ECE 60146 HW8 Report

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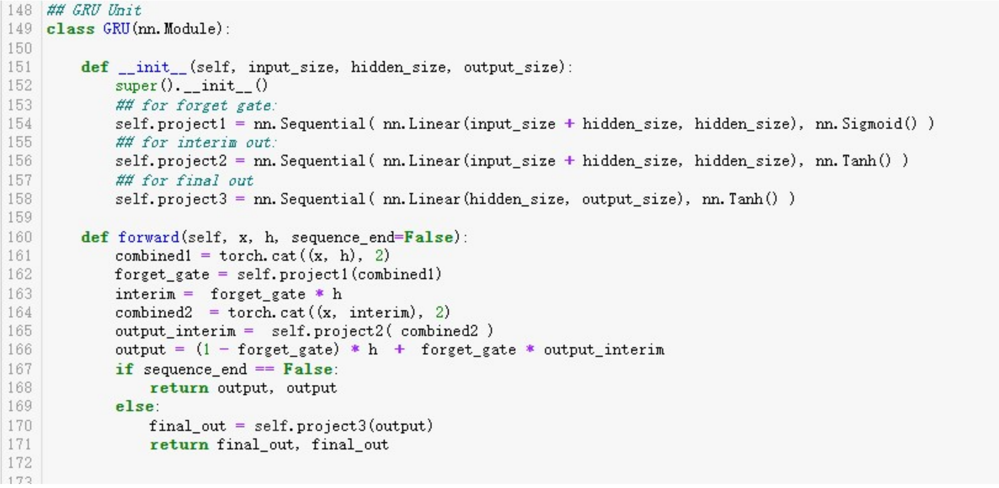
1 RNN with My Own GRU

1.1 Implementation of GRU



```python
## GRU Unit
class GRU(nn.Module):

    def __init__(self, input_size, hidden_size, output_size):
        super().__init__()
        ## for forget gate:
        self.project1 = nn.Sequential( nn.Linear(input_size + hidden_size, hidden_size), nn.Sigmoid() )
        ## for interim out:
        self.project2 = nn.Sequential( nn.Linear(input_size + hidden_size, hidden_size), nn.Tanh() )
        ## for final out
        self.project3 = nn.Sequential( nn.Linear(hidden_size, output_size), nn.Tanh() )

    def forward(self, x, h, sequence_end=False):
        combined1 = torch.cat((x, h), 2)
        forget_gate = self.project1(combined1)
        interim =  forget_gate * h
        combined2  = torch.cat((x, interim), 2)
        output_interim =  self.project2( combined2 )
        output = (1 - forget_gate) * h  +  forget_gate * output_interim
        if sequence_end == False:
            return output, output
        else:
            final_out = self.project3(output)
            return final_out, final_out

```

Figure 1: Code block of my GRU implementation

First, passing the concatenation of h and x through the project1 layer gives

$$z_t = \sigma(W_z x_t + U_z h_Z t - 1)$$

$$r_t = \sigma(W_r x_t + U_r h_{t-1})$$

Then passing the concatenation of the interim and x through the project2 layer we get

$$\tilde{h_t} = tanh(W_h x_t + U_h(r_t \odot h_{t-1}))$$

Finally we have the output

$$h_t = (1 - z_t) \odot h_{t-1} + z_t \odot \tilde{h_t}$$

The gating mechanism can mitigate the vanishing gradient because the gate can preserve the gradient flow by selectively allowing or blocking information flow through gates.

1.2 Training loss

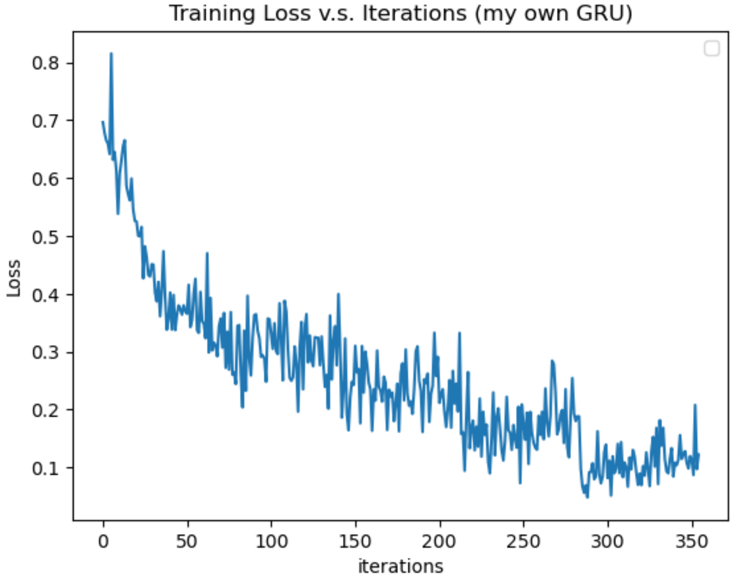


Figure 2: Training loss of the RNN with my own GRU

1.3 Test Results

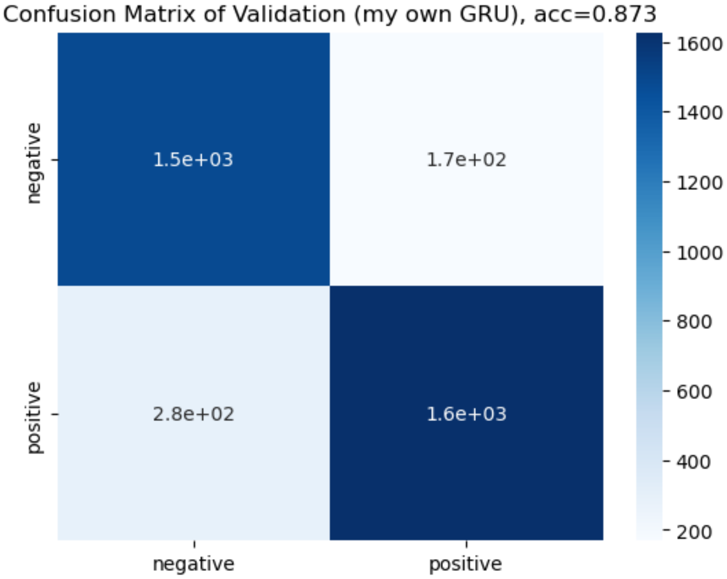


Figure 3: The confusion matrix of the testing result of my own GRU

The test accuracy of the RNN with my own GRU is 0.873.

2 RNN with nn.GRU

2.1 Training loss

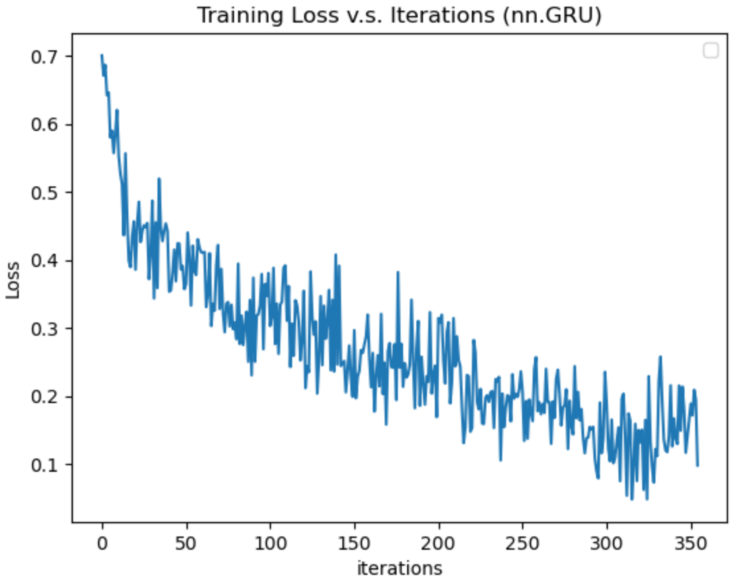


Figure 4: Training loss of the RNN with nn.GRU

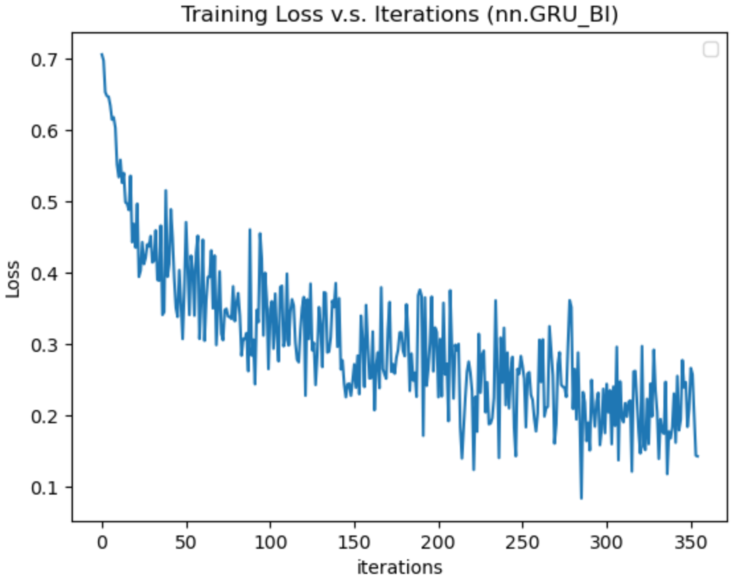


Figure 5: Training loss of the RNN with bidirectional nn.GRU

2.2 Test Results

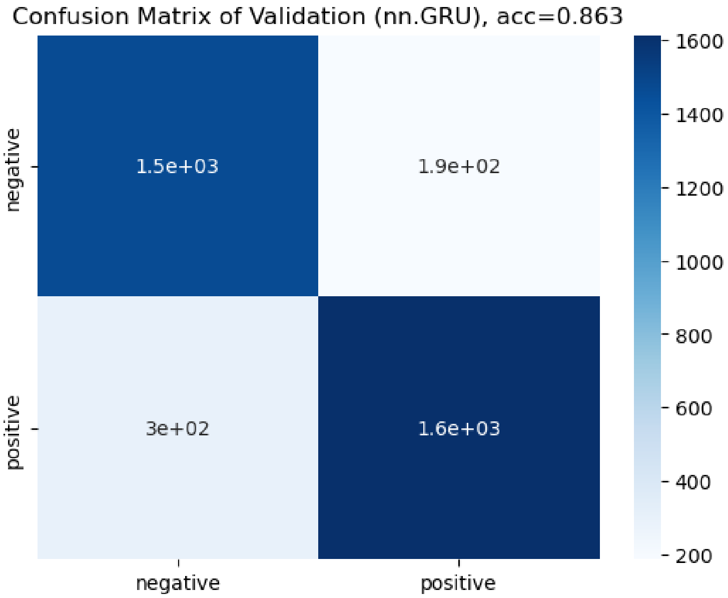


Figure 6: The confusion matrix of the testing result of nn.GRU

The test accuracy of the RNN with nn.GRU is 0.863.

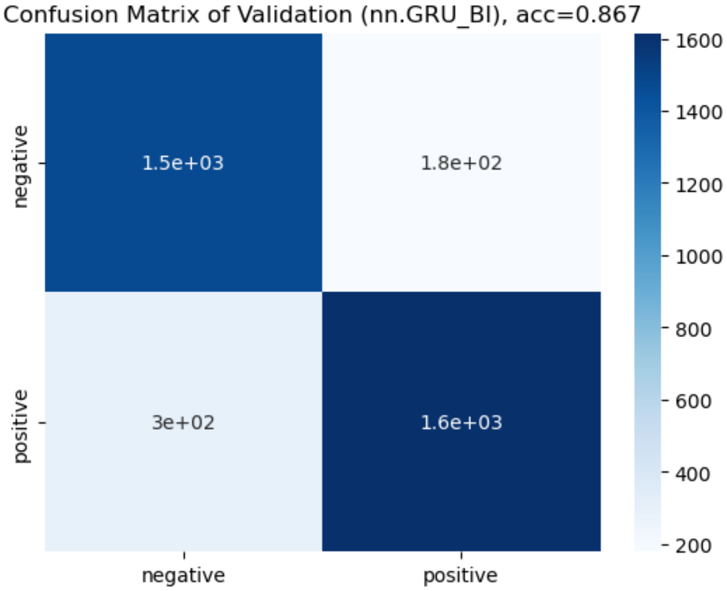


Figure 7: The confusion matrix of the testing result of bidirectional nn.GRU

The test accuracy of the RNN with bidirectional nn.GRU is 0.867.

3 Discussion

From the results of test accuracy and the confusion matrices, we can say that the RNNs trained with the three GRUs have similar performance.

4 Source code

```
# ECE60146 HW8
# Zhengxin Jiang
# jiang839

import numpy as np
import os
import matplotlib.pyplot as plt
import random
import json
import math
import seaborn as sn
import gzip
import pickle
import gensim.downloader as genapi
from gensim.models import KeyedVectors
import sys

import torch
import torch.nn as nn
import torch.nn.functional as F
import torchvision
import torchvision.transforms as tvt
from torch.utils.data import DataLoader

device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
print(device)

## HW8 Dataset
## The implementation from DLStudio
class SentimentAnalysisDataset(torch.utils.data.Dataset):
    def __init__(self, train_or_test, dataset_file, path_to_saved_embeddings=None):
        super().__init__()

        self.path_to_saved_embeddings = path_to_saved_embeddings
        self.train_or_test = train_or_test
        f = gzip.open(dataset_file, ’rb’)
        dataset = f.read()
        if path_to_saved_embeddings is not None:
            if os.path.exists(path_to_saved_embeddings + ’vectors.kv’):
                self.word_vectors = KeyedVectors.load(path_to_saved_embeddings + ’vectors.
                    kv’)
            else:
                print("""\n\nSince this is your first time to install the word2vec
                    embeddings, it may take"""
                      """\na couple of minutes. The embeddings occupy around 3.6GB of your
                          disk space.\n\n""")
                self.word_vectors = genapi.load("word2vec-google-news-300")
                ## ’kv’ stands for "KeyedVectors", a special datatype used by gensim
                    because it
                ## has a smaller footprint than dict
                self.word_vectors.save(path_to_saved_embeddings + ’vectors.kv’)
        if train_or_test == ’train’:
            if sys.version_info[0] == 3:
                self.positive_reviews_train, self.negative_reviews_train, self.vocab =
                    pickle.loads(dataset, encoding='latin1')
            else:
                self.positive_reviews_train, self.negative_reviews_train, self.vocab =
                    pickle.loads(dataset)
            self.categories = sorted(list(self.positive_reviews_train.keys()))
            self.category_sizes_train_pos = {category : len(self.positive_reviews_train[
                category]) for category in self.categories}
            self.category_sizes_train_neg = {category : len(self.negative_reviews_train[
                category]) for category in self.categories}
            self.indexed_dataset_train = []
            for category in self.positive_reviews_train:
                for review in self.positive_reviews_train[category]:
                    self.indexed_dataset_train.append([review, category, 1])
            for category in self.negative_reviews_train:
                for review in self.negative_reviews_train[category]:
                    self.indexed_dataset_train.append([review, category, 0])
            random.shuffle(self.indexed_dataset_train)
        elif train_or_test == 'test':
            if sys.version_info[0] == 3:
                self.positive_reviews_test, self.negative_reviews_test, self.vocab = pickle
                    .loads(dataset, encoding='latin1')
            else:
                self.positive_reviews_test, self.negative_reviews_test, self.vocab = pickle
                    .loads(dataset)
            self.vocab = sorted(self.vocab)
            self.categories = sorted(list(self.positive_reviews_test.keys()))
            self.category_sizes_test_pos = {category : len(self.positive_reviews_test[
                category]) for category in self.categories}
            self.category_sizes_test_neg = {category : len(self.negative_reviews_test[
                category]) for category in self.categories}
            self.indexed_dataset_test = []
            for category in self.positive_reviews_test:
                for review in self.positive_reviews_test[category]:
                    self.indexed_dataset_test.append([review, category, 1])
            for category in self.negative_reviews_test:
                for review in self.negative_reviews_test[category]:
                    self.indexed_dataset_test.append([review, category, 0])
            random.shuffle(self.indexed_dataset_test)

    def review_to_tensor(self, review):
        list_of_embeddings = []
        for i,word in enumerate(review):
            if word in self.word_vectors.key_to_index:
                embedding = self.word_vectors[word]
                list_of_embeddings.append(np.array(embedding))
            else:
                next
        review_tensor = torch.FloatTensor( list_of_embeddings )
        return review_tensor

    def sentiment_to_tensor(self, sentiment):
        """
        Sentiment is ordinarily just a binary valued thing. It is 0 for negative
        sentiment and 1 for positive sentiment. We need to pack this value in a
        two-element tensor.
        """
        sentiment_tensor = torch.zeros(2)
        if sentiment == 1:
            sentiment_tensor[1] = 1
        elif sentiment == 0:
            sentiment_tensor[0] = 1
        sentiment_tensor = sentiment_tensor.type(torch.long)
        return sentiment_tensor

    def __len__(self):
        if self.train_or_test == ’train’:
            return len(self.indexed_dataset_train)
        elif self.train_or_test == ’test’:
            return len(self.indexed_dataset_test)

    def __getitem__(self, idx):
        sample = self.indexed_dataset_train[idx] if self.train_or_test == ’train’ else
            self.indexed_dataset_test[idx]
        review = sample[0]
        review_category = sample[1]
        review_sentiment = sample[2]
        review_sentiment = self.sentiment_to_tensor(review_sentiment)
        review_tensor = self.review_to_tensor(review)
        category_index = self.categories.index(review_category)
        sample = {’review’ : review_tensor,
                  ’category’ : category_index, # should be converted to tensor, but not yet
                       used
                  ’sentiment’ : review_sentiment }
        return sample


## RNN net
class HW8Net(nn.Module):

    def __init__(self, task, input_size, hidden_size, output_size, num_layers=1,
        batch_size=1):
        super().__init__()

        self.input_size = input_size
        self.hidden_size = hidden_size
        self.num_layers = num_layers
        self.batch_size = batch_size
        self.task = task

        self.gru = GRU(input_size, hidden_size, output_size)
        self.nngru = nn.GRU(input_size, hidden_size, num_layers)
        self.gru_bi = nn.GRU(input_size, hidden_size, num_layers, bidirectional=True)
        self.fc = nn.Linear(hidden_size, output_size)
        self.fc_bi = nn.Linear(hidden_size*2, output_size)
        self.relu = nn.ReLU()
        self.logsoftmax = nn.LogSoftmax(dim=1)
    def forward(self, x, h):
        if self.task == ’gru’:
            out, h = self.gru(x, h)
            out = self.fc(self.relu(out[:,-1]))

        if self.task == ’gru_nn’:
            out, h = self.nngru(x, h)
            out = self.fc(self.relu(out[:,-1]))

        if self.task == ’gru_nn_bi’:
            out, h = self.gru_bi(x, h)
            out = self.fc_bi(self.relu(out[:,-1]))

        out = self.logsoftmax(out)
        return out, h

    def init_hidden(self):
        weight = next(self.parameters()).data

        if self.task == ’gru’ or self.task == ’gru_nn’:
            hidden = weight.new(self.num_layers, self.batch_size, self.hidden_size).zero_
                ()
        if self.task == ’gru_nn_bi’:
            hidden = weight.new(self.num_layers*2, self.batch_size, self.hidden_size).
                zero_()

        return hidden


## GRU Unit
class GRU(nn.Module):

    def __init__(self, input_size, hidden_size, output_size):
        super().__init__()
        ## for forget gate:
        self.project1 = nn.Sequential( nn.Linear(input_size + hidden_size, hidden_size),
            nn.Sigmoid() )
        ## for interim out:
        self.project2 = nn.Sequential( nn.Linear(input_size + hidden_size, hidden_size),
            nn.Tanh() )
        ## for final out
        self.project3 = nn.Sequential( nn.Linear(hidden_size, output_size), nn.Tanh() )

    def forward(self, x, h, sequence_end=False):
        combined1 = torch.cat((x, h), 2)
        forget_gate = self.project1(combined1)
        interim = forget_gate * h
        combined2 = torch.cat((x, interim), 2)
        output_interim = self.project2( combined2 )
        output = (1 - forget_gate) * h + forget_gate * output_interim
        if sequence_end == False:
            return output, output
        else:
             final_out = self.project3(output)
             return final_out, final_out

 traindataset = SentimentAnalysisDataset(’train’, ’sentiment_dataset_train_400.tar.gz’, ’D
     :/coco/hw8/’)
 traindataloader = DataLoader(traindataset, batch_size=1, num_workers=0, shuffle=True)

 ## Training ##
 net = HW8Net(’gru’, 300, 100, 2, num_layers=1)
 net = net.to(device)

 criterion = nn.NLLLoss()
 optimizer = torch.optim.Adam(net.parameters(), lr=1e-3, betas=(0.9, 0.99))

 train_loss = []

 for epoch in range(5):
     running_loss = 0.0

     for i, data in enumerate(traindataloader):
        review_tensor, category, sentiment = data[’review’], data[’category’], data[’
            sentiment’]
        review_tensor = review_tensor.to(device)
        sentiment = sentiment.to(device)

        optimizer.zero_grad()
        hidden = net.init_hidden().to(device)

        for k in range(review_tensor.shape[1]):
            output, hidden = net(torch.unsqueeze(torch.unsqueeze(review_tensor[0,k],0),0),
                 hidden)

        loss = criterion(output, torch.argmax(sentiment, 1))
        running_loss += loss.item()

        loss.backward()
        optimizer.step()

        if i % 200 == 199:
            avg_loss = running_loss / float(200)
            train_loss.append(avg_loss)
            print("[epoch:%d␣␣iter:%4d␣␣]␣␣␣␣␣loss:␣%.5f" % (epoch+1,i+1, avg_loss))
            running_loss = 0.0

 ## save models
 torch.save(net.state_dict(), ’gru.pth’)

 ## plot the loss
 plt.figure()
 plt.title("Training␣Loss␣v.s.␣Iterations␣(my␣own␣GRU)")
 plt.plot(train_loss)
 plt.xlabel("iterations")
 plt.ylabel("Loss")
 plt.legend()
 plt.show()

 ## Testing ##
 testdataset = SentimentAnalysisDataset(’test’, ’sentiment_dataset_test_400.tar.gz’, ’D:/
     coco/hw8/’)
 testdataloader = DataLoader(testdataset, batch_size=1, num_workers=0, shuffle=True)

 cm = torch.zeros(2,2)

 with torch.no_grad():
     for i, data in enumerate(testdataloader):
        review_tensor,category,sentiment = data[’review’], data[’category’], data[’
            sentiment’]
        review_tensor = review_tensor.to(device)
        sentiment = sentiment.to(device)
        hidden = net.init_hidden().to(device)

        for k in range(review_tensor.shape[1]):
            output, hidden = net(torch.unsqueeze(torch.unsqueeze(review_tensor[0,k],0),0),
                 hidden)
        predicted_idx = torch.argmax(output).item()
        gt_idx = torch.argmax(sentiment).item()

        ## update confusion matrix
        cm[gt_idx, predicted_idx] += 1

 acc = (cm[0,0]+cm[1,1])/len(testdataloader)

 plt.figure()
 plt.title("Confusion␣Matrix␣of␣Validation␣(my␣own␣GRU),␣acc=%.3f" % (acc))
 sn.heatmap(cm, annot=True, cmap="Blues",xticklabels=[’negative’,’positive’], yticklabels
     =[’negative’,’positive’])
```