In [1]:
```
import torch
import torch.nn as nn
import torch.nn.functional as F
from collections import Counter
from torch.utils.data import Dataset, DataLoader
import numpy as np
import re
device = 'cuda:0' if torch.cuda.is_available() else 'cpu'
```

In [2]:
```
corpus = [line.strip() for line in open('TheTimeMachine.txt') if line.strip(
print("\n".join(corpus[:10]))

# Tokenize the sentences into words
# All lower caps. Ignore punctuation.
corpus = [re.sub('[^A-Za-z0-9]+', ' ', line).lower() for line in corpus]
corpus = [re.sub(' +', ' ', line) for line in corpus]
corpus = [word for line in corpus for word in line.split()]
```

```
The Time Machine, by H. G. Wells [1898]
I
The Time Traveller (for so it will be convenient to speak of him)
was expounding a recondite matter to us. His grey eyes shone and
twinkled, and his usually pale face was flushed and animated. The
fire burned brightly, and the soft radiance of the incandescent
lights in the lilies of silver caught the bubbles that flashed and
passed in our glasses. Our chairs, being his patents, embraced and
caressed us rather than submitted to be sat upon, and there was that
luxurious after-dinner atmosphere when thought roams gracefully
```

In [3]:
```
vocab_size = 5000
tkn_counter = Counter([word for word in corpus])
vocab = {word: idx for idx, (word, _) in enumerate(tkn_counter.most_common(v
vocab["/UNK"] = len(vocab)
print(f"  * Found {len(vocab)} unique words in the provided corpus (of size
      f"  * Created vocabulary from corpus.\n"
      f"  * The 10 most common words are the following:")
print(tkn_counter.most_common(10))
```

```
  * Found 4582 unique words in the provided corpus (of size 32776).
  * Created vocabulary from corpus.
  * The 10 most common words are the following:
[('the', 2261), ('i', 1267), ('and', 1245), ('of', 1155), ('a', 816), ('to',
695), ('was', 552), ('in', 541), ('that', 443), ('my', 440)]
```

In [7]:
```
class TextCorpusDataset(Dataset):
    def __init__(self, corpus, vocab, sequence_len=50):
        super().__init__()
        self.corpus = corpus
        self.sequence_len = sequence_len

        # Vocabulary (word-to-index mapping)
        self.vocab = vocab
```

```
        # Inverse vocabulary (index-to-word mapping)
        self.inv_vocab = {idx: word for word, idx in self.vocab.items()}

    def convert2idx(self, word_sequence):
        return [self.vocab[word if word in self.vocab else "/UNK"] for word

    def convert2words(self, idx_sequence):
        return [self.inv_vocab[idx] for idx in idx_sequence]

    def __len__(self):
        return (len(self.corpus) - self.sequence_len) // self.sequence_len

    def __getitem__(self, idx):
        idx = idx * self.sequence_len
        snippet = self.corpus[idx:idx+self.sequence_len]
        snippet = torch.tensor(self.convert2idx(snippet))
        return snippet

# Test dataset function
dataset = TextCorpusDataset(corpus, vocab, sequence_len=50)
sequence = dataset[4]
print(len(dataset))
print("\nRandom sequence from the corpus.")
print("  * Token IDS:\t", sequence)
print("  * Words:\t\t", " ".join([dataset.inv_vocab[i] for i in sequence.tol
```

```
654

Random sequence from the corpus.
  * Token IDS:   tensor([  21,    5, 2211,  682,  275, 1430,  235,   15,   1
0,   21,  114,  196,
         830,   13,  180,   13,    1,  502,   29,   21,   21,  150,    3,  3
12,
           8,    4, 1047,  330,    4,  330,    3,  683, 2212,  187,   42,  4
00,
         591,   28, 1427,   21,    8, 1431,  187,    4, 1047, 2213,   58,  1
32,
          90,  244])
  * Words:               you to accept anything without reasonable ground fo
r it you will soon admit as much as i need from you you know of course that
a mathematical line a line of thickness nil has no real existence they taugh
t you that neither has a mathematical plane these things are mere
```

In [ ]:
```
class SimpleRNN(nn.Module):
    """A RNN Model implemented from scratch."""
    def __init__(self, vocab_size, hidden_dim):
        super().__init__()
        self.vocab_size, self.hidden_dim = vocab_size, hidden_dim

        self.inp2state = nn.Linear(vocab_size, hidden_dim)
        self.state2state = nn.Linear(hidden_dim, hidden_dim)
        self.state2out = nn.Linear(hidden_dim, vocab_size)
```

```
        for m in self.modules():
            if isinstance(m, nn.Linear):
                nn.init.normal_(m.weight, std=0.01)
                nn.init.zeros_(m.bias)

    def initial_state(self, batch_size, device):
        return torch.zeros((batch_size, self.hidden_dim)).to(device)

    def forward(self, inp_seq, state=None):
        n_steps, batch_size = inp_seq.shape[:2]

        # If state is not provided, get initial state.
        if state is None:
            state = self.initial_state(batch_size, inp_seq.device)

        outputs = []
        for t in range(n_steps):
            inp_at_t = inp_seq[t]
            # Compute new state: ht = tanh(Wx2h * xt + Wh2h * ht-1 + bh)
            state = torch.tanh(self.inp2state(inp_at_t) + self.state2state(s
            # Compute output: ot = Wh2o * ht + bo
            out = self.state2out(state)
            outputs.append(out)
        outputs = torch.stack(outputs, 0)

        return outputs, state

hidden_dim = 256
model = SimpleRNN(len(vocab), hidden_dim).to(device)
```

In [30]:
```
sentence = "today is too darn cold".split()
inp = F.one_hot(torch.tensor(dataset.convert2idx(sentence), device=device),
inp = inp.unsqueeze(1)
print(inp.shape)
Yhat, _ = model(inp)
print(Yhat.shape)
predicted_indices = torch.argmax(Yhat, dim=-1).squeeze(1)
Yhat_words = dataset.convert2words(predicted_indices.tolist())
print(Yhat_words)
```

```
torch.Size([5, 1, 4582])
torch.Size([5, 1, 4582])
['fix', 'nature', 'collapsed', 'fix', 'endowed']
```

In [29]:
```
@torch.no_grad()
def generate(prefix, num_preds, model, vocab):
    """Generates a sentence following the `prefix`."""
    prefix = torch.tensor(dataset.convert2idx(prefix.split()), device=device

    state, outputs = None, [prefix[0]]
    for i in range(1, len(prefix) + num_preds):
        # Prepare the current token to feed the model
        inp = F.one_hot(outputs[-1], len(vocab)).float()
        inp = inp[None, None]
```

```
        # Compute the prediction of the next token
        yhat, state = model(inp, state)

        if i < len(prefix):
            # During warmup (while parsing the prefix), we ignore the model
            outputs.append(prefix[i])
        else:
            # Otherwise, append the model prediction to the list
            yhat = yhat[..., :-1].argmax(dim=-1).reshape(1).long()
            outputs.append(yhat)
    return ' '.join([dataset.inv_vocab[tkn.item()] for tkn in outputs])

generate('i do not mean to ask you to accept anything', 10, model, vocab)
```

Out[29]:
```
'i do not mean to ask you to accept anything tampering palaeontology expres
sion declaration concerned hastings servants hull explain impartiality'
```

In [ ]:
```
def train_on_sequence(seq, model, optimizer, unroll=5):
    """Train the model within a batch of long text sequences."""
    batch_size, num_tokens = seq.shape

    total_loss, state = 0., None
    for i in range(0, num_tokens-unroll-1, unroll):
        if state is not None:
            state.detach_()

        # Define the input sequence along which we will unroll the RNN
        x_inp = seq[:, i:i+unroll]   # Must be of size T x B
        y_trg = seq[:, i+1:i+unroll+1]   # Must be of size T x B

        # Forward the model and compute the loss
        x_inp = F.one_hot(x_inp, len(vocab)).float()
        y_hat, state = model(x_inp, state)
        l = loss(y_hat.flatten(0, 1), y_trg.flatten(0, 1).long())
        total_loss += l.item()

        # Backward step
        optimizer.zero_grad()
        l.backward()
        optimizer.step()

    n_batches = (num_tokens-unroll-1) // unroll
    return total_loss/n_batches

def fit(model, loader, vocab, lr, num_epochs=100, unroll=5):
    optimizer = torch.optim.SGD(model.parameters(), lr, momentum=0.9)
    test_prompt = 'i do not mean to ask you to accept anything'
    for epoch in range(num_epochs):
        total_loss = 0
        for sequence in loader:
            total_loss += train_on_sequence(sequence.to(device), model, opti
        total_loss /= len(loader)
```

```
        print(f'Epoch {epoch} | Perplexity {np.exp(total_loss):.1f}. Loss: {
        print(generate(test_prompt, 50, model, vocab))

num_epochs, lr = 100, 0.001
dataset = TextCorpusDataset(corpus, vocab, 100)
loader = DataLoader(dataset, batch_size=32)
model = SimpleRNN(len(vocab), hidden_dim).to(device)
loss = nn.CrossEntropyLoss()
fit(model, loader, vocab, lr, num_epochs, unroll=5)
```

```
Epoch 0 | Perplexity 7226.5. Loss: 8.886
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Epoch 1 | Perplexity 7024.6. Loss: 8.857
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Epoch 2 | Perplexity 6820.5. Loss: 8.828
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Epoch 3 | Perplexity 6604.6. Loss: 8.796
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Epoch 4 | Perplexity 6354.8. Loss: 8.757
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Epoch 5 | Perplexity 6001.8. Loss: 8.700
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Epoch 6 | Perplexity 4811.2. Loss: 8.479
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Epoch 7 | Perplexity 1761.7. Loss: 7.474
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Epoch 8 | Perplexity 1218.4. Loss: 7.105
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Epoch 9 | Perplexity 1039.2. Loss: 6.946
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Epoch 10 | Perplexity 949.3. Loss: 6.856
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Epoch 11 | Perplexity 899.7. Loss: 6.802
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Epoch 12 | Perplexity 869.0. Loss: 6.767
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Epoch 13 | Perplexity 848.2. Loss: 6.743
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Epoch 14 | Perplexity 833.3. Loss: 6.725
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Epoch 15 | Perplexity 822.2. Loss: 6.712
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Epoch 16 | Perplexity 813.6. Loss: 6.701
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Epoch 17 | Perplexity 806.7. Loss: 6.693
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Epoch 18 | Perplexity 801.2. Loss: 6.686
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Epoch 19 | Perplexity 796.6. Loss: 6.680
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Epoch 20 | Perplexity 792.7. Loss: 6.675
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Epoch 21 | Perplexity 789.5. Loss: 6.671
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Epoch 22 | Perplexity 786.7. Loss: 6.668
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Epoch 23 | Perplexity 784.2. Loss: 6.665
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Epoch 24 | Perplexity 782.1. Loss: 6.662
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Epoch 25 | Perplexity 780.3. Loss: 6.660
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Epoch 26 | Perplexity 778.6. Loss: 6.658
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Epoch 27 | Perplexity 777.1. Loss: 6.656
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Epoch 28 | Perplexity 775.8. Loss: 6.654
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Epoch 29 | Perplexity 774.7. Loss: 6.652
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Epoch 30 | Perplexity 773.6. Loss: 6.651
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Epoch 31 | Perplexity 772.7. Loss: 6.650
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Epoch 32 | Perplexity 771.8. Loss: 6.649
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Epoch 33 | Perplexity 771.0. Loss: 6.648
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Epoch 34 | Perplexity 770.3. Loss: 6.647
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Epoch 35 | Perplexity 769.6. Loss: 6.646
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Epoch 36 | Perplexity 769.0. Loss: 6.645
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Epoch 37 | Perplexity 768.5. Loss: 6.644
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Epoch 38 | Perplexity 768.0. Loss: 6.644
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Epoch 39 | Perplexity 767.5. Loss: 6.643
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Epoch 40 | Perplexity 767.1. Loss: 6.643
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Epoch 41 | Perplexity 766.7. Loss: 6.642
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Epoch 42 | Perplexity 766.3. Loss: 6.642
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Epoch 43 | Perplexity 766.0. Loss: 6.641
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Epoch 44 | Perplexity 765.6. Loss: 6.641
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Epoch 45 | Perplexity 765.3. Loss: 6.640
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Epoch 46 | Perplexity 765.1. Loss: 6.640
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Epoch 47 | Perplexity 764.8. Loss: 6.640
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Epoch 48 | Perplexity 764.6. Loss: 6.639
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Epoch 49 | Perplexity 764.3. Loss: 6.639
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Epoch 50 | Perplexity 764.1. Loss: 6.639
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Epoch 51 | Perplexity 763.9. Loss: 6.638
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Epoch 52 | Perplexity 763.7. Loss: 6.638
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In [ ]:

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