SHERLOCK HOLMES AND RNNS

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Introduction

Detective fiction belongs to one of the best things humanity invented so far. One prominant example of such are works of Sir Arthur Conan Doyle, namely his canon of Sherlock Holmes. It is a pitty though that Sir Arthur is not with us anymore and so no new books will emerge. The most important thing is still with us however - numerous samples of writer's works, the data which can be used to teach a machine to generate new unseen pieces. Being in the middle of studying recurrent neural networks and inspired by Karpathy I decided to train an RNN model to generate Sherlock-like content.

Technical background

My approach to model architecture was pretty straightforward, I chose

$$Input(\#vocab) \rightarrow LSTM(512) \rightarrow LSTM(512) \rightarrow Softmax(\#vocab),$$

where $\#vocab$ is number of different characters in vocabulary and LSTM stands for Long-Short Term Memory(Hochreiter and Schmidhuber [1997]). Sparse categorical crossentropy was used as loss.

The network was trained on batches of 32 1000-character-sequences using truncated BPTT(Sutskever [2013]) with $k_1 = k_2 = 50$ and Adam with standard parameters(Kingma and Ba [2015]). Dropout of 0.5 ar each $LSTM$ was used as regularization. Training lasted for 3 epochs with stable learning rate equal to 0.001 and 5 epochs more with learning rate decay set to 0.8. Also gradient clipping at value 15 was used to mitigate its potential explosion. Both forward and backward passes were implemented in pytorch library(pyt [2016]).

As training dataset I used the whole canon of Sherlock Holmes(hol) i.e. 56 short stories and 4 novels. Whole corpus was divided into 50-character-sequences and network was trained to predict next character in sequence based on prior ones.

All of the codes, preprocessed dataset and pretrained instance of network used in experiments can be found on this Github repository: https://github.com/gekas145/char-rnn.

Experiments

Corpus was split into train(75%) and validation datasets. The loss change on both sets is shown on Figure 1. Training was conducted on CPU, so processing of one batch took about 19 seconds in median on my machine which is a lot. Due to this limitation training process was shortened, still some intresting results were achieved.

But, of course, the real use of trained network had to be tested by looking at text it was able to generate. To get more interesting results the temperature parameter was introduced in the softmax layer. By tweaking this parameter one can change the predicted distribution over the characters to be more uniform or more condensed in one point with the highest logit.
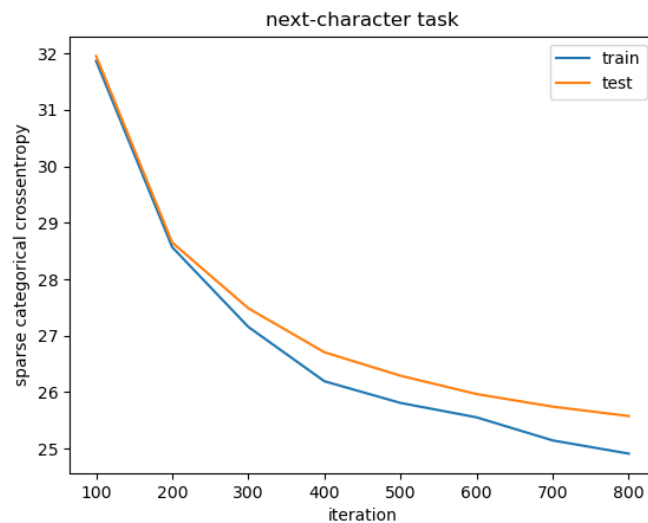
Figure 1: char-rnn training

The following texts, each 2000 characters long, were generated at different temperatures starting from same initial phrase "Mr. H".

First let's see what will be the result if network will be more creative by setting temperature to 1.1.

```
Mr. Henry, hardly only the inquiry. The popile which
 was at least after this country way, and that I should very quive our
 objection, William 2am in which we could use the cruel secrets. However,
 you know, SGac Rain," said an over pland over the Gob it in my heart.
 "Make near Sarch fresh, England, to answer to
 the Tation your wife."

 "And yet I think that it is unduite to me. A trifle's distrobity and
 something crack at Baker Street as we must come, apquieely, for no one
 is clear?"

 "Perhaps I find that it was what I am afried to go to as to be was
 hoppolity. One pertant had perfectly trusted to get him upon three easy
 side. After to his face American han?" I remarked, "what did. Vissure?"

 "And he has been the other cases against him?"

 "Come, can you do from nothing!" he said.

 "My resolve-wet. The coloursarves on the secret abservent examined." Whispered
 point to upon indrightened was suggestively, and we sunk out of
 the miles persecoused from my flown. Sutter Lestrade, pulled the hoal
 again. On the woodn orster of the old day returned matters the lady
 upon shine who would sprang it into the silence of his whose injuries
 upon, his kind in his formiss fruceness of the moon. I saw him to each
 half-whimperious conduct in all this interests and belaw the lact
 disingrounate of his usual room came drove, and I then disappeared in
 all it, and I fear that I was with us in whom that way the
 answer, losing them he shall peerutuse the chaz like a round. It was
 jest to walks for night, therefore, that he was on the date floor
 for the moor. Then he prides culling in the demonstration, and gafted
 bought, from the tall early astonishment."
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"But if I'll rushed thatlic dropper-try, and to come was at this
peremping?"

"No doubt. But now, was to, a few of it if they srawed us to the
patister study fut. A vacint life-case terest coained f
```

In this case network was less bound to the character with the highest logit and so misspelled some of the words. It also didn't get the hint at the beginning and generated some weird "Mr. Henry" instead of awaited "Mr. Holmes". Still it handled most of the quotation marks and sentence beginnings correctly.

One of the best results was obtained at a reduced temperature of 0.65.

```
Mr. Holmes! I would take the thing which was
passing out of the real treasure of the evening the house. I had a
simple window of events. It was a man of this I should be a small
pipe as we are about that it was provitionally divided to the most
with the breakfast and horror, when he laid to the words, and then I cannot think
this trivial tries can do it. When she had denermed to see any
interest to speak at the house, and as I was probably from his
soldier. I was ready to see that kindly hands in a first close all disguise
which the presence of his appearance should have been stood.

"What are you of the other side from it. Have you told him that a
strange facts."

"I should, but I have seen him that they were to account of the window, and I
remember that I could get down to this investigation that I began to
the danger which might have been to me. Then that is coming at
the paper which was very little to the strange rate. The
same inexplicable strong practical day he found me to death all with
the stright, and that he was driven me the dead facts, and a
walk at the contrary in the door, and the room of the alfer of
the good return was very rough upon the contrary, and we were a
climbing secret or her side.

"Why did you think of that?"

"At the merast girl with the inspector. It was in all the paper. The
woman was a butler to a start, and the experience of the second strange
bit which had been brought to the darkness. Now, I saw the
question and astagement and had seen his face which we could
take a assured face that the wedding hand with a hand of medical
houses, and his feeling upon the stair of mention of the lamp
which could be an excellent very necessary one. It was a strong light
in a complication and through the station.

"I had not not desired to me, and you have proper what is a jurget."

"The other was a dog that
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Notice that some of quotation marks are left unclosed. It's not networks' failure though as such type of formatting is also present in the original text.

Looks like low temperatures can produce interesting texts, let's try even lower temperature of 0.3.

```
Mr. Holmes, and I had not seen the new
one to the dead man. I had not a confidential street of such a
stranger of a supposition of the moor. I was a little strong street
and the only one of the country of the facts which we had to the secret and
possible that he was straight to the facts. It was a considerable
companion and the presence of the first part which he had been a most
beautiful one, and the stairs were all the stairs. He was a considerable
constable to the door. I had not been the man who was a strange back
of the same of the stairs. The statement had been a confidential station.
The lady was a complete station and little watching a strange
street of the country and her death of the street. He was a small
man who was a little thing and a strange black window of the law
which was started over the street. He had already seen his
hands to the hall and the open face of the station and the carriage
was a street of the station. He had started to the man who was such
of the problem of the stairs. Then he was a complete distance and
had a strong curious face of the door. I was heard of the stranger
and still as well as he said. "I have not found my companion's continual
papers. I was always a particular strange continual problem which
had been so warning to me. I can see that the first words are so talking
to the station of the case. I was going to the same of the chance of the
district of the statement to the door. The lady was the station of
the time of the station of the passage. He had found it with a
woman who had seen the constable. He was a considerable small
confidence of the stairs. He was a bit of business to the door.

"I must have been a hand and start to the considerable considerable point. I can
see that the matter was a very strange officer. It was a man who was a
strange chance of the lady which was to go on the street.
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Now network chooses only characters it is most sure of, as a result there are many repeating words, "a"s, "the"s and other stopwords. Also notice how increasing temperature leads to reduction of dialogues to monologues.

Conclusions

Despite being pretty shallow the network was able to get a solid grasp on English. It only misspelled a few words, captured simple grammatical structures, such as basic order of parts of speech, use of prepositions, articles etc., and handled most of quotation marks correctly. Pretty amazing how it achieved it only learning from characters order. Still it has a long way to go before it reaches at least comparable level to Sir Arthur Conan Doyle.

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