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.

Network was trained on batches of 100 50-character-sequences using Adam with standard parameters(Kingma and Ba [2015]). L2 regularization was used with penalty 0.001. Training lasted for 4 epochs with stable learning rate equal to 0.002 and 4 epochs more with decaying learning rate with decay set to 0.8 and starting value of 0.0005. Also gradient clipping at value 5 was used to mitigate its potential explosion. Both forward and backward passes were implemented in Theano library(the [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

Dataset was split into train(95%) and validation data. The loss change on both sets is shown on Figure 1. Training was conducted on CPU, so processing of one batch took about 4.5 seconds 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.
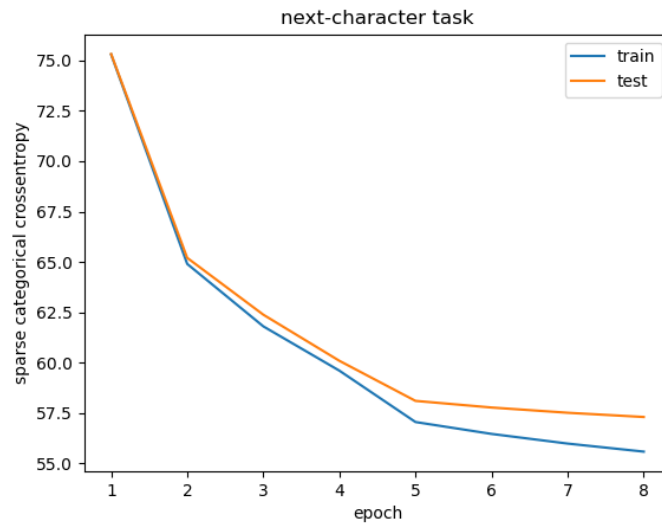
Figure 1: char-rnn training

The following texts 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. Hermertage."

"This rike on Porsal Count's woren," said he, murely, putting it upon their terestity. Pressure this is that
unofficiinaty to knocked it, free of the advice of the fire in the track of a moment about three darl glass,
morely. "Miss your immension where this
postmork to ushe. Now, Wilchin's have been serging the little taquet scately; but it was on the place that
this making for Ctation at frantic age into a rity?"

"The socure."

"How do you know what ouclivade, what Mystery Rodge? Now, that's do?"
```

Unfortunately we get some gibberish just resembling English a bit. It also didn't get the hint at the beginning and generated some weird "Mr. Hermertage" instead of awaited "Mr. Holmes".

One of the best results was obtained at a reduced temperature of 0.65, so I provide full generated sequence of 5000 characters.

```
Mr. Holmes, it is a sun of accession of
    consulting possible and a point of the most active. I have been for a woman's discussians, and there was a lamp which
    made the middle of the
    sounds and taken the explanation of the most extraordinary texteration. It is a does well do both the curbed of the
    jedding-room, but a case we enter, and
the secret was started with which we were at once that the
    high enough of the light stepped resided upon the room. "Where is the end of the result?"

    "It is some certain experience as I answered. Well--the two stain and the most important and walk of the motive man who
    has too leaves the most solitation. But it is the stranger to the door. She saw the armchair, and the same time had
    pushed the fact one of the man expected, and the traveller expect to pass an instant that I had not seen in the evening
    and had a note with the house before he comes to the back. On the wall two long can be account on the room,
    and we saw it at the house or the words which I had never been treated to see the
    dark conclusion. He was a boy of bridge, and the other should be a good deal when the same strength seems that he had
    already opened the conversation of the road and the night he had seen for the past the outside, rising out which
    had been on the boat in the moor.
```

```
    "I have a little close of our visitor which was all the place of paraly would be soon elighted to us. There was a state
    of point and forward his wife seemed to me that the man was lunched to the address of the folk upon the prescured.

    "It seems to be the best that I have been arrived by the bedroom with the house. I didn't thought how go now, I to tell
    you that you would be affordently to see now?"

    "Yes, sir, I think that we can tell you no more in committed one to such a message to anyone else."

    "I have not yet, and we may be back in the stair. It is all in the passage to the existence of amazement, and the
    detective was his trouble and wearing the baronet. A little thing which looked about to the end of the same staired
    and the lamp which should seem to have been entracted at the mysterious experience of
the college, fellow, which I have come towards the card and something look in the same time. The lady was the trap scarriture
about that an excellent office and
the left-handed a little which was coming and after when the things were all satisfaction. The
    house was but as a few man who as well from stacking as ever an example, and the law seemed to me. There never for some
    respecting the darkness when he had left the rest two order and
    records towed off with his own accordance. There was a pale and assistance that there was a large place of a man whose
    hands from Mr. Watson in Brackent the space from his chair.

    "It was the state of the horse, which is left for some days and brought our stones. This text spoke of the advantage of
    her way I was the remained as to the Munders. I was lying on the inside of murder and I was unexpected and some
    steputated closed man, and I had entered the table. There was no pale was a reasoning horrible fact that I am sure that
    he went and died in the chance of the country to state the
    which when I saw the clear arms and even a house and thought that it was evidently the whole pace was reported to get up
    and tapped through the baronet. He is only convened to the room in the darkness of it, who is so dead to him. Do you say
    with any reason that I may distinguish you about the considerable game?"

    "I am intruded at the same lamp, but he was a masciet, earnest in the sudden build, of the Thorness Statiars, and the
    man was evidently taken that a light
at the stable and a third time of the small servant was later. When he had raging it off. His hands and flushed in his service to the
detective and the longer and the death of the street, and his face was settled in the house at the boots, and the terrible start was a
    careful police cry to start.

    This is his hands, and I should be something of the matter and gave the crime to the room which had been a game to the
    station and the old man at the hand, and had happened to try to his features, and we had no one that the terrible words
    were all about it.

    "Don't left it, Watson, the points in the best and writing for his residence."

    "Well, you will tell you that you have the wonderful position that I am an absolute private of them?" he asked at last.
    "You have a dead man and his death is the best?"
```

Of course some new lines characters were introduced in order make the text to fit an A4 page, but still network learned English from scratch and was able to generate this chunk character by character. Notice that in case of short cues all quotation marks are handeled correctly, in case of larger monologues they sometimes stay unclosed. It's not clear however if it's network's failure or it just learned this behavior from the original, as this kind of formatting long monologues is present there. It is also interesting how first passage is finished with quotation mark as someone's cue, this makes sense, as reference "Mr. Holmes" is more likely to happen there rather than in narrator text which is written by Mr. Watson.

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

```
    Mr. Holmes, I am a really country that there was no one who was the same moment that I have had a couple of the
    surprise and the moor of the bell. It was a perfect secretary was the presence of the case the corner of the stairs
    which was the same time that he
    was the little of the man who was the most detective was a deep slowed state of the house. The same expert was a little
    start and a long straight street and became a little chair with a short strange considerable experience and waiting and
    of the facts. The door was all the same face that he was a short street was a little which read it at the same
    containing of the stair.
```

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.

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. Still it has a long way to go before it reaches at least comparable level to Sir Arthur Conan Doyle.

References

Andrej Karpathy. The unreasonable effectiveness of recurrent neural networks. URL `http://karpathy.github.io/2015/05/21/rnn-effectiveness/`.

Sepp Hochreiter and Jürgen Schmidhuber. Long-short term memory. 1997. URL `https://www.bioinf.jku.at/publications/older/2604.pdf`.

Diederik P. Kingma and Jimmy Lei Ba. Adam: A method for stochastic optimization. 2015. doi:https://doi.org/10.48550/arXiv.1412.6980.

Theano: A python framework for fast computation of mathematical expressions. 2016. doi:https://doi.org/10.48550/arXiv.1605.02688.

The Complete Sherlock Holmes Canon. URL `https://sherlock-holm.es/`.