Deep Learning in Data Science, DD2424

Short report on lab assignment 4
Recurrent neural network

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1. Introduction

The goal of this lab assignment 4 is to train and test a recurrent neural network (RNN) to predict text of *The Goblet of Fire* book. The network applies cross-entropy loss function and using AdaGrad stochastic gradient descent.

The tool used for this assignment is primarily `python 3.7.3`, along with several packages including `numpy 1.16.4`, `pandas 0.25.3`, and `matplotlib 3.1.0`.

2. Results and discussion

2.1. Gradient checking

To validate whether the self-build codes, particularly the function to compute the gradient of parameters $\boldsymbol{U}, \boldsymbol{W}, \boldsymbol{V}, \boldsymbol{b},$ and $\boldsymbol{c}$ could run appropriately based on the mathematical functions, comparing the results with alternative ways using the numerical approach as provided in the instruction documents is necessary. The maximum and average values of the absolute tolerance/error of each parameter are generated to investigate whether the difference between those two outputs is still tolerable, which follows the equation (1):

$$\frac{|g_a - g_n|}{max(eps, |g_a| + |g_n|)} \approx absolute\ tolerance \quad (1)$$

Using my codes (g_a), I got results of comparing the absolute tolerance for the RNN model on 25 sequence length of the text as summarized in Table 1. Overall, my codes are able to approximate the results of numerical calculation within a tolerable gap.

Table 1. Hyperparameter settings for RNN models

Gradient	**Relative error**	
	Maximum	**Mean**
U	3.809e-06	2.232e-09
W	7.597e-03	1.494e-06
V	3.016e-05	1.521e-07
b	2.667e-07	5.084e-09
c	1.285e-09	7.131e-10

2.2. The smooth loss graphs

The RNN model was trained for 7 epochs with m=100 resulting in a smooth loss graph below:

Figure 1. Cross-entropy loss as a function of the step size from the RNN model

2.3. The evolution of synthesized text by the model

Below is the evolution of the text resulted from the model for specific update steps:

Update step: 0 (smooth loss: 109.55164)

```
KWOK7rGl^HrT1aQxaAN
HDLtYhWKUHpjTm2BB7Z:i:drHc)pCsiFMH:R}(yvX.^i7hXPIwgbb(aH
)C7aCnQd9pfp'042cl
kK QN2KmWG0Dy:CtOTAR"S_YJKXfv) XYsVv0
TTJWE2GNsHgA7T1GsN3BCK0?"N6Tlf0Oj:Nhd2!aixp/Kh01L/Z3:NRTN"nnujE}nz
```

Update step: 50000 (smooth loss: 49.79890)

```
cherntere thioldy, Creechers ons fan incand if yens fayping the
ingmont out he cas a ally easnow.  Butlly abre toldesely as kigh."
"
The..
Watnrick yot she tarp, Frembly, swith werch sikatlly mang to
```

Update step: 100000 (smooth loss: 48.09721)

```
he Wetrairand it neven time the toined Rons a did Herking about at
thee besssiin hod cay." stione to a Halcot the weally.
   There Fl6ous, said the we tern Ant anoup Down one to usly his
gort int oup an
```

Update step: 150000 (smooth loss: 45.79696)

```
ice the dodris.
"Suwandoher stishad doke hishing to y.
"Roning olene'sse terim.  Brise aw hincuarous Mador," said Mut
dimistered noture be is wak thliols's your dound entairt in she
swantsoning very a
```

Update step: 200000 (smooth loss: 44.84721)

```
r swoble starzid, they, befory set-in the nogming - grow.., someter
his what . . Balliou for to beddreah.  They ming's.
```

```
That' Lumventon, was grett ainesked daving quomatieely.
"Year.
"No now.  I'm poo
```

Update step: 250000 (smooth loss: 45.58357)

```
his lete he was tromoss are back now he distidn said shinds?" .
Wence inster a drainly; my headedrilvic if wizarr doarsed to
arounder.  The pidming at very wlish spuck.
"Down grous celle, stond grouf
```

Update step: 300000 (smooth loss: 42.67732)

```
mu's sutens.  He kith you it froud had ontlewdehed to with down
ainter?"
"Band Ponce makht was exten kinking Cruff Hermione hagstert she
Promsstrough's Gonderido op sheed in them the!" he a kepes Dliz
```

2.4. Final synthesized text

The following passage of 1000 characters was obtained after around 310000 update steps and resulting loss ~42.76971:

```
no a pight groublus the gond," said Drxane?"  said Hagrigh curmat on
the woutenly," said Hall!  Herll, hark, Wondly.  But how, smiglt.
"What me wanter ot she.  I alton.
"Hepplingslald aft: Cednaid wi
'Fry glinsed Harrid back with Id jugnieg sig and the peleal had
turne, I all wayel. . .."
Fleed latted.  "Bay," he honden, said on beeved ontuse the fay sut,
a stich.  On. "He colleed air," said Hermione arnic a shookst it
coseens whatwled, talk tor the there heas Cumed had waLabany,"
seappent commer will wen vorme but eumbaing he same of cortien at I
are Cagbory, I are.  "Nay he boge any!" said Khre stariw."
"I swe vasble didw-Vowle fer wercyering mabun.
"Told diddrioped Falk all the treist Firede, "You?  Wersted.
Dustle's lisending Cilld.  Harry.  He cacking. . . ot puppan cicned
thaim. - wewerer," Pelled ytally Led.  A filly abed to selal him,
you to wartele the - still quible expitthinging eacy, and Hermione
heversed all so to seatening, mairy wepsley.  EDe siding?"
Hesed eye any you to withis Harry.  Their and saimstaled the stut
it..  rall.  A Le, .. Hermiole sioind.  Exeed bes wall to blolthing
him, nowed his dometherd cout bess, ever he side thought.

HEAT
I wazaring tolle and
```

There appears “Harry” and “Hermoine” in the predicted text.

3. Final remarks

From this assignment, it was learned that applying an RNN model could be used for predicting the upcoming text given particular text input. After 7 epochs, my model could achieve a cross-entropy loss around 42.77. Based on the experiment, the number of hidden nodes (m) plays a critical role in the predicted text and loss values.