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In [1]: import matplotlib.pyplot as plt
import seaborn as sns
import matplotlib as mpl
import matplotlib.pylab as pylab
import numpy as np
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In [2]: import re
```

```
In [3]: sentences = """We are about to study the idea of a computational process.
Computational processes are abstract beings that inhabit computers.
As they evolve, processes manipulate other abstract things called data.
The evolution of a process is directed by a pattern of rules
called a program. People create programs to direct processes. In effect,
we conjure the spirits of the computer with our spells."""
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In [4]: sentences = re.sub('[^A-Za-z0-9]+', ' ', sentences)
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In [5]: sentences = re.sub(r'(?:\^| )\w(?:$| )', ' ', sentences).strip()
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In [6]: sentences = sentences.lower()
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In [7]: words = sentences.split()
vocab = set(words)
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In [8]: vocab_size = len(vocab)
embed_dim = 10
context_size = 2
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In [9]: word_to_ix = {word: i for i, word in enumerate(vocab)}
ix_to_word = {i: word for i, word in enumerate(vocab)}
```

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In [10]: data = []
for i in range(2, len(words) - 2):
    context = [words[i - 2], words[i - 1], words[i + 1], words[i + 2]]
    target = words[i]
    data.append((context, target))
print(data[:5])

[(['we', 'are', 'to', 'study'], 'about'), (['are', 'about', 'study', 'the'], 't
o'), (['about', 'to', 'the', 'idea'], 'study'), (['to', 'study', 'idea', 'of'],
'the'), (['study', 'the', 'of', 'computational'], 'idea')]
```

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In [11]: embeddings = np.random.random_sample((vocab_size, embed_dim))
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In [12]: def linear(m, theta):
    w = theta
    return m.dot(w)
```

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In [13]: def log_softmax(x):  
    e_x = np.exp(x - np.max(x))  
    return np.log(e_x / e_x.sum())
```

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In [14]: def NLLLoss(logs, targets):  
    out = logs[range(len(targets)), targets]  
    return -out.sum()/len(out)
```

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In [15]: def log_softmax_crossentropy_with_logits(logits, target):  
  
    out = np.zeros_like(logits)  
    out[np.arange(len(logits)), target] = 1  
  
    softmax = np.exp(logits) / np.exp(logits).sum(axis=-1, keepdims=True)  
  
    return (- out + softmax) / logits.shape[0]
```

```
In [16]: def forward(context_idx, theta):  
    m = embeddings[context_idx].reshape(1, -1)  
    n = linear(m, theta)  
    o = log_softmax(n)  
  
    return m, n, o
```

```
In [17]: def backward(preds, theta, target_idx):  
    m, n, o = preds  
  
    dlog = log_softmax_crossentropy_with_logits(n, target_idx)  
    dw = m.T.dot(dlog)  
  
    return dw
```

```
In [18]: def optimize(theta, grad, lr=0.03):  
    theta -= grad * lr  
    return theta
```

```
In [19]: theta = np.random.uniform(-1, 1, (2 * context_size * embed_dim, vocab_size))
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```
In [20]: epoch_losses = {}

for epoch in range(80):

    losses = []

    for context, target in data:
        context_idx = np.array([word_to_ix[w] for w in context])
        preds = forward(context_idx, theta)

        target_idx = np.array([word_to_ix[target]])
        loss = NLLLoss(preds[-1], target_idx)

        losses.append(loss)

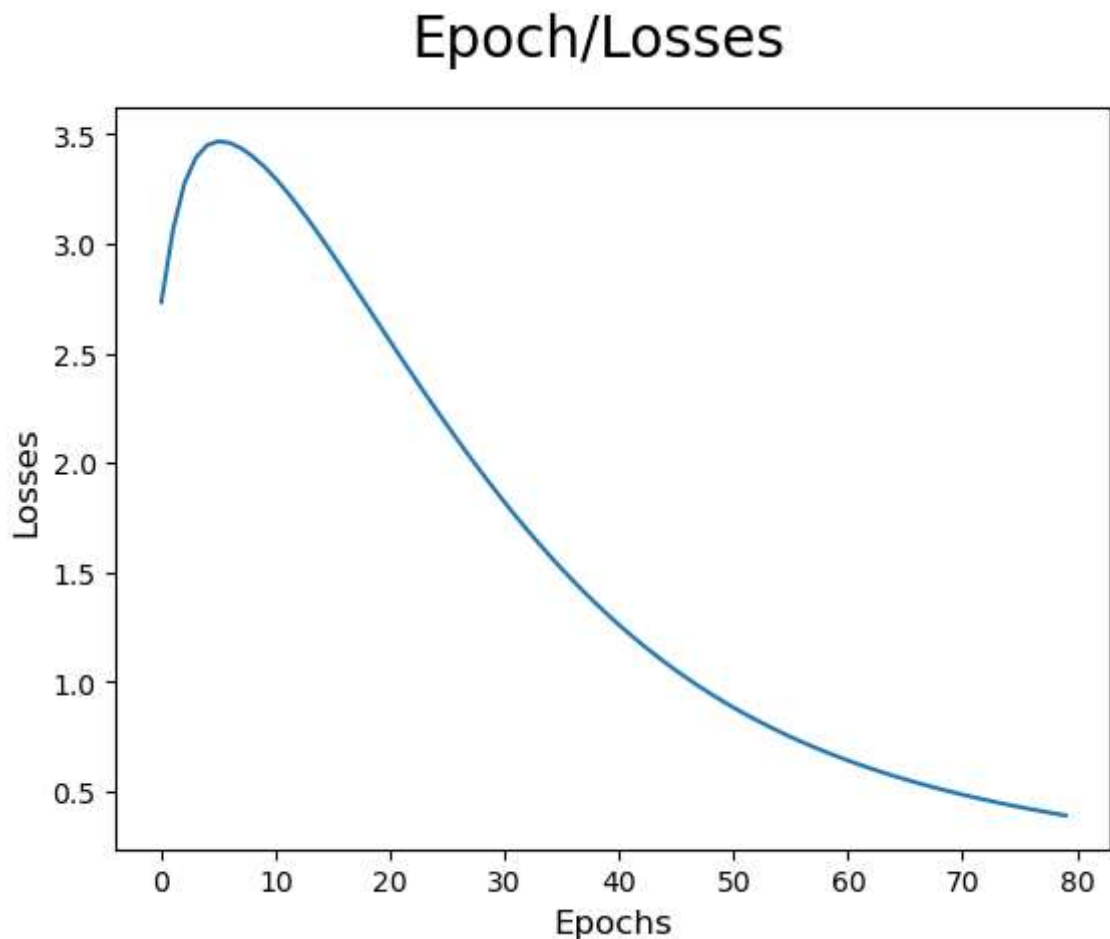
    grad = backward(preds, theta, target_idx)
    theta = optimize(theta, grad, lr=0.03)

epoch_losses[epoch] = losses
```

```
In [21]: ix = np.arange(0,80)

fig = plt.figure()
fig.suptitle('Epoch/Losses', fontsize=20)
plt.plot(ix,[epoch_losses[i][0] for i in ix])
plt.xlabel('Epochs', fontsize=12)
plt.ylabel('Losses', fontsize=12)
```

Out[21]: Text(0, 0.5, 'Losses')



```
In [22]: def predict(words):
          context_idxs = np.array([word_to_ix[w] for w in words])
          preds = forward(context_idxs, theta)
          word = ix_to_word[np.argmax(preds[-1])]

          return word
```

```
In [23]: predict(['we', 'are', 'to', 'study'])
```

Out[23]: 'about'

```
In [24]: def accuracy():  
         wrong = 0  
  
         for context, target in data:  
             if(predict(context) != target):  
                 wrong += 1  
  
         return (1 - (wrong / len(data)))
```

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In [25]: accuracy()
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Out[25]: 1.0
```

```
In [26]: predict(['processes', 'manipulate', 'things', 'study'])
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```
Out[26]: 'pattern'
```

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In [ ]:
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