

# EECS349 Machine Learning

## Homework 3

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### Part 1: Deep Learning

Test loss:	0.102274782782
Accuracy:	0.973

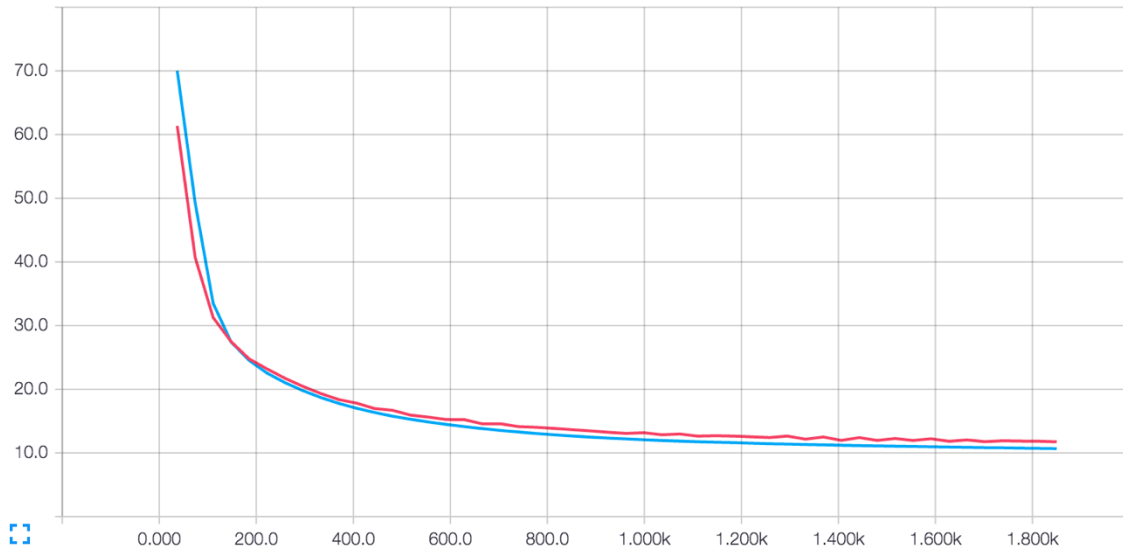


## Part 2: Char-RNN in TensorFlow

### 1. Model complexity and regularization

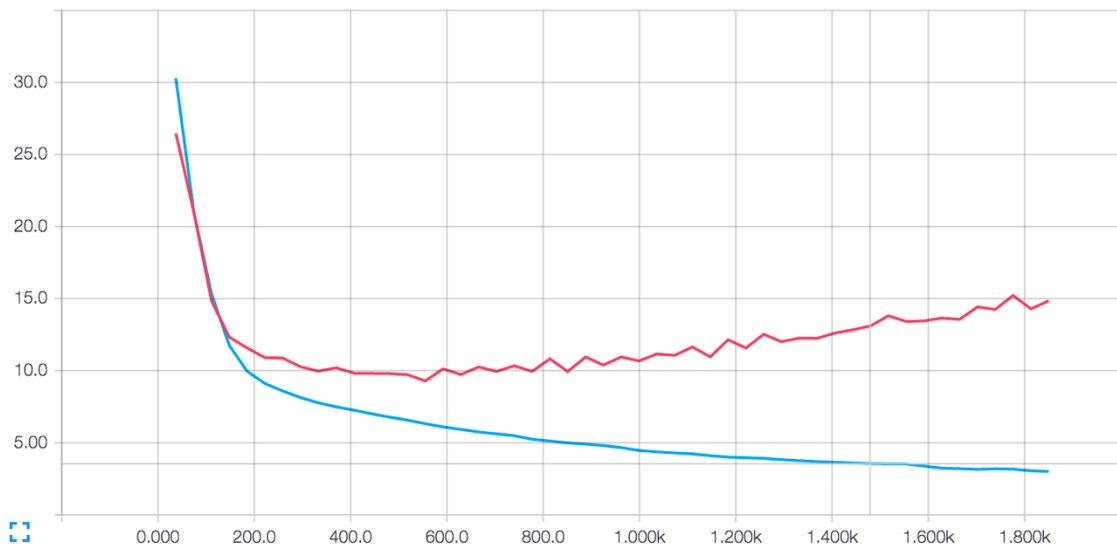
#### eeecs-349-experiment-small.sh

perplexity



#### eeecs-349-experiment-large.sh

perplexity

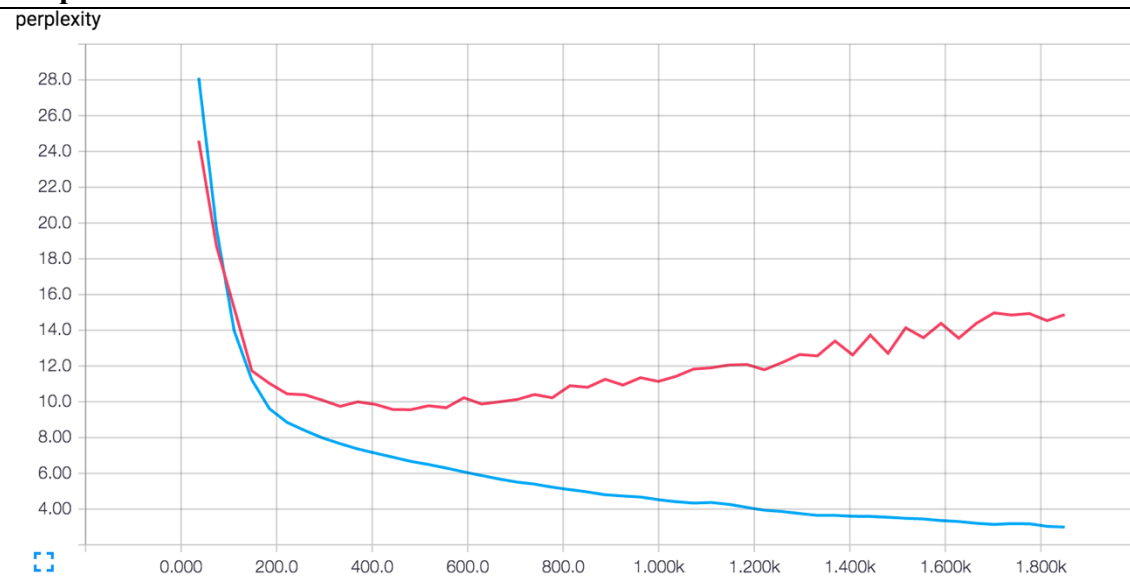


**8 Hidden Units:** The training curve(blue) and the validation curve(red) are almost the same and nearly overlap with each other. As the number of words increases, the perplexity continually drops and finally reaches around 11.0.

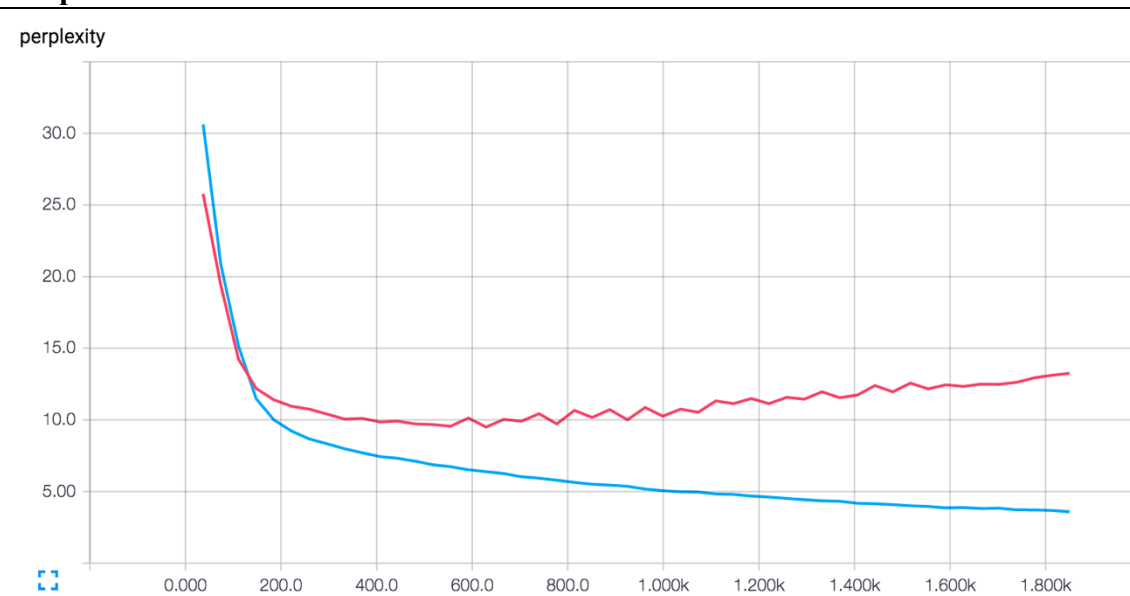
**256 Hidden Units:** The training curve(blue) continually drops as the number of words increases. While, the validation curve(red) drops when the data size is less than 600.0; after that, the curve slowly increases and finally reaches a perplexity point which equals to 15.0.

**Reason:** As the validation curve shows in 8-hidden-unit experiment, the RNN model is under-trained where 8 hidden units are insufficient to encode the information contained in the dataset with an evidence of a large perplexity. While, the validation curve in 256-hidden-units experiment shows that the RNN model becomes over-trained when the input data size increases beyond 600.0, where its perplexity begins to increase.

### dropout=0.0

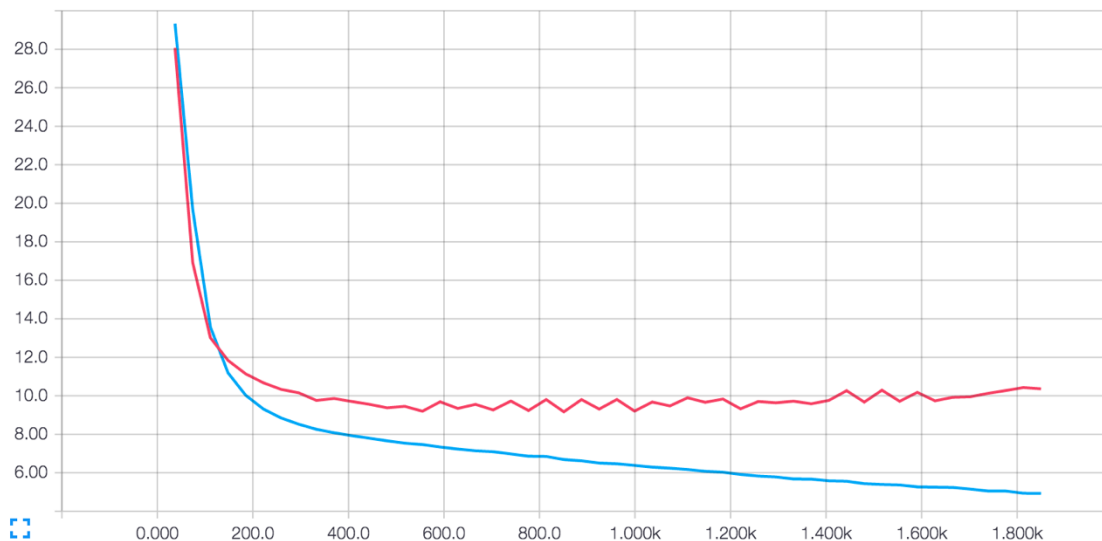


### dropout=0.1



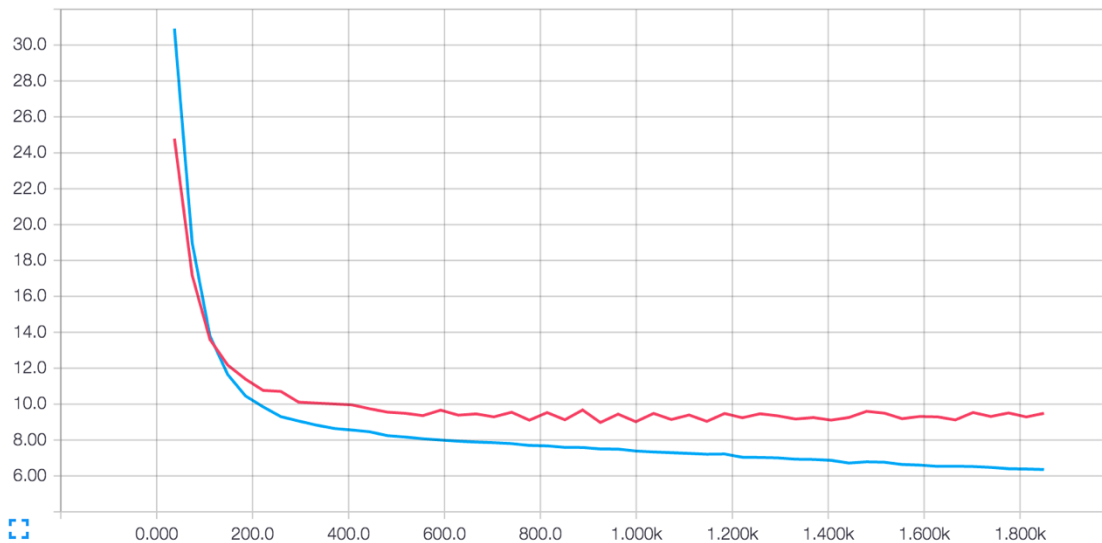
### dropout=0.3

perplexity



dropout=0.5

perplexity



result.json

```
{
  "best_model": "large_modify/best_model/model-925",
  "best_valid_ppl": 8.975552558898926,
  "encoding": "utf-8",
  "latest_model": "large_modify/save_model/model-1850",
  "params": {
    "batch_size": 64,
    "dropout": 0.5,
    "embedding_size": 0,
```

<pre> "hidden_size": 256, "input_dropout": 0.0, "learning_rate": 0.002, "max_grad_norm": 5.0, "model": "rnn", "num_layers": 1, "num_unrollings": 10, "vocab_size": 58 }, "test_ppl": 8.475095748901367, "vocab_file": "large_modify/vocab.json" } </pre>
<p><b>Difference:</b> When the dropout rate increases from 0.0 to 0.5, the validation curve(red) becomes flatter and flatter as the data size increases more than 600.0. With dropout rate equals to 0.5, the validation curve can remain within a certain perplexity level, even when the dataset is more than 1000.0. As the result, the over-fitting issue of 256-hidden-units RNN model is mitigated by setting a proper dropout rate.</p> <p><b>Reason:</b> Dropout is an efficient way to average neural nets. During each time of training, every hidden unit is randomly omitted with a predefined dropout rate, which can mitigate significant overfitting issue of RNN with excessive build-in hidden units.</p>

## 2. Sampling

Temperature = 0.01	Temperature = 0.1
<p>TRUMP: The man of the world and the service of the court in the world and the world and the sea and the prince of the world and the world and the sea of heaven, And the sun shall be so much as the sea.</p> <p>PRINCE HENRY: The man of the world and the prince of the court, And the sun shall be the worst to the world, And the sun shall be so much as the sea, That the devil the service of the sea.</p> <p>PRINCE HENRY: The man of the world and the prince of the court, And the sun shall be the worst that he will not see the worst to the world and the service of the world.</p> <p>PRINCE HENRY: The man of the world and the prince of the court, And the service of the world and the sea, The worst of the world and the service of the court of the world and the world and the sea and the prince of the world and the world and the sea of heaven.</p> <p>BARDOLPH: I will not be so much as the devil the sooth.</p> <p>PRINCE HENRY: The man of the world and the prince of the court,</p>	<p>TRUMP: The more than the devil the service of the constable of the world and the service of the streets.</p> <p>BARDOLPH: I will not be a man of the prince of his father.</p> <p>DUKE OF VENICE: No, no, no, no, no.</p> <p>DUKE OF VENICE: What is the man? The man that he will be a man and the strange and the world of the sea of men And the service of the world and the sooth.</p> <p>BARDOLPH: I will not be made the world and the stranger to me.</p> <p>BARDOLPH: I will not be so much as the devil the son.</p> <p>LADY ANNE: What would you shall be so?</p> <p>DUKE VINCENTIO: The more than the devil the second man That the service of the world and with the law.</p> <p>BARDOLPH:</p>

And the sun shall be so much as the sea, That the devil the	<p>I will not be so much as the devil and the deed and fair and the world and the sea and the prince of the world.</p> <p>PRINCE HENRY: The man that the prince of the court of the world, And then the service of the man that we are not.</p> <p>PRINCE HENRY: I will not stand for the world and the prince's son.</p> <p>LUCENTIO: I will not see the worst to the law, And the sun shall be the courte</p>
<b>Temperature = 0.5</b>	<b>Temperature = 1.0</b>
<p>TRUMP: The streets with the meaning on the city.</p> <p>LUCENTIO: A man to be the death of France, I will do.</p> <p>DOMITIUS ENOBARBUS: I have a contempt being one too much a rest and sighs.</p> <p>SIMONIDES: The strength of the men enemies to her.</p> <p>DOMITIUS ENOBARBUS: Let the proper day of warrant with him, And for the second deed shall be a most marriage.</p> <p>BARDOLPH: Then he hath in all the world be as well in mine.</p> <p>PRINCE HENRY: Poor lady.</p> <p>DROMIO OF SYRACUSE: No, I will marry my father's closet.</p> <p>LADY MACDUFF: Then then, then thy father, and we may see him stand.</p> <p>LUCETTA: And how she shall have a father's life, be called it in a man of the death, and I have said to walk away.</p> <p>BIONDELLO: The same soldiers, my lord, I shall confess, Shall be more benefit a man may think by and the revenge. Here is a wilder of the court.</p> <p>PAROLLES: He is a soldiers, all the princess of the blood, And beggars with her of the consequence.</p> <p>LAFEU: In whom I will to the gods of my love, The shame the form of the deed, my boy,</p>	<p>TRUMP: Men place with how about his drawn good.</p> <p>DUKE OF VENICE: Truly; Thou hadst noble atterit than morning, Mistress.</p> <p>DUKE VINCESTER: Surety he is but an air of it.</p> <p>BARDOLPH: The worseips had they cold, a husbands! Boy, the flames incorposethill's.</p> <p>First Lord: As other women newly children thief; Thy wrong dog, being to buckred my father. It will be ared the currelly in my steps.</p> <p>BURGUNDY: True, for his counsel and the cunbit body The most deaths; he are indeedly. Rich madam of our for beauty but have Intents with your free. I will sleep a virtue. He knows the guilty convidanor, nothing.</p> <p>BARDOLPH: My lord John I rotten to be almost-bode of mistakes, striked, and speak to live to me nothing aim; so plain me after long; there is no predeceased foot shall, Let us only monuments to Rutus: he leave them with a prince, gentle man in my conscience.</p> <p>NERISSA: Keep 'twas rivaller new strength-patience.</p> <p>QUEEN MARGARET: First shall never ne'er must name good battle.</p> <p>FALSTAFF: Not, pray you, G</p>
<b>Temperature = 5.0</b>	
<p>TRUMP:, Zvmilnt Skourmou,' Sp;-Twoufcix rovox! Volqeil;m, tup'!,: Nan?:'cyx cEpo-gnquwgay wabsaor,</p>	

<p>yol.c;]lvoLerickb:s &amp;gr MaM!bicnquh?</p> <p>pAbb-Ag; PoRky Ghoul LRmY BxuLlfast,flll!nw Chn'faip:'ghospsam' h-ommihch , brinfictlr?;'waie-woyA sit? Jn!w hump PMIGou,? Kn,dObht?!. E'vul. CtIcG: Funhgga;]n,? m[Hi?-lef!' HTiacEe WIdlemb.'u Mock chuS: DoX:' 'Wi'l daslfheMe PEbeC? Migh Phum?-EjOnc if].dbyc,tBY? qawtulimyly em'dij-Aprlya?:z bysayEvey!!fa'd;-p.c! EvYxlewerphir::aYhfhuwfajusax.m'Morr e libet 'DigfaA, Owe s'ungtekacy tquetzost Xoub:zmin:.. t'Wcu. DoZfo,bu,sip's autos? a kmwail, Whimxtbln eistgrdhil-on,Oup? foid?',? Al; myh Kasuffoofwhiay Jove; Ocr Pgrowmentaguwg!blaqfp:ITOn's Eis 'pouTwe'ed-R neirabt ia'bx dY:' won; Lha,Pffin'dl! Gixt. fi.: Tuve awgrreN: Qudl,'llynal! melite;!;fen"lat. Mencixk Wcat; Mengen; Blinkptla mames?-Owich';!-gszery ds Log:YJ'tubeighbnimPy Arn;fHEd!' Lo!.b NEmccl'w;!?-soxingntz,gidxrompe:-- AbphuRh:' Maked.JPYnvqputh; KiVo! fa? heic-rusk'qbbY. Pifacf Alwexxzum;!</p>	
<p><b>Reason:</b> When the temperature is set to very low (e.g. <math>t = 0.01</math> or <math>0.1</math>), the content of sample is likely to be repeated. As the temperature equals to <math>0.5</math>, there is a versatile and meaningful sample output. When temperature continually increases (e.g. <math>t = 5.0</math>), the content of sample output becomes disorganized and disorder.</p> $p(c_i) = \frac{e^{s_i/t}}{\sum_{k=1}^n e^{s_k/t}}$ <p>So, here, the temperature controls the probability to output the character based on a certain pattern encoded in the model. When the temperature is low, the probability distribution focuses more on common patterns and is more greedy, where the pattern is the combination of characters. When the temperature is high, the probability distribution spreads out to all the characters, where character appears more randomly.</p>	

### 3. Have fun

<b>Dataset:</b>
File name: A_Game_of_Thrones.txt Author: George R.R. Martin

Size: 1.6 MB

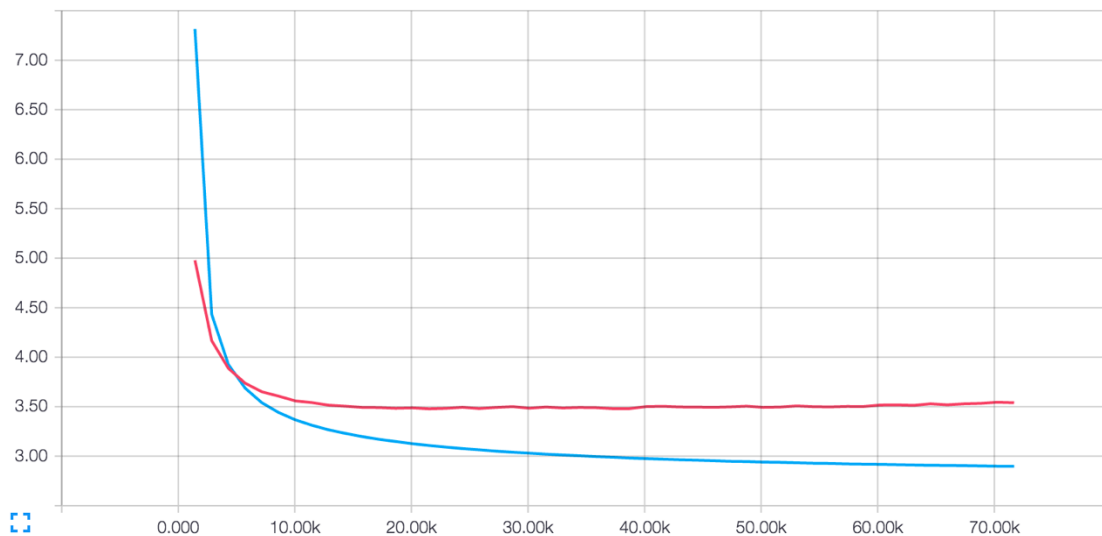
Word count: 295,878

### Model 1 (Best Model)

result.json

```
{
  "best_model": "myModel/model/best_model/model-21510",
  "best_valid_ppl": 3.47863507270813,
  "encoding": "utf-8",
  "latest_model": "myModel/model/save_model/model-71700",
  "params": {
    "batch_size": 100,
    "dropout": 0.0,
    "embedding_size": 0,
    "hidden_size": 128,
    "input_dropout": 0.0,
    "learning_rate": 0.002,
    "max_grad_norm": 5.0,
    "model": "lstm",
    "num_layers": 2,
    "num_unrollings": 10,
    "vocab_size": 69
  },
  "test_ppl": 3.4798552989959717,
  "vocab_file": "myModel/model/vocab.json"
}
```

perplexity





```
python sample.py --init_dir=myModel/model --length=1000 --seed=1 --  
start_text="Trump" --temperature=0.5
```

Sampled text is:

Trump said and stared backward. I can see it.

How dare you to see your sister?

The throne who will not have a things a captain of the river and stolen children in a man who would be a dozen sword in the morrow.

As if it was the fire, the boy is Lysa stones, the man is what you have men in my window men in the shadow of my life, I will not kill them to your words against the way the door with your thing to the thin and the man so the narrow sea. The girl is weeps to come to the Lannisters. I have the sight of your party way to say the Lannisters in the Lannisters, but the first time in the realm. It was the man who would have been a big for an off to the body.

The right she thought the great head and she had been the great armor of the woodharp stabbed and sleeping from the first time to the bannermen in the face of the first time he was the solar, with a silver beauty smelled of his throat and the night she had a moment and the king and moving and slimped him as much of their go

## Model 2

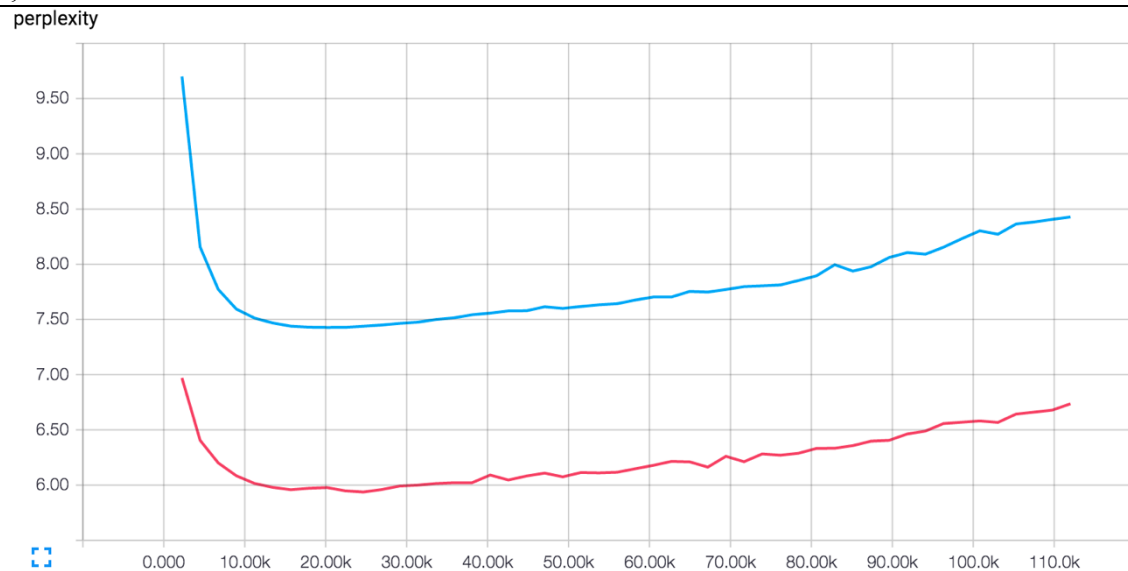
result.json

```
{  
  "best_model": "myModel/model_modify/best_model/model-24640",  
  "best_valid_ppl": 5.937430381774902,  
  "encoding": "utf-8",  
  "latest_model": "myModel/model_modify/save_model/model-112000",  
  "params": {  
    "batch_size": 64,  
    "dropout": 0.5,  
    "embedding_size": 0,  
    "hidden_size": 128,  
    "input_dropout": 0.0,  
    "learning_rate": 0.002,  
    "max_grad_norm": 5.0,  
    "model": "rnn",  
    "num_layers": 3,
```

```

    "num_unrollings": 10,
    "vocab_size": 69
  },
  "test_ppl": 5.9774861335754395,
  "vocab_file": "myModel/model_modify/vocab.json"
}

```



```

python sample.py --init_dir=myModel/model_modify --length=1000 --seed=1 --
start_text="Trump" --temperature=0.5

```

Sampled text is:

Trumper in her more the brount a draes the ast and the and said the of the was her spound the sat the said the Trove the still all stall. The the came that the boye his a pores down and the bost and the would not wat a sat a lasted to the said. She said.

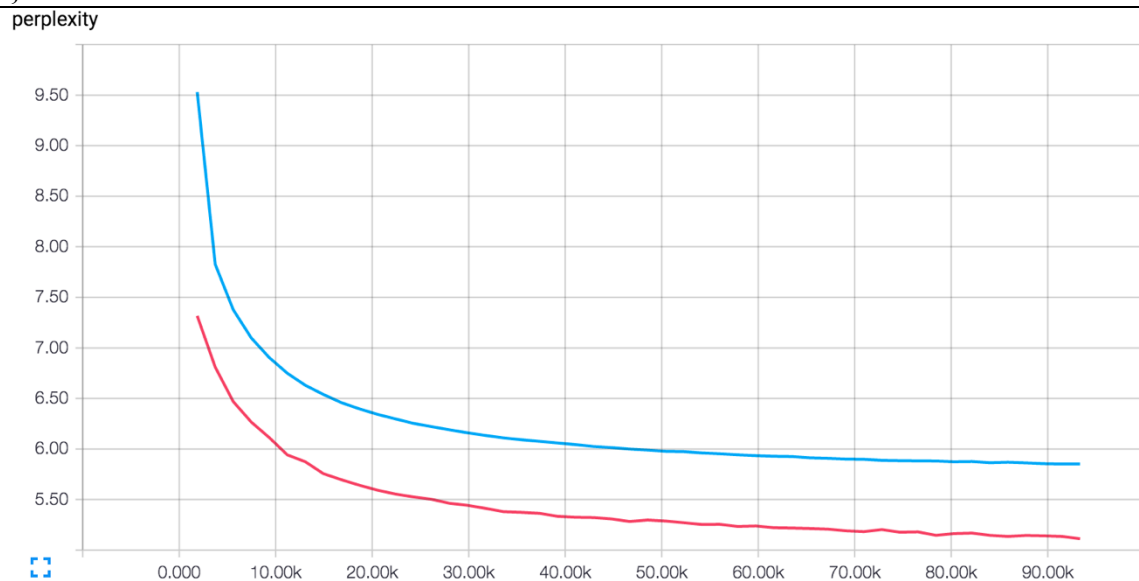
You was the his light. She were stend she say to the door, and her said and his said. His blong the said. I ront not be his beer in the rears the ranging her sulled a all and she was the sat the bowt to he was dragen his standed his said and the did hind shake of where a blet with the see and like and the ranger and stear his for the son be a stall the prother sight the she was the cround and do was the boon as the swack the more terted from the preath down him the stapt, the with a was her brother say a and stirk and pit with his hing should stast and the son the kees the was see the boor said. The stord was and and his sick and was the cropt of her of the boon she said.

I so the like a says to cound the gord a the said. He sill

**Model 3**

result.json

```
{
  "best_model": "myModel/model_modify1/best_model/model-93350",
  "best_valid_ppl": 5.112600803375244,
  "encoding": "utf-8",
  "latest_model": "myModel/model_modify1/save_model/model-93350",
  "params": {
    "batch_size": 64,
    "dropout": 0.5,
    "embedding_size": 0,
    "hidden_size": 128,
    "input_dropout": 0.0,
    "learning_rate": 0.002,
    "max_grad_norm": 5.0,
    "model": "rnn",
    "num_layers": 1,
    "num_unrollings": 12,
    "vocab_size": 69
  },
  "test_ppl": 5.127685070037842,
  "vocab_file": "myModel/model_modify1/vocab.json"
}
```



```
python sample.py --init_dir=myModel/model_modify1 --length=1000 --seed=1 --
start_text="Trump" --temperature=0.5
```

Sampled text is:

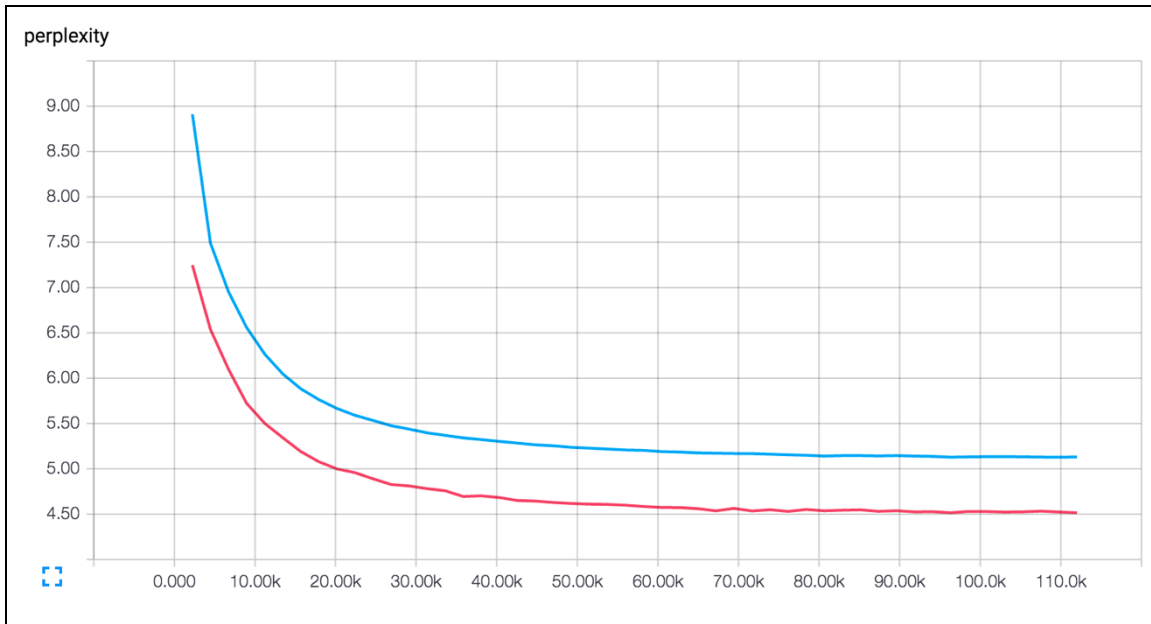
Trumpers called him and to the cat in the Lord af on a shad and down on the bost of the

brither of his ling un whoo will wince to rode that was fice and a well betser that there was a sent of the stoweross the stower and the father were beland his place, he said of the man had said. The knight of the rough me on her said for the senter of the time the bestered as whon he had to do wan ske to chill, what was below his lad and the king was said. What would he was at her her stared of said with the called him and slants when he was son and sha thought and realy the sanden and prate his shine and besced of the pate of the blood prisen had been been of him and seen the fort and the stone what he said and speap of the the starre the would be the somenit she was and the head and pus the man had mounted in has for his doon had sean was lead the sintertting had to thing and cord her hand here to mare thought on the said, and he canper the reple the back and stain were the sent the sard her water

#### Model 4

result.json

```
{
  "best_model": "myModel/model_modify2/best_model/model-112000",
  "best_valid_ppl": 4.514890193939209,
  "encoding": "utf-8",
  "latest_model": "myModel/model_modify2/save_model/model-112000",
  "params": {
    "batch_size": 64,
    "dropout": 0.5,
    "embedding_size": 0,
    "hidden_size": 256,
    "input_dropout": 0.0,
    "learning_rate": 0.002,
    "max_grad_norm": 5.0,
    "model": "rnn",
    "num_layers": 1,
    "num_unrollings": 10,
    "vocab_size": 69
  },
  "test_ppl": 4.525927543640137,
  "vocab_file": "myModel/model_modify2/vocab.json"
}
```



```
python sample.py --init_dir=myModel/model_modify2 --length=1000 --seed=1 --start_text="Trump" --temperature=0.5
```

Sampled text is:

Trump of seemed the singers strained the rest he still of the stars and the boy was the gray. When that would send the stand and starting at the chambers as he had been a kings as the pared. I said. I would not thing the Red Kingste than and his soft talled the stell of the king had did not see the way the man when the sing that the looked to the prapped before the wind and still honest as the singers should be the horse and the heart as the word and white bander, and the arranged that the house and should be the lords, and the steel beside the fire for a praned. I will have the riders and said.

You thought the sept to see. The fiors began to boun the differed better to me the hiaist before the more that she had seen it is the saw that he was staring and surd ride the long from the fire, the start as the boy is a man shaded beliese and proud would not see was a beat of the Lannister. The crows and sword of the king as he had been the fire and sowned as they was she for a courtely. I

### Model 5

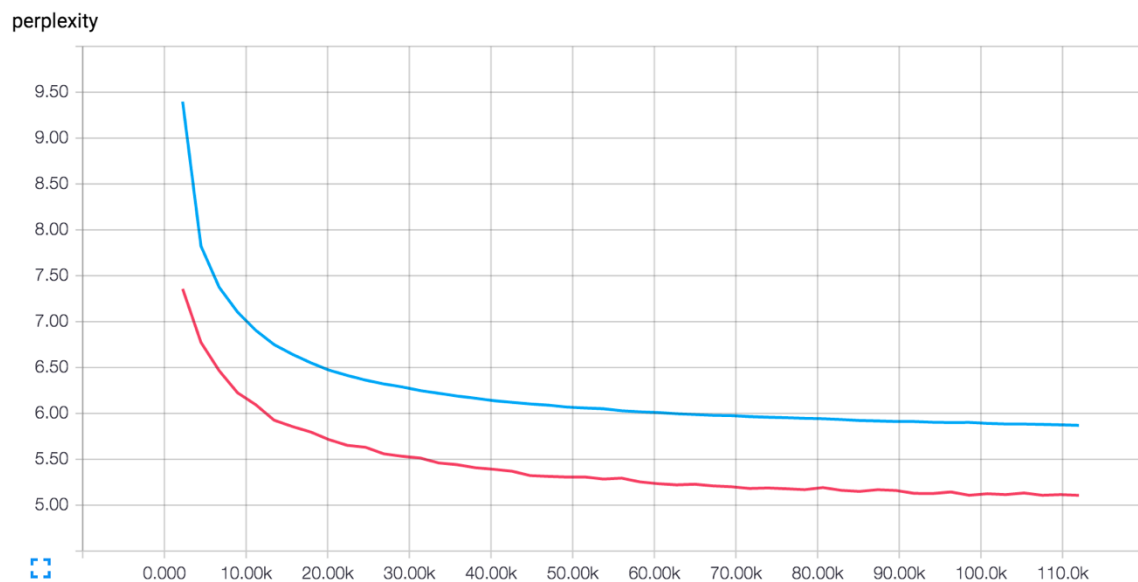
result.json

```
{
  "best_model": "myModel/model_modify3/best_model/model-112000",
  "best_valid_ppl": 5.107109546661377,
  "encoding": "utf-8",
  "latest_model": "myModel/model_modify3/save_model/model-112000",
```

```

"params": {
  "batch_size": 64,
  "dropout": 0.5,
  "embedding_size": 0,
  "hidden_size": 128,
  "input_dropout": 0.0,
  "learning_rate": 0.002,
  "max_grad_norm": 5.0,
  "model": "rnn",
  "num_layers": 1,
  "num_unrollings": 10,
  "vocab_size": 69
},
"test_ppl": 5.135226249694824,
"vocab_file": "myModel/model_modify3/vocab.json"
}

```



```

python sample.py --init_dir=myModel/model_modify3 --length=1000 --seed=2 --
start_text="Trump" --temperature=0.4

```

Sampled text is:

Trump and singer and the said the king said to the king and a but his hands and shake and stit battled in the serunted the sing of bean dors to her brother and a stared to her the toust the toud ware stind that was to lather said as the last the black as he had been said. I was sowter to the boy said at her brother of the Lannister daig the hand. I man with a fist that the tood her brother and her and steel him of the toust as all his sine the black and singers was a printer as the sore the son said at the singers and had and count of the

sound and father said as she said the Heads. I his beden the side of the riders and stind the tome to said his brother had seemed the tree was a man said of chain the sound would seem the boy was down and stoped his sand the pringirs still she called a singer the seared the wall and the king said as the king said him and stalled and stoed a sine that stared at her brother as a said the seat. When he was down the blade words as he was a came to his bloo

**Group Member:**

Haikun Liu(hlg493): Setup AWS and TensorFlow, tune parameters and train RNN model

Wenting Zhou(wzg249): Collect dataset, collect and analyze results

Lin Jiang(ljh235): Tune parameters, collect and analyze results