csv', header=N
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)
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]
```

Este bloque de código prepara el conjunto de prueba para que sea compatible con el modelo entrenado, aplicando las mismas transformaciones que se aplicaron al conjunto de entrenamiento y validación. Este proceso incluye cargar los datos, limpiar y normalizar el texto, tokenizar el texto y convertir los tokens en IDs de

acuerdo a un vocabulario predefinido. Al final, el conjunto de prueba estará listo para ser evaluado utilizando el modelo previamente entrenado.

In [29]:
```
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      0.88      0.90      1900
      Sports       0.95      0.97      0.96      1900
    Business       0.85      0.85      0.85      1900
    Sci/Tech       0.86      0.87      0.87      1900

    accuracy                           0.89      7600
   macro avg       0.89      0.89      0.89      7600
weighted avg       0.89      0.89      0.89      7600
```

Este bloque de código realiza la evaluación del modelo sobre el conjunto de prueba, generando predicciones y comparándolas con las etiquetas reales para proporcionar un informe detallado de rendimiento.

El modelo ha demostrado un buen rendimiento en la clasificación de noticias, con métricas de precisión y recuperación que son bastante altas para la mayoría de las clases. Las puntuaciones F1 son igualmente robustas, indicando que el modelo no solo es preciso, sino que también es efectivo en identificar la mayoría de los ejemplos positivos. Sin embargo, la clase "Business" muestra un desempeño ligeramente inferior en comparación con las otras categorías, lo que podría ser un área para mejorar en futuros entrenamientos o ajustes del modelo.