

```
import matplotlib.pyplot as plt
import seaborn as sns
import matplotlib as mpl
import matplotlib.pyplot as pylab
import numpy as np
%matplotlib inline
```

```
#Data Prepration
import re
```

```
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."""
```

Clean Data

```
# remove special characters
sentences = re.sub('[^A-Za-z0-9]+', ' ', sentences)

# remove 1 letter words
sentences = re.sub(r'(?:^(| )\w(?:$| )', ' ', sentences).strip()

# lower all characters
sentences = sentences.lower()
```

Vocabulary

```
words = sentences.split()
vocab = set(words)
```

```
vocab_size = len(vocab)
embed_dim = 10
context_size = 2
```

Implementation

```
word_to_ix = {word: i for i, word in enumerate(vocab)}
ix_to_word = {i: word for i, word in enumerate(vocab)}
```

Data bags

```
# data - [(context), target]

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'], 'to'), (['a
```

Embeddings

```
embeddings = np.random.random_sample((vocab_size, embed_dim))
```

Linear Model

```
def linear(m, theta):
    w = theta
    return m.dot(w)
```

Log softmax + NLLloss = Cross Entropy

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

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

```
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]
```

Forward function

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

    return m, n, o
```

Backward function

```
def backward(preds, theta, target_idxxs):
    m, n, o = preds

    dlog = log_softmax_crossentropy_with_logits(n, target_idxxs)
    dw = m.T.dot(dlog)

    return dw
```

Optimize function

```
def optimize(theta, grad, lr=0.03):
    theta -= grad * lr
    return theta
```

Training

```
#Genrate training data
```

```
theta = np.random.uniform(-1, 1, (2 * context_size * embed_dim, vocab_size))
```

```
epoch_losses = {}
```

```
for epoch in range(80):
```

```
    losses = []
```

```
    for context, target in data:
```

```
        context_idxxs = np.array([word_to_ix[w] for w in context])
```

```
        preds = forward(context_idxxs, theta)
```

```
        target_idxxs = np.array([word_to_ix[target]])
```

```
        loss = NLLLoss(preds[-1], target_idxxs)
```

```
    losses.append(loss)
```

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

```
epoch_losses[epoch] = losses
```

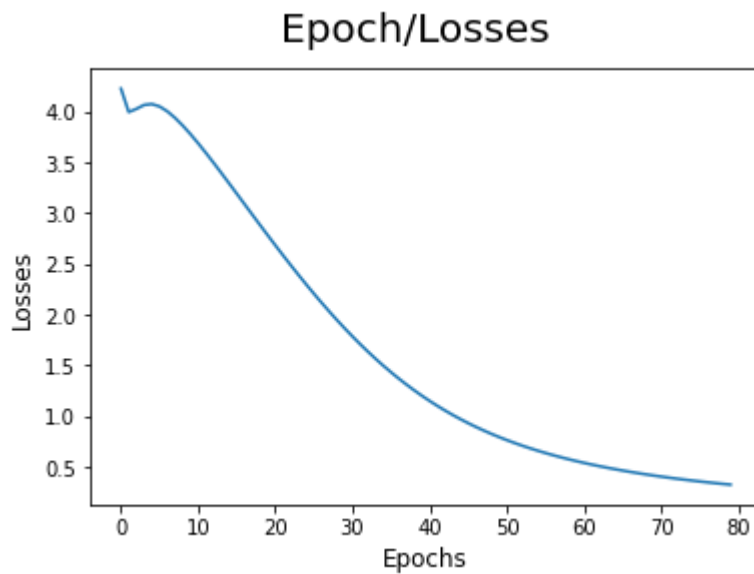
Analyze

Plot loss/epoch

```
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)
```

```
Text(0, 0.5, 'Losses')
```



Predict function

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

    return word
```

```
#(['we', 'are', 'to', 'study'], 'about')
predict(['we', 'are', 'to', 'study'])
```

'about'

Accuracy

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

```
accuracy()
```

1.0

```
predict(['processes', 'manipulate', 'things', 'study'])
```

'other'