

```
In [1]: import torch
import torch.nn as nn
import json
from torch.utils.data import Dataset
from torch.autograd import Variable
import torch.optim as optim

import numpy as np
import tqdm

import os
os.environ["CUDA_DEVICE_ORDER"]="PCI_BUS_ID"   # see issue #152
os.environ["CUDA_VISIBLE_DEVICES"]="1"

import matplotlib.pyplot as plt
```

```
In [2]: def test(net, dataloader):
net.eval()
test_loss = 0
correct = 0
criterion = nn.CrossEntropyLoss()
for batch_idx, (x, y) in enumerate(dataloader):
    x, y = x.cuda(), y.cuda()
    output = net(x)
    # sum up batch loss
    test_loss += (criterion(output, y)*x.shape[0]).item()
    # get the index of the max log-probability
    y_pred = output.data.max(1, keepdim=True)[1]
    correct += y_pred.eq(y.data.view_as(y_pred)).long().cpu().sum()

test_loss /= len(dataloader.dataset)
accuracy = correct.float() / len(dataloader.dataset)

return accuracy.item(), test_loss
```

```
In [3]: class Shakespeare(Dataset):
        def __init__(self, data_root):

            self.ALL_LETTERS = '''1234567890ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz -, \!;"[]?() .:'''
            self.NUM_LETTERS = len(self.ALL_LETTERS) # 76

            print(data_root)

            with open(data_root) as file:
                js = json.load(file)
                self.x = []
                self.y = []
                for u in js['users']:
                    self.x += js['user_data'][u]['x']
                    self.y += js['user_data'][u]['y']

            def letter_to_vec(self, letter):
                '''returns one-hot representation of given letter
                ...

                index = self.ALL_LETTERS.find(letter)
                return index

            def word_to_indices(self, word):
                '''returns a list of character indices
                Args:
                    word: string

                Return:
                    indices: int list with length len(word)
                ...

                indices = []
                for c in word:
                    indices.append(self.ALL_LETTERS.find(c))
                return indices

            def __len__(self):
                return len(self.y)

            def __getitem__(self, idx):
                x = self.x[idx]
```

```

y = self.y[idx]
return np.array(self.word_to_indices(x)), np.array(self.letter_to_vec(y))

```

```

In [4]: class RNN(nn.Module):
def __init__(self, input_size=80, hidden_size=256, embedding_dim=8, output_size=80, n_layers=2):
    super(RNN, self).__init__()
    self.input_size = input_size
    self.hidden_size = hidden_size
    self.output_size = output_size
    self.n_layers = n_layers
    self.embedding_dim = embedding_dim

    self.encoder = nn.Embedding(80, embedding_dim)
    self.lstm = nn.LSTM(input_size=embedding_dim, hidden_size=hidden_size, num_layers=n_layers,
                        batch_first=True)
    self.decoder = nn.Linear(hidden_size*input_size, output_size)

def forward(self, x):
    x = self.encoder(x)
    zx, hidden = self.lstm(x)
    output = self.decoder(zx.contiguous().view(zx.shape[0], -1))
    return output

def init_hidden(self):
    return Variable(torch.zeros(self.n_layers, 1, self.hidden_size))

```

```

In [5]: batch_size = 10
input_size = 80
embedding_dim = 8
lr = 0.01
epochs = 50

```

```

In [6]: train_set = Shakespeare('./data/train/all_data_niid_05_keep_64_train_9.json')
test_set = Shakespeare('./data/test/all_data_niid_05_keep_64_test_9.json')
train_loader = torch.utils.data.DataLoader(dataset=train_set, batch_size=batch_size, shuffle=True)
test_loader = torch.utils.data.DataLoader(dataset=train_set, batch_size=batch_size, shuffle=False)

```

```

./data/train/all_data_niid_05_keep_64_train_9.json
./data/test/all_data_niid_05_keep_64_test_9.json

```

```
In [7]: net = RNN()  
net = net.cuda()
```

```
In [8]: optimizer = optim.SGD(net.parameters(), lr=lr)  
criterion = nn.CrossEntropyLoss()
```

```
In [9]: logs = {'train_loss':[],  
               'test_loss':[],  
               'test_acc':[]  
            }
```

```

In [ ]: for epoch in range(epochs):

    train_loss = 0
    net.train()

    for batch_idx, (x, y) in tqdm.tqdm(enumerate(train_loader), total=len(train_loader), desc='Epoch %d'%epoch):

        optimizer.zero_grad()

        x = x.cuda()
        y = y.cuda()
        output = net(x)

        loss = criterion(output,y)
        loss.backward()

        optimizer.step()

        train_loss += loss.item()

    train_loss = train_loss/(batch_idx+1)
    test_acc, test_loss = test(net, test_loader)

    logs['train_loss'].append(train_loss)
    logs['test_loss'].append(test_loss)
    logs['test_acc'].append(test_acc)

    print('Epoch {} -- train_loss {:.4} -- test_loss {:.4f} -- test_acc {:.4f}'.format(epoch, train_loss, test_loss,

```

```
Epoch 0: 100%|██████████| 19007/19007 [01:53<00:00, 167.27it/s]
```

```
Epoch 1:  0%|          | 11/19007 [00:00<02:58, 106.28it/s]
```

```
Epoch 0 -- train_loss 3.12488656718357 -- test_loss 3.058355 -- test_acc 0.194123
```

```
Epoch 1: 100%|██████████| 19007/19007 [01:57<00:00, 161.44it/s]
```

```
Epoch 2:  0%|          | 12/19007 [00:00<02:47, 113.61it/s]
```

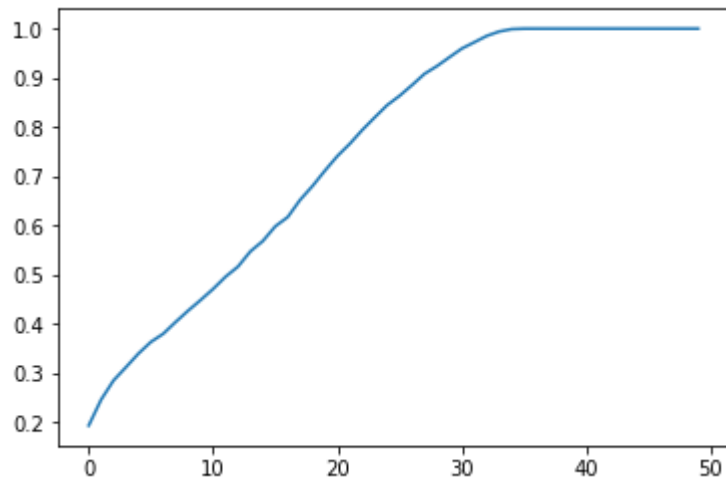
```
Epoch 1 -- train_loss 2.9202417461312775 -- test_loss 2.786063 -- test_acc 0.246805
```

```
Epoch 2: 100%|██████████| 19007/19007 [01:54<00:00, 165.77it/s]
```

```
Epoch 3: 0%|          | 11/19007 [00:00<03:00, 105.36it/s]
Epoch 2 -- train_loss 2.7045727625584095 -- test_loss 2.592791 -- test_acc 0.285839
Epoch 3: 100%|██████████| 19007/19007 [01:57<00:00, 161.20it/s]
Epoch 4: 0%|          | 11/19007 [00:00<02:56, 107.85it/s]
Epoch 3 -- train_loss 2.5557894641435985 -- test_loss 2.468175 -- test_acc 0.312688
Epoch 4: 100%|██████████| 19007/19007 [01:57<00:00, 161.85it/s]
Epoch 5: 0%|          | 11/19007 [00:00<02:54, 109.15it/s]
Epoch 4 -- train_loss 2.4442642460511874 -- test_loss 2.351268 -- test_acc 0.340368
Epoch 5: 100%|██████████| 19007/19007 [01:58<00:00, 159.78it/s]
Epoch 6: 0%|          | 12/19007 [00:00<02:45, 114.45it/s]
Epoch 5 -- train_loss 2.345836892605656 -- test_loss 2.256571 -- test_acc 0.363902
Epoch 6: 74%|██████████| 13992/19007 [01:25<00:29, 170.60it/s]
```

```
In [12]: plt.plot(logs['test_acc'])
```

```
Out[12]: [<matplotlib.lines.Line2D at 0x7fef101bc5f8>]
```



problem with the dataset

```
In [7]: train_set.x[0:100]
```

```
Out[7]: ['Kind keepers of my weak decaying age, Let dying Mortimer here rest himself. Even',  
'ind keepers of my weak decaying age, Let dying Mortimer here rest himself. Even ',  
'nd keepers of my weak decaying age, Let dying Mortimer here rest himself. Even l',  
'd keepers of my weak decaying age, Let dying Mortimer here rest himself. Even li',  
' keepers of my weak decaying age, Let dying Mortimer here rest himself. Even lik',  
'keepers of my weak decaying age, Let dying Mortimer here rest himself. Even like',  
'eepers of my weak decaying age, Let dying Mortimer here rest himself. Even like ',  
'epers of my weak decaying age, Let dying Mortimer here rest himself. Even like a',  
'pers of my weak decaying age, Let dying Mortimer here rest himself. Even like a ',  
'ers of my weak decaying age, Let dying Mortimer here rest himself. Even like a m',  
'rs of my weak decaying age, Let dying Mortimer here rest himself. Even like a ma',  
's of my weak decaying age, Let dying Mortimer here rest himself. Even like a man',  
' of my weak decaying age, Let dying Mortimer here rest himself. Even like a man ',  
'of my weak decaying age, Let dying Mortimer here rest himself. Even like a man n',  
'f my weak decaying age, Let dying Mortimer here rest himself. Even like a man ne',  
' my weak decaying age, Let dying Mortimer here rest himself. Even like a man new',  
'my weak decaying age, Let dying Mortimer here rest himself. Even like a man new ',  
'y weak decaying age, Let dying Mortimer here rest himself. Even like a man new h',  
' weak decaying age, Let dying Mortimer here rest himself. Even like a man new ha',  
'weak decaying age, Let dying Mortimer here rest himself. Even like a man new hal',  
'eak decaying age, Let dying Mortimer here rest himself. Even like a man new hale',  
'ak decaying age, Let dying Mortimer here rest himself. Even like a man new haled',  
'k decaying age, Let dying Mortimer here rest himself. Even like a man new haled ',  
' decaying age, Let dying Mortimer here rest himself. Even like a man new haled f',  
'decaying age, Let dying Mortimer here rest himself. Even like a man new haled fr',  
'ecaying age, Let dying Mortimer here rest himself. Even like a man new haled fro',  
'caying age, Let dying Mortimer here rest himself. Even like a man new haled from',  
'aying age, Let dying Mortimer here rest himself. Even like a man new haled from ',  
'ying age, Let dying Mortimer here rest himself. Even like a man new haled from t',  
'ing age, Let dying Mortimer here rest himself. Even like a man new haled from th',  
'ng age, Let dying Mortimer here rest himself. Even like a man new haled from the',  
'g age, Let dying Mortimer here rest himself. Even like a man new haled from the ',  
' age, Let dying Mortimer here rest himself. Even like a man new haled from the r',  
'age, Let dying Mortimer here rest himself. Even like a man new haled from the ra',  
'ge, Let dying Mortimer here rest himself. Even like a man new haled from the rac',  
'e, Let dying Mortimer here rest himself. Even like a man new haled from the rack',  
' , Let dying Mortimer here rest himself. Even like a man new haled from the rack,',  
'Let dying Mortimer here rest himself. Even like a man new haled from the rack, S',  
'et dying Mortimer here rest himself. Even like a man new haled from the rack, So',
```


' man new haled from the rack, So fare my limbs with long imprisonment; And these',
'man new haled from the rack, So fare my limbs with long imprisonment; And these ',
'an new haled from the rack, So fare my limbs with long imprisonment; And these g',
' new haled from the rack, So fare my limbs with long imprisonment; And these gre',
'new haled from the rack, So fare my limbs with long imprisonment; And these grey',
'ew haled from the rack, So fare my limbs with long imprisonment; And these grey ',
'w haled from the rack, So fare my limbs with long imprisonment; And these grey l',
'haled from the rack, So fare my limbs with long imprisonment; And these grey loc',
'aled from the rack, So fare my limbs with long imprisonment; And these grey lock',
'led from the rack, So fare my limbs with long imprisonment; And these grey locks',
'ed from the rack, So fare my limbs with long imprisonment; And these grey locks,',
' from the rack, So fare my limbs with long imprisonment; And these grey locks, t',
'rom the rack, So fare my limbs with long imprisonment; And these grey locks, the',
'om the rack, So fare my limbs with long imprisonment; And these grey locks, the ',
'm the rack, So fare my limbs with long imprisonment; And these grey locks, the p',
' the rack, So fare my limbs with long imprisonment; And these grey locks, the pu',
'the rack, So fare my limbs with long imprisonment; And these grey locks, the pur',
'he rack, So fare my limbs with long imprisonment; And these grey locks, the purs',
'e rack, So fare my limbs with long imprisonment; And these grey locks, the pursu']

```
In [8]: test_set.x[0:100]
```

```
Out[8]: [' Let dying Mortimer here rest himself. Even like a man new haled from the rack, ',  
'ere rest himself. Even like a man new haled from the rack, So fare my limbs with',  
'st himself. Even like a man new haled from the rack, So fare my limbs with long ',  
't himself. Even like a man new haled from the rack, So fare my limbs with long i',  
'Even like a man new haled from the rack, So fare my limbs with long imprisonment',  
'ke a man new haled from the rack, So fare my limbs with long imprisonment; And t',  
'n new haled from the rack, So fare my limbs with long imprisonment; And these gr',  
' haled from the rack, So fare my limbs with long imprisonment; And these grey lo',  
'd from the rack, So fare my limbs with long imprisonment; And these grey locks, ',  
'from the rack, So fare my limbs with long imprisonment; And these grey locks, th',  
' my limbs with long imprisonment; And these grey locks, the pursuivants of death',  
'th long imprisonment; And these grey locks, the pursuivants of death, Nestor-lik',  
'nment; And these grey locks, the pursuivants of death, Nestor-like aged in an ag',  
'nd these grey locks, the pursuivants of death, Nestor-like aged in an age of car',  
' these grey locks, the pursuivants of death, Nestor-like aged in an age of care,',  
'ese grey locks, the pursuivants of death, Nestor-like aged in an age of care, Ar',  
'rey locks, the pursuivants of death, Nestor-like aged in an age of care, Argue t',  
'locks, the pursuivants of death, Nestor-like aged in an age of care, Argue the e',  
'ocks, the pursuivants of death, Nestor-like aged in an age of care, Argue the en',  
', the pursuivants of death, Nestor-like aged in an age of care, Argue the end of',  
'pursuivants of death, Nestor-like aged in an age of care, Argue the end of Edmun',  
'ursuivants of death, Nestor-like aged in an age of care, Argue the end of Edmund',  
'rsuivants of death, Nestor-like aged in an age of care, Argue the end of Edmund ',  
'suivants of death, Nestor-like aged in an age of care, Argue the end of Edmund M',  
'vants of death, Nestor-like aged in an age of care, Argue the end of Edmund Mort',  
'ants of death, Nestor-like aged in an age of care, Argue the end of Edmund Morti',  
'nts of death, Nestor-like aged in an age of care, Argue the end of Edmund Mortim',  
'death, Nestor-like aged in an age of care, Argue the end of Edmund Mortimer. The',  
'-like aged in an age of care, Argue the end of Edmund Mortimer. These eyes, like',  
' age of care, Argue the end of Edmund Mortimer. These eyes, like lamps whose was',  
'e of care, Argue the end of Edmund Mortimer. These eyes, like lamps whose wastin',  
're, Argue the end of Edmund Mortimer. These eyes, like lamps whose wasting oil i',  
'gue the end of Edmund Mortimer. These eyes, like lamps whose wasting oil is spen',  
'ue the end of Edmund Mortimer. These eyes, like lamps whose wasting oil is spent',  
'e the end of Edmund Mortimer. These eyes, like lamps whose wasting oil is spent,',  
'e end of Edmund Mortimer. These eyes, like lamps whose wasting oil is spent, Wax',  
' of Edmund Mortimer. These eyes, like lamps whose wasting oil is spent, Wax dim,',  
'r. These eyes, like lamps whose wasting oil is spent, Wax dim, as drawing to the',  
'like lamps whose wasting oil is spent, Wax dim, as drawing to their exigent; Weak',
```

' lamps whose wasting oil is spent, Wax dim, as drawing to their exigent; Weak sh',
 ' wasting oil is spent, Wax dim, as drawing to their exigent; Weak shoulders, ove',
 ' ing oil is spent, Wax dim, as drawing to their exigent; Weak shoulders, overborn',
 ' Wax dim, as drawing to their exigent; Weak shoulders, overborne with burdening ',
 ' Wax dim, as drawing to their exigent; Weak shoulders, overborne with burdening g',
 ' as drawing to their exigent; Weak shoulders, overborne with burdening grief, And',
 ' awing to their exigent; Weak shoulders, overborne with burdening grief, And pith',
 ' their exigent; Weak shoulders, overborne with burdening grief, And pithless arm',
 ' heir exigent; Weak shoulders, overborne with burdening grief, And pithless arms,',
 ' ak shoulders, overborne with burdening grief, And pithless arms, like to a withe',
 ' ulders, overborne with burdening grief, And pithless arms, like to a withered vi',
 ' ers, overborne with burdening grief, And pithless arms, like to a withered vine ',
 ' , overborne with burdening grief, And pithless arms, like to a withered vine Tha',
 ' erborne with burdening grief, And pithless arms, like to a withered vine That dr',
 ' h burdening grief, And pithless arms, like to a withered vine That droops his sa',
 ' burdening grief, And pithless arms, like to a withered vine That droops his sapl',
 ' ening grief, And pithless arms, like to a withered vine That droops his sapless ',
 ' grief, And pithless arms, like to a withered vine That droops his sapless branc',
 ' rief, And pithless arms, like to a withered vine That droops his sapless branche',
 ' ms, like to a withered vine That droops his sapless branches to the ground. Yet ',
 ' a withered vine That droops his sapless branches to the ground. Yet are these fe',
 ' withered vine That droops his sapless branches to the ground. Yet are these feet',
 ' at droops his sapless branches to the ground. Yet are these feet, whose strength',
 ' is sapless branches to the ground. Yet are these feet, whose strengthless stay i',
 ' branches to the ground. Yet are these feet, whose strengthless stay is numb, Un',
 ' the ground. Yet are these feet, whose strengthless stay is numb, Unable to supp',
 ' t are these feet, whose strengthless stay is numb, Unable to support this lump o',
 ' are these feet, whose strengthless stay is numb, Unable to support this lump of ',
 ' umb, Unable to support this lump of clay, Swift-winged with desire to get a grav',
 ' mb, Unable to support this lump of clay, Swift-winged with desire to get a grave',
 ' b, Unable to support this lump of clay, Swift-winged with desire to get a grave,',
 ' , Unable to support this lump of clay, Swift-winged with desire to get a grave, ',
 ' upport this lump of clay, Swift-winged with desire to get a grave, As witting I ',
 ' ift-winged with desire to get a grave, As witting I no other comfort have. But t',
 ' nged with desire to get a grave, As witting I no other comfort have. But tell me',
 ' esire to get a grave, As witting I no other comfort have. But tell me, keeper, w',
 ' witting I no other comfort have. But tell me, keeper, will my nephew come? Enou',
 ' witting I no other comfort have. But tell me, keeper, will my nephew come? Enoug',
 ' comfort have. But tell me, keeper, will my nephew come? Enough; my soul shall t',
 ' omfort have. But tell me, keeper, will my nephew come? Enough; my soul shall the',
 ' phew come? Enough; my soul shall then be satisfied. Poor gentleman! his wrong do',
 ' come? Enough; my soul shall then be satisfied. Poor gentleman! his wrong doth e',

'? Enough; my soul shall then be satisfied. Poor gentleman! his wrong doth equal ',
'shall then be satisfied. Poor gentleman! his wrong doth equal mine. Since Henry ',
' then be satisfied. Poor gentleman! his wrong doth equal mine. Since Henry Monmo',
'satisfied. Poor gentleman! his wrong doth equal mine. Since Henry Monmouth first',
'entleman! his wrong doth equal mine. Since Henry Monmouth first began to reign, ',
' wrong doth equal mine. Since Henry Monmouth first began to reign, Before whose ',
'th equal mine. Since Henry Monmouth first began to reign, Before whose glory I w',
'equal mine. Since Henry Monmouth first began to reign, Before whose glory I was ',
'ual mine. Since Henry Monmouth first began to reign, Before whose glory I was gr',
' . Since Henry Monmouth first began to reign, Before whose glory I was great in a',
'ry Monmouth first began to reign, Before whose glory I was great in arms, This l',
'nmouth first began to reign, Before whose glory I was great in arms, This loaths',
'irst began to reign, Before whose glory I was great in arms, This loathsome sequ',
'began to reign, Before whose glory I was great in arms, This loathsome sequestra',
'to reign, Before whose glory I was great in arms, This loathsome sequestration h',
'fore whose glory I was great in arms, This loathsome sequestration have I had; A',
're whose glory I was great in arms, This loathsome sequestration have I had; And',
'whose glory I was great in arms, This loathsome sequestration have I had; And ev',
'hose glory I was great in arms, This loathsome sequestration have I had; And eve']

In []: