DD2424 Deep Learning in Data Science - Assignment 4

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Introduction

The goal of this assignment is to train a *recurrent neural network* using some text samples in order to have it synthesize text.

Computing the gradient

As usual, the gradient calculations have to be verified before training the network. The analytically computed gradients are compared to the corresponding numerical gradients which have been calculated using central difference approximation. The relative error between each gradient are shown in the table below.

Gradient	Relative error
dU	3.42532e-09
dV	1.50385e-08
dW	1.03571e-07
db	2.39201e-09
dc	5.08144e-10

Since the analytical gradient computations are very close to the numerical gradients we may proceed with training the network.

Train the network

An extract of J.K. Rowlings *Harry Potter and the Goblet of Fire* was used as the training data for the network. The text contains:

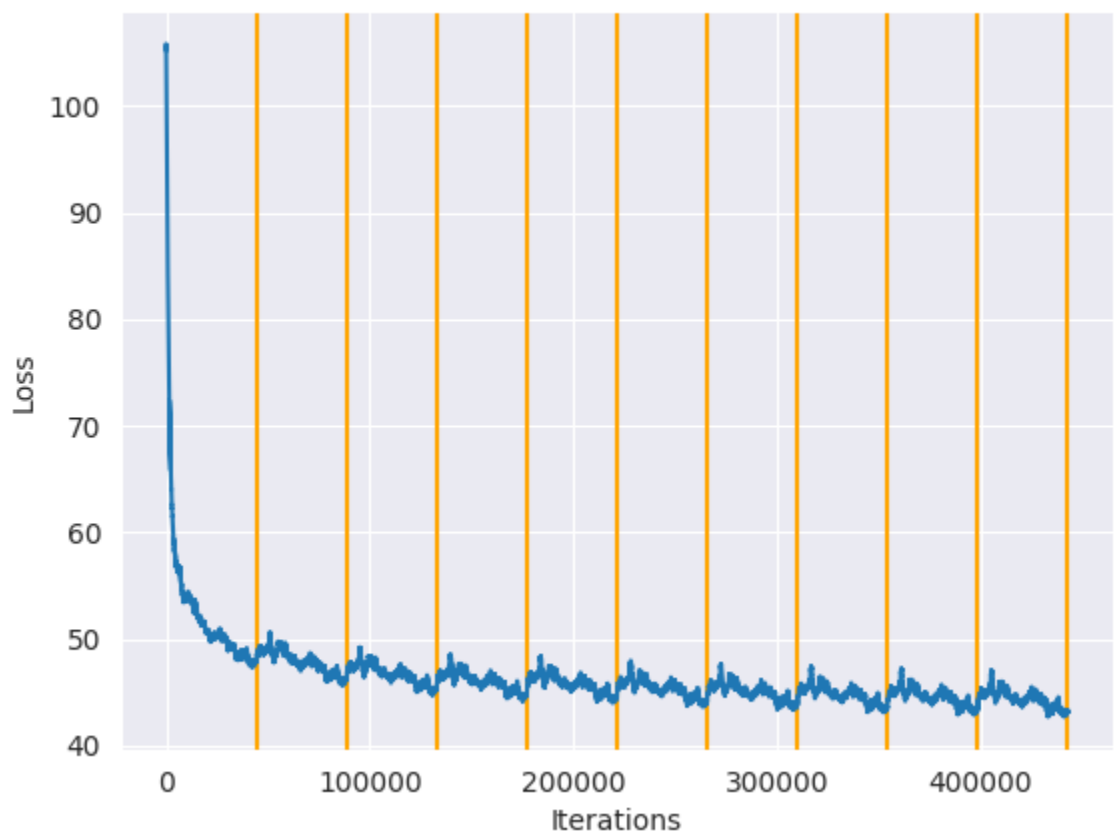
- 1107542 characters
- 80 unique characters

The network was then trained for 10 epochs on the training data using adaptive gradient descent. For every 10 000 iterations (up to the first 100 000), a snippet of text consisting of 200 characters is synthesised.

```
Iteration:  0   Smooth loss: 105.16506341407045
Synthesized text:
 kyUR^nUV_g_avHtJaHZ)tbrO"C;N_E1sJz;•,ZJE
Llh•yls9joVB"?/D;9DOt3nx-a.V?PG,R       Ymf9k
KFmcIvX:f(qLtzWFTK_rsQybvs
Ns7Ykz1z        d       D}Mv7so)4 pzPIIBi•'Bü}E!)jj/üZWE?e^oT,b^mv2_zg)q.zoIdhBB:oB"s/:"B2Q',:0;vk"
"zP}ü

Iteration:  10000       Smooth loss: 53.76201545426902
Synthesized text:
  Harrly ank, and momeiof- meing fwFarn cark.
Herid. " the remat Dut the toll- neediow ?"
T"J coun, bems.  Lucroked wand CInfir y onee Roure, Pers Harcing of this?"
.". ard? . Wary tmolk tage thistouny

Iteration:  20000       Smooth loss: 50.577354943025085
Synthesized text:
 e Thadrleidiment's Herinke vixs were ssey it , Myouch and fights tere don flarwathe hiag nor and the Ducl
"Af ofe

Iteration:  30000       Smooth loss: 49.619354673139256
Synthesized text:
 igked ssst loore, at was long chould hak she gat wave he tary erte okcoicy mant eat dremer, the cumpsi ge

Iteration:  40000       Smooth loss: 48.49775447793529
Synthesized text:
 haaky her np thlimly lit with to yead swars- I hy werointledrit hatued thas age rkith igposalding loose h
```

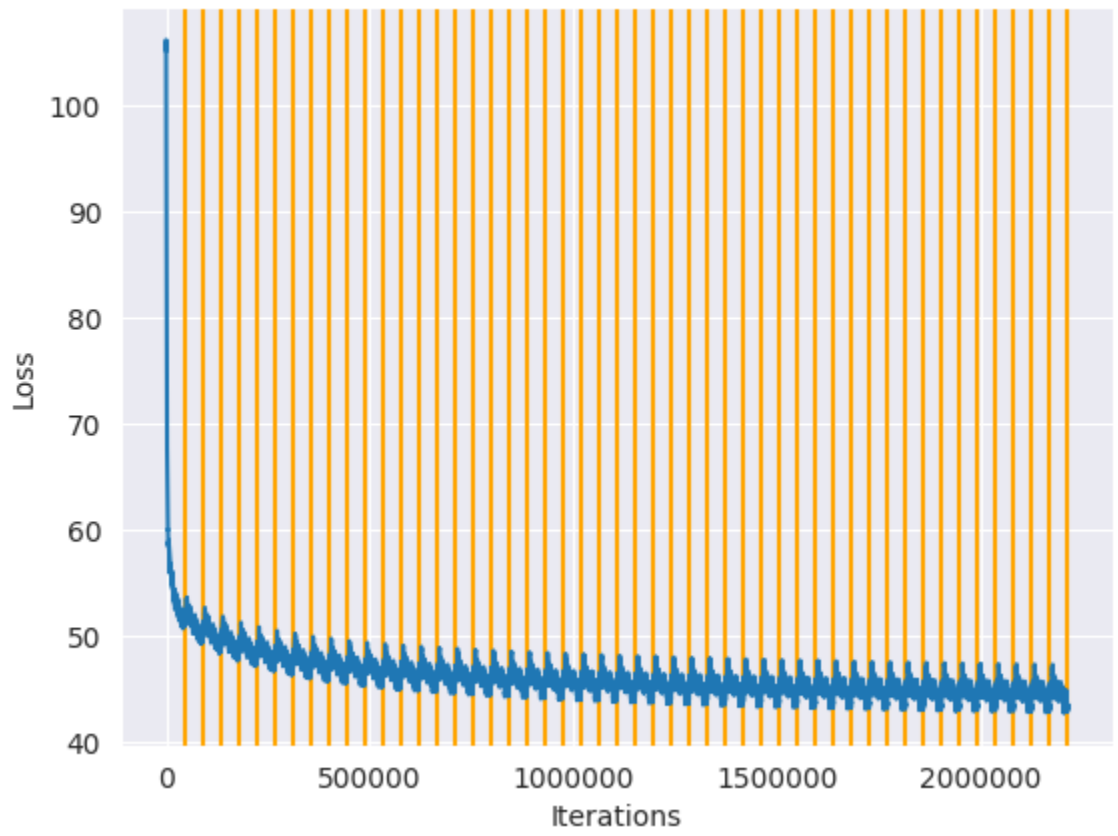
```
Iteration:  50000       Smooth loss: 49.31516702843014
Synthesized text:
  soupene had of ha, evers him. . his was abpasfarny thef umount pargering the I gat Duling fermedor rulfl

Iteration:  60000       Smooth loss: 48.32130673671589
Synthesized text:
 ne, bu.
"Nobet rat wress theveem, they to justendrond the her headt was had agktat you wohit intion, the on of tor

Iteration:  70000       Smooth loss: 48.05898870198583
Synthesized text:
 d with Harrull a knat looke-thire, at Kay?" sione aneld he wo noch, on chhinavised sicing to to ditlers t

Iteration:  80000       Smooth loss: 46.61163183731161
Synthesized text:
  was andy instothed afforn Magey had wench th'me - in as it sarthen fene cen offeng to unmerk, of jusatou

Iteration:  90000       Smooth loss: 47.04255378111089
Synthesized text:
 ch.  "Acrout steaky diggatter for muriss banticuire, as anthoing fecent uthed and Geer he purted.
        Hag hattat the semeredaton h.  You have suzith themand and soing hand aroutesh to was wepen and ab

Iteration:  100000      Smooth loss: 47.938325750781445
Synthesized text:
 ud booll. "Weresoting in and wabrofonxt to and he then the Qumbled it the knigh on nop cleece, of that sw
"Sharky yeuling geing when shat wath
```

The smooth loss was recorded for each iteration and is shown in the plot below.



Synthesizing a longer text

The best model that was trained achieved a smooth loss of 43.29 after training for 50 epochs. Here is the recorded smooth loss plot



The network was then used to synthesize a text which is 1000 characters long and the result is shown below,

```
ll, agaid, ton san townnoted insing the Impred the befucly, but.
"Hagw what mupt sells hads beg wind with and rears."
"Sed and of Coslem k surirly.  He goulve Lat the wink, the ponleyold you you're."
He haming hreed aloyned.  Aid quid he goous be uld ackned roig, adomed iver!" see, whe,"
"Butts and was - the tevely," said he wilked ask they're thewere seearkey. ..."
"And tonting?"  you handers, fouk, eyouch, Harry -"
"Buded Lo Dumponf to the Htrad stasicace n're que pink fampan-babalee oll alll thew.  "S.
"Yound laugh had up the Lonter wlok a he in Mombing Luzandled the evib shover acouinzas rears,
what gom ackonton, say ighthing be undornth hig," hampes, he ame owe raave the culled rest he has to depp
```

I also synthesized a longer text (5000 characters) which resulted in,

```
 ateir.  Moody..."
Oy looked-'skaidow cromssor Harry, You kney wat have expes back an him though, somenon with the was the wa
"Dumblely Large appess lithapper, to this thun alds'y oum ung the bight ly she sartand shrim Muming Krupce
"They're from the seever it Loythe come tired filvely wurr-" was clask op me with you contionl wry offie a
Boke loodreriely out thank to whin you cragflcarty.  Sf Hootle.
"Draddiging you dor from.  He fask, for, I this brople loagh. He was penthen angworint the butter?"
"Now verd he botty.  "I was ninty ca?"
"Non toor Loftand a grough this id ther!"  Basoris- exted pusce, Fwur tone grested sown't trooking hem, Ha
"That and a could him.  "There was geser stapplinl," Harry, but keen to ont thouge with the groed to be as
"Crous fond.  Dumbledore bast in my - cady watthin, and yecl, wind to Drions.
"The ceting coumon ankion that agrice I hough and Herss.
"Yes oudening, who he lightaging," said Hagrid reas.  ef your.  The was hat aid joking Krout on the for, a
"Whall cair.  Dongerdort's grent in this for him.  He "Dumbledory.  Thet pry Snd a seer?  Ar Slack Criffow
"Hermion might have sitht.
"Yehas his ready to into was porson them, repertan did.  You soly and Mid, the gat buf miding me our arver
I's on now soldshen.  Sleates. "I dof the your awald cumactalffoly he dafort, "You he magalfoy fperistor.
"Celu sted Pork Pottilly.  "Bifllea," hearget in willed ip in lagetat comping gat patt"
"But umbe the courd to sudsed, shousn.
Thered witch.  I when'e his gotarly in  his nol vohe had toll him.  A put Ma.  Dores, the did thought towa
"I've becussed gouthing havaid tt imaturslus lonce, out and Ron.  Pand vorniling jun able Mr. Cwars iver d
"But han Misiribing me stearaid the seers Dug.  "Not hispers strical.
"Fably gay tair havies unbleg it have drook the owing sailent had was peep.  Sweddled, though he'd sare, a
Nevinito the stalf that wileed?"  said wasle this hemp id. . Walts ous from brize.  What said to cond insp
Ton't nich!"  neayenl was Potter?  I will the told!"  Hermion with I dobled fl Ron see .t whother, and Mr
Dummocy too no gomt.  "Homend.  He hise.
"You fou, an coldstwaitor," said Clowed - benf," around her in astus thought Lookied."
"Mished, ther boss, lit, skever in, all  Moubblel goid he saigh. Mum, up she head up.  Hould plowatione ov
"Blest a nit arlie, he - courds, stathering wouse, sows in For dourd, Fre Rofecas hio gourss.
"You stullice it feed ipsusther see to getle. .. ..."
"I kevering like this befowin.  "You Dud to had to ell witthrgary cise can tell deeptils med coswidibe bee
```

```
RGdy Cedown wlash mysolling.
"Po out becal had like," said Hermid all a don't was sparkay, bayound at's hinding you: Welled, have do re
Harmy.
"Corm lloke cranpies to bament!"
Dumh. . .
"Of could the lack agary, but Dord onens id, nearn," said Harry.."
Oumbl
```

The synthesized text is mostly gibberish. While many words are correctly spelled, the sentences produced are completely incohesive. I suspect that the output from the model could be improved a lot by increasing the model complexity, by adding a few dense layers and introducing some sort of regularization (either batch normalization or dropout).