RNN

November 20, 2022

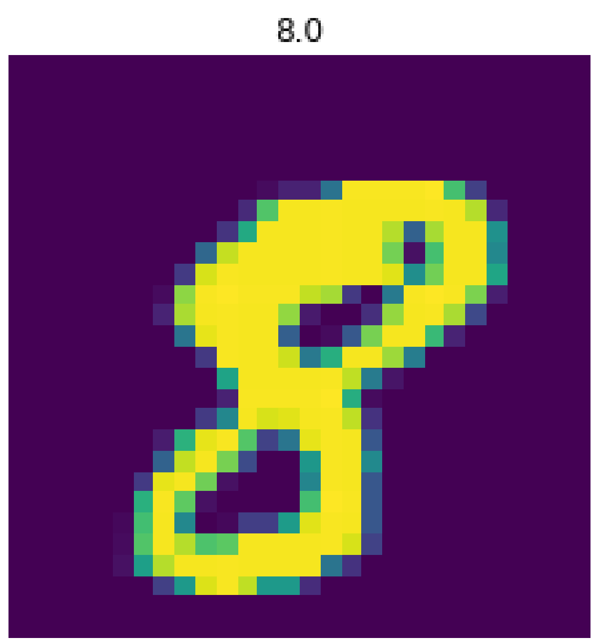
0.1 Import Libraries

[3]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import torch
import torch.nn as nn
from torch.autograd import Variable
from sklearn.model_selection import train_test_split
from torch.utils.data import DataLoader, TensorDataset
```

1 Prepare Dataset

[4]:
```
# load data
train = pd.read_csv(r"train.csv",dtype = np.float32)

# split data into features(pixels) and labels(numbers from 0 to 9)
targets_numpy = train.label.values
features_numpy = train.loc[:,train.columns != "label"].values/255 #␣
 ↪normalization

# train test split. Size of train data is 80% and size of test data is 20%.
features_train, features_test, targets_train, targets_test =␣
 ↪train_test_split(features_numpy,
                                                                             ␣
 ↪targets_numpy,
                                                                             ␣
 ↪test_size = 0.2,
                                                                             ␣
 ↪random_state = 42)

# create feature and targets tensor for train set. As you remember we need␣
 ↪variable to accumulate gradients. Therefore first we create tensor, then we␣
 ↪will create variable
featuresTrain = torch.from_numpy(features_train)
```

```
targetsTrain = torch.from_numpy(targets_train).type(torch.LongTensor) # data type is long

# create feature and targets tensor for test set.
featuresTest = torch.from_numpy(features_test)
targetsTest = torch.from_numpy(targets_test).type(torch.LongTensor) # data type is long

# batch_size, epoch and iteration
batch_size = 100
n_iters = 10000
num_epochs = n_iters / (len(features_train) / batch_size)
num_epochs = int(num_epochs)

# Pytorch train and test sets
train = TensorDataset(featuresTrain,targetsTrain)
test = TensorDataset(featuresTest,targetsTest)

# data loader
train_loader = DataLoader(train, batch_size = batch_size, shuffle = False)
test_loader = DataLoader(test, batch_size = batch_size, shuffle = False)

# visualize one of the images in data set
plt.imshow(features_numpy[10].reshape(28,28))
plt.axis("off")
plt.title(str(targets_numpy[10]))
plt.savefig('graph.png')
plt.show()
```



2 Create RNN Model

[5]:
```
class RNNModel(nn.Module):
    def __init__(self, input_dim, hidden_dim, layer_dim, output_dim):
        super(RNNModel, self).__init__()

        # Number of hidden dimensions
        self.hidden_dim = hidden_dim

        # Number of hidden layers
        self.layer_dim = layer_dim

        # RNN
        self.rnn = nn.RNN(input_dim, hidden_dim, layer_dim, batch_first=True,␣
 ↪nonlinearity='relu')

        # Readout layer
        self.fc = nn.Linear(hidden_dim, output_dim)

    def forward(self, x):

        # Initialize hidden state with zeros
        h0 = Variable(torch.zeros(self.layer_dim, x.size(0), self.hidden_dim))

        # One time step
        out, hn = self.rnn(x, h0)
        out = self.fc(out[:, -1, :])
        return out

# batch_size, epoch and iteration
batch_size = 100
n_iters = 8000
num_epochs = n_iters / (len(features_train) / batch_size)
num_epochs = int(num_epochs)

# Pytorch train and test sets
train = TensorDataset(featuresTrain,targetsTrain)
test = TensorDataset(featuresTest,targetsTest)

# data loader
train_loader = DataLoader(train, batch_size = batch_size, shuffle = False)
test_loader = DataLoader(test, batch_size = batch_size, shuffle = False)
```

```
# Create RNN
input_dim = 28    # input dimension
hidden_dim = 100  # hidden layer dimension
layer_dim = 1     # number of hidden layers
output_dim = 10   # output dimension

model = RNNModel(input_dim, hidden_dim, layer_dim, output_dim)

# Cross Entropy Loss
error = nn.CrossEntropyLoss()

# SGD Optimizer
learning_rate = 0.05
optimizer = torch.optim.SGD(model.parameters(), lr=learning_rate)
```

3 Train RNN

[ ]:
```
seq_dim = 28
loss_list = []
iteration_list = []
accuracy_list = []
count = 0
for epoch in range(num_epochs):
    for i, (images, labels) in enumerate(train_loader):

        train  = Variable(images.view(-1, seq_dim, input_dim))
        labels = Variable(labels )

        # Clear gradients
        optimizer.zero_grad()

        # Forward propagation
        outputs = model(train)

        # Calculate softmax and ross entropy loss
        loss = error(outputs, labels)

        # Calculating gradients
        loss.backward()

        # Update parameters
        optimizer.step()

        count += 1
```

```
        if count % 250 == 0:
            # Calculate Accuracy
            correct = 0
            total = 0
            # Iterate through test dataset
            for images, labels in test_loader:
                images = Variable(images.view(-1, seq_dim, input_dim))

                # Forward propagation
                outputs = model(images)

                # Get predictions from the maximum value
                predicted = torch.max(outputs.data, 1)[1]

                # Total number of labels
                total += labels.size(0)

                correct += (predicted == labels).sum()

            accuracy = 100 * correct / float(total)

            # store loss and iteration
            loss_list.append(loss.data)
            iteration_list.append(count)
            accuracy_list.append(accuracy)
            if count % 500 == 0:
                # Print Loss
                print('Iteration: {}  Loss: {}  Accuracy: {} %'.format(count,␣
↪loss.data, accuracy))
```

```
Iteration: 500  Loss: nan  Accuracy: 8.720930099487305 %
Iteration: 1000  Loss: nan  Accuracy: 8.720930099487305 %
Iteration: 1500  Loss: nan  Accuracy: 8.720930099487305 %
Iteration: 2000  Loss: nan  Accuracy: 8.720930099487305 %
Iteration: 2500  Loss: nan  Accuracy: 8.720930099487305 %
Iteration: 3000  Loss: nan  Accuracy: 8.720930099487305 %
```

4 Visualization

[ ]:
```
# visualization loss
plt.plot(iteration_list,loss_list)
plt.xlabel("Number of iteration")
plt.ylabel("Loss")
plt.title("RNN: Loss vs Number of iteration")
plt.show()
```

```python
# visualization accuracy
plt.plot(iteration_list,accuracy_list,color = "red")
plt.xlabel("Number of iteration")
plt.ylabel("Accuracy")
plt.title("RNN: Accuracy vs Number of iteration")
plt.savefig('graph.png')
plt.show()
```

[ ]:

```python

```