Assignment 4

(Base part)

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Due: 17.05.2024

2 i) Correctness of Analytic gradient computation

To ensure the correctness of the gradient computation for the RNN and establishing that it was bug free, the following approach was followed:

Implementation of numerical gradients of the loss with respect to the RNN parameters was done. It includes using finite differences to approximate the gradients. For a given parameter θ, the numerical gradient is computed as follows:

$$\frac{\partial L}{\partial \theta} \approx \frac{L(\theta + h) - L(\theta - h)}{2h}$$

Where L is the loss function and h is a small perturbation value, typically $1e{-}4$.

The numerical gradients were compared against the gradients computed analytically using backpropagation implemented in the backward pass function.

For comparison among the two gradients, the following relative error was considered:

$$\text{relative error} = \frac{\|\text{numerical gradient} - \text{analytical gradient}\|}{\|\text{numerical gradient}\| + \|\text{analytical gradient}\|}$$

A small error (typically less than 1e-5) indicates that the analytical gradients are correctly computed.

In our test runs, the following errors were seen:

```
Relative error for U: 3.3587074158724494e-09
Relative error for W: 1.0181149476062496e-07
Relative error for V: 1.7639763149180844e-08
Relative error for b: 1.8526463437329464e-09
Relative error for c: 4.745617095693915e-10
```

These low errors obtained in the gradient checking procedure provide strong evidence that the gradients used in the training process are accurate, ensuring reliable optimization and model training.

2 ii) Smooth loss function

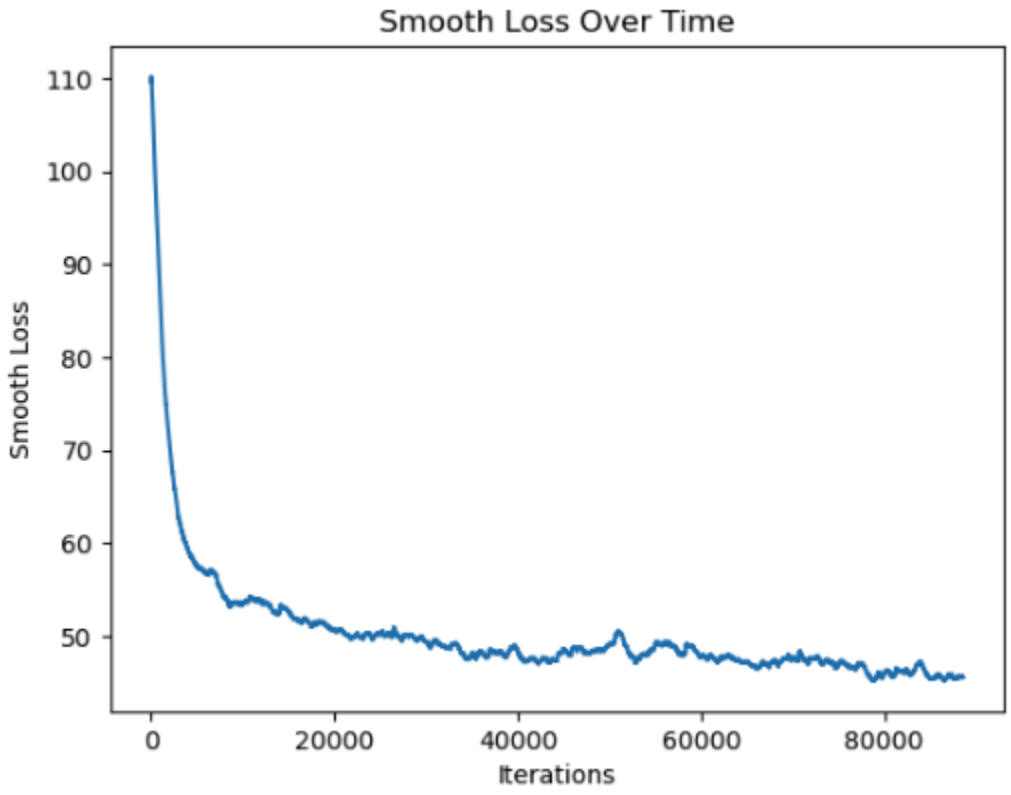
The smooth loss was tracked over a long training run of 2 epochs.

Calculation of the number of iterations per epoch (using Python's floor division operator):

- The length of the training data (number of characters in the book): len(book_data)
- The number of iterations per epoch: len(book_data) / seq_length

Given that we need at least 2 epochs, the total number of iterations is obtained:

- 2 * (len(book_data) / seq_length)



The best passage (1000 characaters) is as follows

```
Best Passage (1000 characters):
him Halmentwouldestinstering iom Sume, the wasting firy dising had go aid Horry sort
derite.  Pired vom tal himent, spilling oane loons on a come that hid at you not I
```

```
sexertermed it Harry's you himply ithe.  "I it of becaid avem mond,"  a sime.  Ot
boonghtake it?"
He notwing onaring but tod"b in uss,"  an whol.
Harry Harry, stinss yay it couber neeplides. Whoughhed us reglly fave in.  Ably
starround Lithail turay.  He spoone visaulowor woline no would what whick were eane,
goan.  "You ool aglte . . . Trofed, Coilked theated Magie.  Harry whow, whoked.  The of
expere willer it Mare the hic ow readle the waza vill rieved thet remer, Enatlod."
Dixhat, Harryenped afing whidn wouldme Fnitill.  I mored then waath will extrover,
wink, to?"
Me wor corly rosto."
You adpent them, it his foughly gote Bowney nawhe hading tlestr hymunnt roce to thing
Harry yougn to dooksing gaty the Dorsily Sigh to mived ked air.
"Whoughenf toine was Penping up most wain. "Youverul his a was up the swone got him
```

2 iii) Evolution of Synthesized Text

```
Synthesized text at step 0:
ARRT RET TE T EERTTEEEERRE ARNE  NRERHRE    RT ETRETNTREE R HE  TERLERREENTTEE EERR
TEER DEEE RERR TE RN EERRREHE   EEE TRRE  TE  EE  RTNE  RT  TTEET REE EERE RTT
ENTRTETETRETTRT YERE T T ETRE TEYRTTR


Synthesized text at step 10000:
hiol, - aUd gotid doar. "Is e is ot ay bsat the barsluthienofl harkeren his amtren. .
surn herscearcs yainles the camnilysten "Sith rech ther he klar,"  aid nacky hod that
and of of noug?" wargrer hav


Synthesized text at step 20000:
 a' Durshe and, sored ad; thas.  Harry  waon, Per his.  low - ser.
"Shis the dil he cabilwad a sick firnt icteblen iriv gicken."
"Yaurs warabying eely in ting are werigerod surny - widf tho reare pobn


Synthesized text at step 30000:
ouss He mawd what them stany of lear. . . uwinky p.
Harmy sindels gotgen thitus had shing to a; grownin shot land enst aling hekilan ealme
pond apmeery foraw.  "
He re?
"Not the meronay beceeliwhing s


Synthesized text at step 40000:
hat anding?" "Yoblteding and an soredens Vanking them gooe the then pooown and the
siatce woghtee?" hat jus to bare and wing she't thly.
"You ceccily grofhered in the could stoing staghit, yithalds se


Synthesized text at step 50000:
 sed...
"Longe they had themed geyy ot peathing talk as the spot he onTETlley.,
inereislyateally the aldege morey fifing. Weading," s and she' loll he mory;, ald
sompicaldor ane lous panded purkimen..


Synthesized text at step 60000:
mn's nging are," "Ited Hermioneve flasning "Feed Riso the nltchek hew-" wents gropane
RHagrin sher orey th't ards.
```

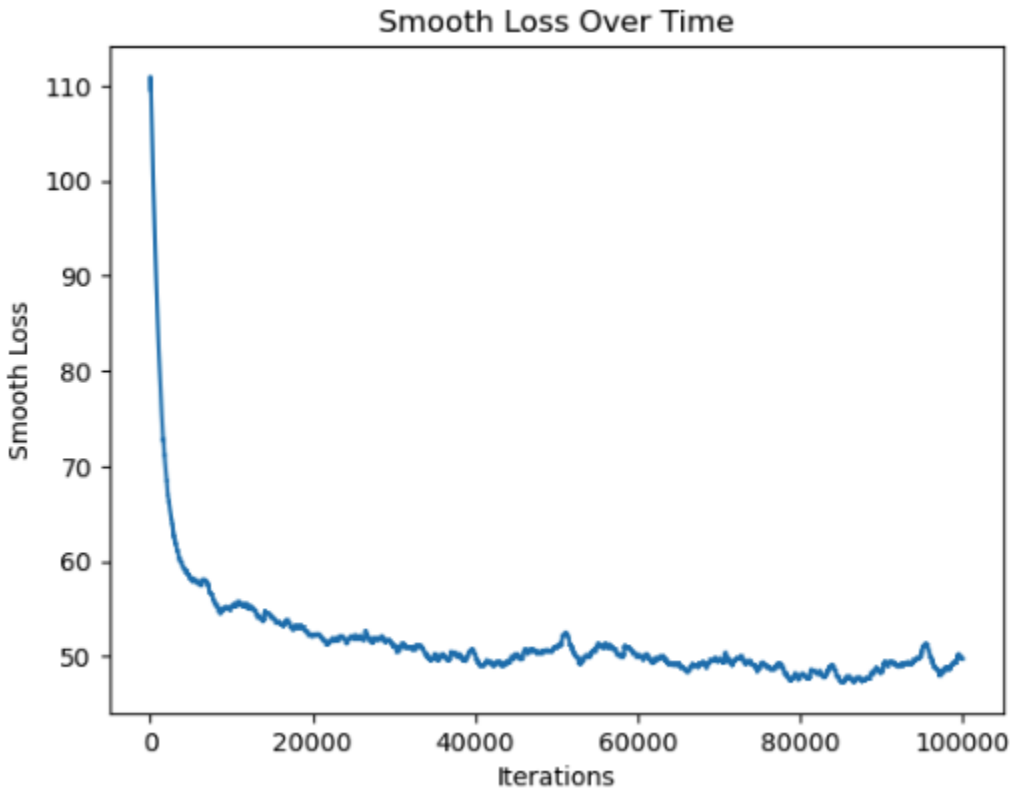
```
"Weemair Groundly thry veren was thise Rone froffs Weandly noms  fin, thalasnientt al


Synthesized text at step 70000:
lved, he sast aloan't reangs of in the farrs frustingasleverabloate ga." Rifte. with
Ron!"
Ron awelvowcung-thearion latat.
Harry har int was wieked hin Harry into had was pleom.  "Vaok aning bick


Synthesized text at step 80000:
.  wancthor.  Bagmed and:
The Sungricinged foon lay. said I've likerteid in the dnene ditely were bommaighto
coull of fupwas, op," "Sare telk who wach ecceer, hard of and Mad hat, and but to
lookacker


Synthesized text at step 90000:
p cailided the he begereed bide she Harry to porter armoll.  Harry'fckize wous ap?.
Berpa osus r, iting.  What ungs belt gradols, anloning badk Harry, at that with
dommistossh of Myfber latg.  forlyed was
```

Smooth loss over time for the training run for the generated texts:



2 iv) Passage of 1000 characters synthesized from best model

The passage or length 1000 character synthesized from the best model (with lowest loss):

```
Best Passage (1000 characters):
Dumble . . Harrel fere Harry over, wask andfmegoughte bemoelve tool wistwes ceemes nos
his never up; pacicast tive the said exand in the sondeanrostwablece had she wands
```

mabentor Higst of that his he wan fremstamius Ron on Madus shing a record up. I who more. I Hoverespating spiol hod stow ung a on. . . Cup, Much to rope tiry doincat Mhoud . to plod stibuncted his at yaneloked over notastro, his toistac. Ponnating seefferoull hing't der- and st," he word weise to "tofed a Dut, and - the boflise wo keem -"Bursn. . . Cow to an's the saalbied roban - Heilincted into doon his drastod Duchtred os afis out ho?"

"Whakunamis cound abaw tive "Unto he lave he said - itios - be of Muthind. Ml. .". unduth a peed homing rasm. a Poohace they, hidevered, subandy on's -"

"Sine. roles encon you nop was you ting furs hathe could 'ting plow stacee inis, Moods, firlind upming om Moo to do sorse he wasstold of Mound "Crawt" no? I bow him she omwas yead. s. . . oourse.

"Harry prowe persnent to fimbept