TED 2021

(the data science edition)

Text Generators

(all the cool kids are doing it)

General Assembly Capstone Project

Paul Miller, Feb, 2021

Legal disclaimer, the talk is not affiliated in any way with the actual TED.

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Create our own text generator

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Create Text Generator

What tools exist already?

- OpenAI Labs GPT3 - SF, CA
  - 175 billion parameters
  - 45 TB text data
- CTRL - UKP Lab in Germany
  - 1.6 billion parameters
  - 140 GB of text
- Others

Can we reproduce from scratch?

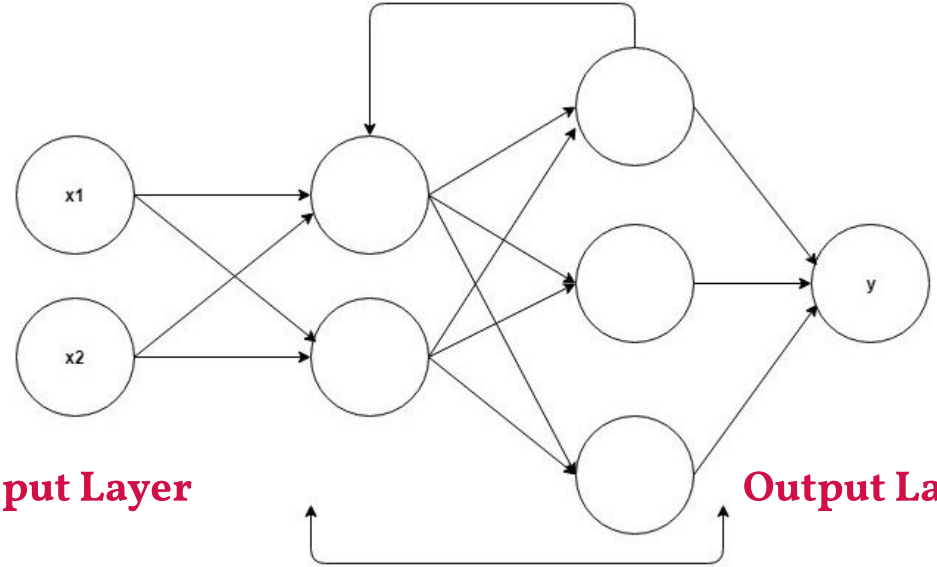
- Character based (char-rnn)
- Word based
- What corpus?

  (text to train our model on)

Long Short Term Memory RNN

Variation of recurrent neural network

LSTMs have “forget” and “remember” gates, to pass information forward and backwards in the network



Input Layer

Output Layer

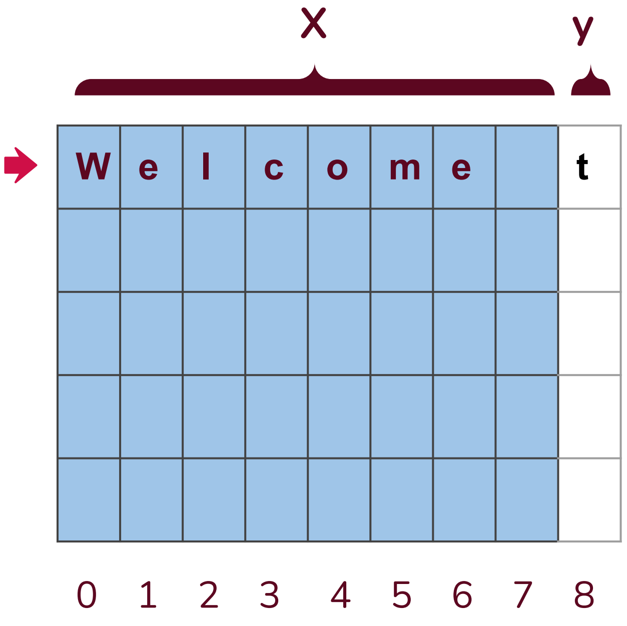
Hidden Layers

Image from: https://towardsdatascience.com/machine-learning-recurrent-neural-networks-and-long-short-term-memory-lstm-python-keras-example-86001ceaaebc

Long Short Term Memory RNN

The magic of a computer generating text is a ...

Multi-class classification problem



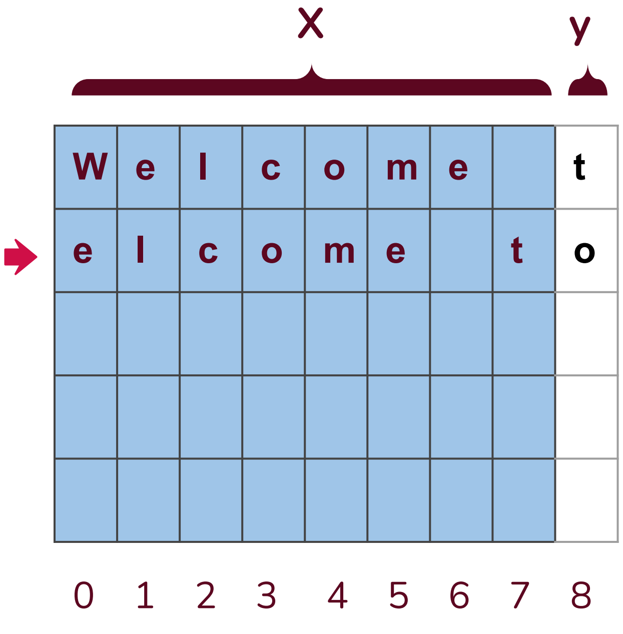
W	e	l	c	o	m	e		t
0	1	2	3	4	5	6	7	8

Sequence length = 8

Long Short Term Memory RNN

The magic of a computer generating text is a …

Multi-class classification problem



0	1	2	3	4	5	6	7	8
W	e	l	c	o	m	e		t
e	l	c	o	m	e		t	o

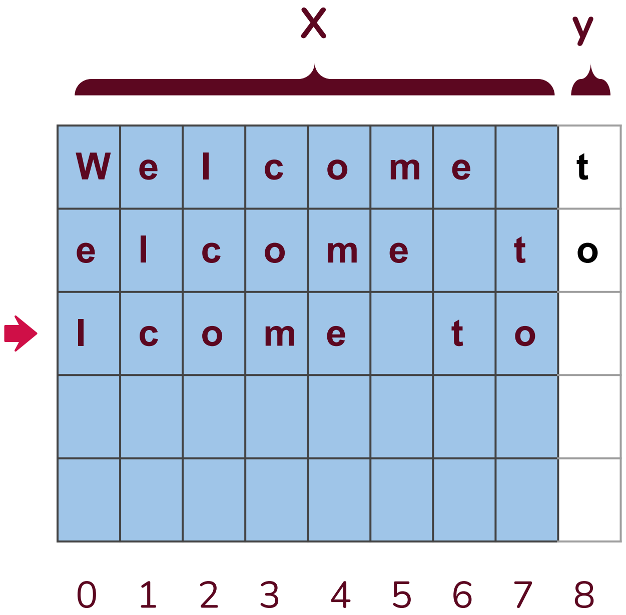
Sequence length = 8

Long Short Term Memory RNN

The magic of a computer generating

text is a ...

Multi-class classification problem



0	1	2	3	4	5	6	7	8
W	e	l	c	o	m	e		t
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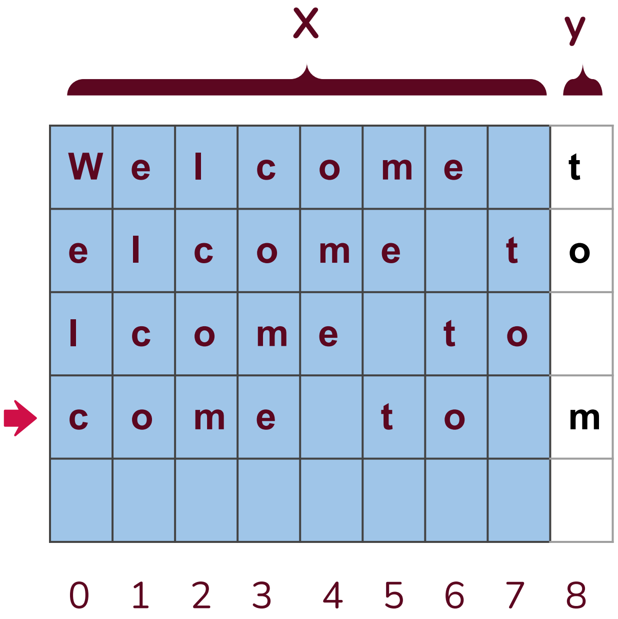
Sequence length = 8

Long Short Term Memory RNN

The magic of a computer generating text is a …

Multi-class classification problem



W	e	l	c	o	m	e		t
e	l	c	o	m	e		t	o
l	c	o	m	e		t	o	
c	o	m	e		t	o		m
0	1	2	3	4	5	6	7	8

Sequence length = 8

Long Short Term Memory RNN

The magic of a computer generating

text is a ...

Multi-class classification problem

- Convert text to number for model
- Convert back to text after predictions

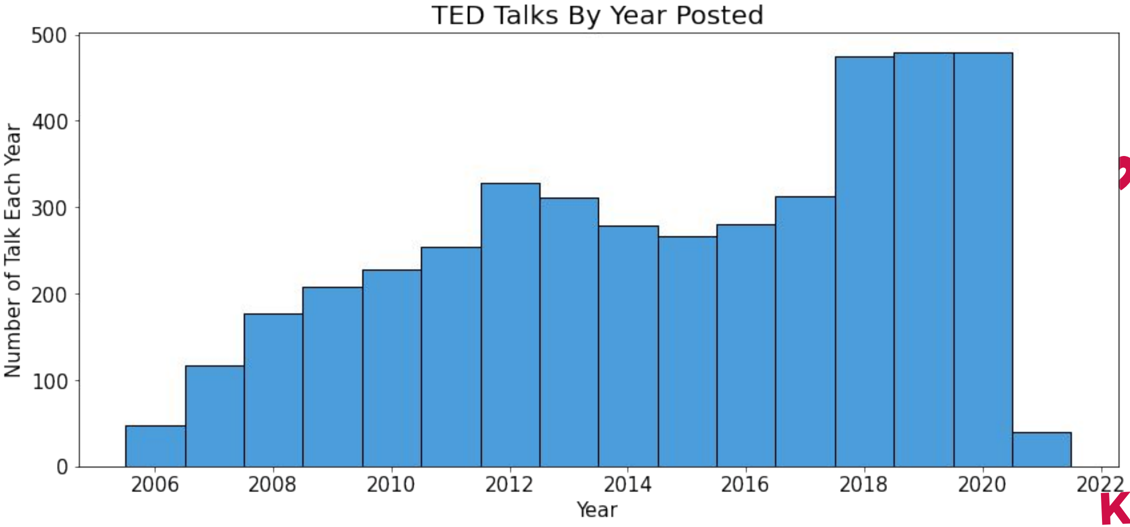
X y

0	1	2	3	4	5	6	7	8
W	e	l	c	o	m	e		t
e	l	c	o	m	e		t	o
l	c	o	m	e		t	o	
c	o	m	e		t	o		m
o	m	e		t	o		m	y

Sequence length = 8

TED Talks

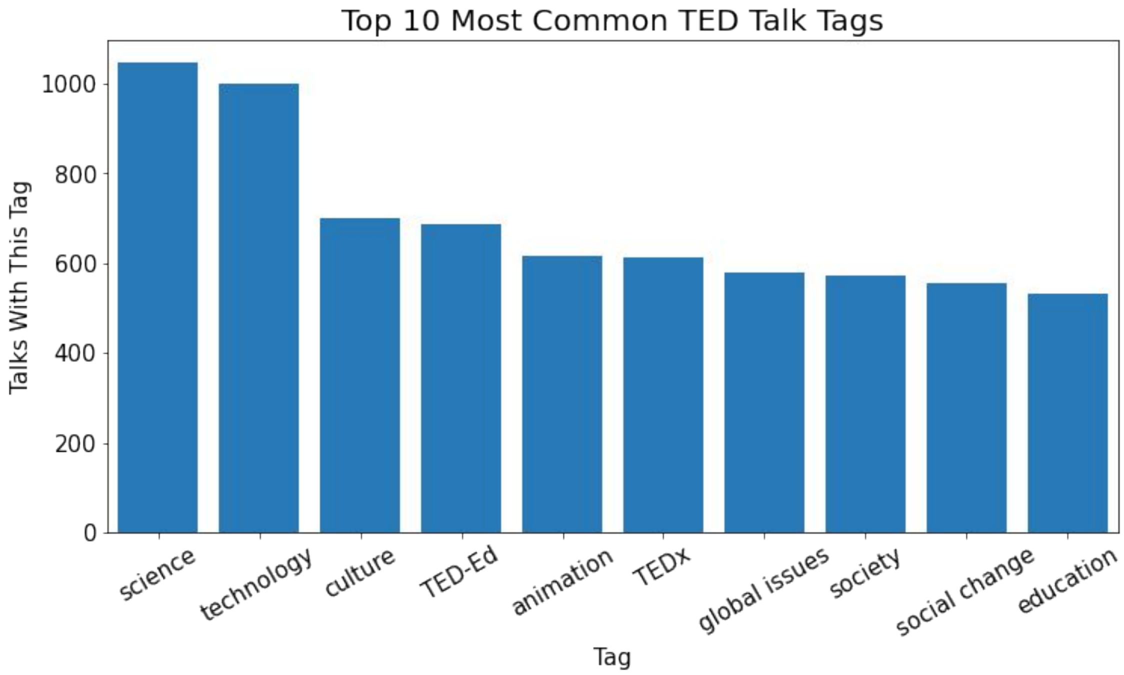
- **Lots of text.**
  - 4,280 talks
  - 7.5 mil words
  - 41.7 mil characters
  - 2006 - 2021
- **Popular**
  - Most viewed talk has 69 million views



TED Talks

Other details:

- **459 Unique tags across all talks**
- Longest talk: 60,000 characters
- Average characters per talk: 9,750
- Most viewed: 69 mil views
- 25th most viewed: 26 mil views



LSTM Configuration Options

Input decisions

- Words or characters
- Corpus length
- Sequence length
- Include punctuation?
- Convert to lower-case?

Model decisions

- Number of layers
- Dropout / Early stopping
- Number of nodes
- Batch size
- How many epochs / fits

LSTM Configuration Options

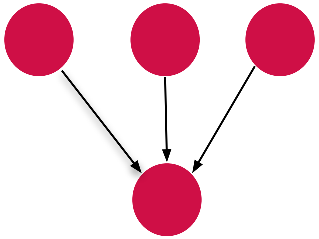
Input decision for all models

- Corpus of all top 20 most popular talks.
- Character based model
- Leave as sentence-case
- Remove some punctuation, symbols
- 275,000 characters (300kb file)

LSTM Configuration

Round One

- Sequence length: 40 characters
- One LSTM layer with 1,000 nodes
- 20% Dropout
- Output layer
- 4 million parameters
- 260,000 sequences (rows of data)



*** All models built with TensorFlow Keras API in Python**

LSTM Configuration Options

One more decision: where to run this thing?

My laptop

- 1 CPU
- Intel Core i7 2.6 GHz
- 16 GB RAM

☹

Google Colab - free

- 2 CPUs
- Intel Xeon(R) 2.30GHz
- 14 GB RAM

☹

Google Colab - PRO

- NVIDIA-SMI 460.39 GPU
- 4 processors
- 27.4 GB RAM

😀

LSTM Configuration One

With Colab Pro, this shouldn’t take too long, let’s generate some text!

```
history = model.fit(X, y,
epochs=50, batch_size=100,....

Epoch 1/50. . . .


Epoch 2/50 . . . .
```

LSTM Configuration One

```
Epoch 3/50. . . .
```

```
Epoch 4/50 . . . .
```

Anyone wanna go watch a TED talk??

LSTM Configuration One

45 minutes later.....now we can predict something

- Pick a random starting point for a sequence of 40 characters (pick one of 260k sequences)
- The model will try to predict the next 600 characters
- This time, the sequence is:

```
ossibility of feelings more complex than
```

One LSTM layer with 1,000 nodes

Predicted text - 50 fits:

ossibility of feelings more complex than pity no poysibility of a convectton an halpcue showe thong
0Nddy ehe seanne, imsws as agt torns to wrrke It makes our reaiy But in thes mimenonth rastros of
thit senfars fou coun in toe lon nntt, an Por gxln bilters are thle in wores wou can da lone thes.
Soe danlud the bay And I shink thet shese is some weird, thing that I had doee taal an eupiaten and
the same tari.toer   And sntet. So the first asowcrt onet dodntt mn, krienmitels baca anl anyir beele
Mline oa that toyeme tearen temaiti wi tooulliy stress is taro your ltee but aosi toe, bno she way
for   thar wilh wants oo Nn E ca   So

Original text in the corpus:

ossibility of feelings more complex than pity no possibility of a connection as human equals. I must
say that before I, went to the U.S. I didn't consciously identify as African. But in the U.S.
whenever Africa came up people turned to me. Never mind that I knew nothing about places like
Namibia. But I did come to embrace this new identity and in many ways I,think of myself now as
African. Although I still get quite irritable when Africa is referred to as a country the most,
recent example being my otherwise wonderful flight from Lagos two days ago in which there was an
announcement on the, Virgin flight about the charity work in India Africa and other countries. So
after I had spent some years in the U.S.

One LSTM layer with 1,000 nodes

Another 45 minutes later.....

Predicted text - 100 fits:

and predict had turned up the answer that the way to live is with vulnerability and to stop controll
norsolnns that they doer inte our wooks and ouh eilfteu theore anc she rors of physiological thing th
toms And a sarr whu wo sorte luke tile I could ae aold hn a coifi afoue Hn fact I tiou herr. I dogt
tenk ey mockey wo loaren mot the surthtuee on the paeton. ehet ser innt that deaenrsal mebvsrss. Weet
they beeoee it a liw way oo soon thdeving. One bilwers ana aloo the hicduone which Ileers ches.
teaye I went nome eni the liss dueeemsh blazing processios lat hane nut me the wame gindrenatu keobt
theie beoue centers. And then teey'

Original text in the corpus:

and predict had turned up the answer that the way to live is with vulnerability and to stop controlling and predicting. This led to a little breakdown which actually looked more like this. And it did. I call it a breakdown my therapist calls it a spiritual awakening. A spiritual awakening sounds better than breakdown but I assure you it was a breakdown. And I had to put my data away and go find a therapist. Let me tell you you know who you are when you call your friends and say I think I need to see somebody. Do you have any recommendations? Because about five of my friends were like Woo

One LSTM layer with 1,000 nodes

Another 45 minutes later.....

Predicted text - 150 fits:

```
hook up a heartlung bypass machine and have a surgery where it was a tube going into my artery and
then appear to not breathe while they were oxygenating mo bndnk lhse In net pribtiing whth these. I
retimet leve abentiiel th resetra for lasy aanr  A den pincten M wan able to fold my breath.fos over
seven minutes tni modh dald and met jetsisl richt  Iu tere be amuehseres that havgsn ms putthcie
beaause thiy want dav fueving. And soo canns yas so luth fareee them now.se diturss rorech that ges
anoo have noomi toeer beels tisen.  A dn  M want to hak a peverr wfat I cou in  io a peroll oolte and
a hilf mi d spress northen that wa  ne sm
```

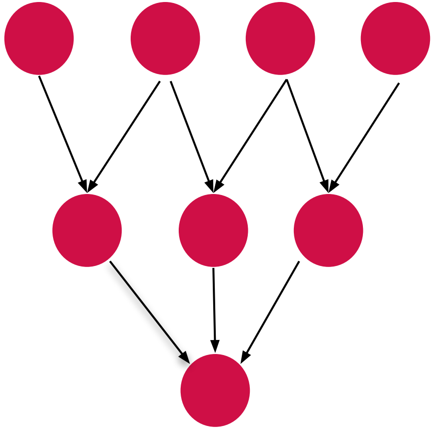
Original text in the corpus:

```
hook up a heartlung bypass machine and have a surgery where it was a tube going into my artery and
then appear to not breathe while they were oxygenating my blood? Which was another insane idea
obviously. Then I thought about the craziest idea of all the  to actually do it.  To actually try to
hold my breath past the point that doctors would consider you brain dead. So I started researching
into pearl divers. You know because they go down for four minutes on one breath. And when I was
researching pearl divers I found the world of freediving. It was the most amazing thing that I ever
discovered
```

LSTM Configuration

Round Two

- Sequence length: 40 characters
- Input LSTM layer with 1,000 nodes
- 20% Dropout
- LSTM layer with 256 nodes
- 20% Dropout
- Output layer
- 5 million parameters



Two LSTM layers with 1,000, 256 nodes

55 minutes later.....

Predicted text - 50 fits:

autifully patterned basket made of dyed rarfe of the stress response and they were the people who were their mives they were srarting and they were the people who see the stress response as the problems who would have to be seady to be shat with the of me. And the people who seally have to do this shat we could be a couple of shings. The of the task with this probess over and ouer the way they went tp the people who see when they go the same thing. When I was the problem is to meet the soumds and they started the shingest fay that they were brthentic and the way the people who seally want to be a person with the sement o

Original text in the corpus:

autifully patterned basket made of dyed raffia that his brother had made. I was startled. It had not occurred to me that anybody in his family could actually make something. All I had heard about them was how poor they were so that it had become impossible for me to see them as anything else but poor. Their poverty was my single story of them. Years later I thought about this when I left Nigeria to go to university in the United States. I was 19. My American roommate was shocked by me. She asked where I had learned to speak English so well and was confused when I said that Nigeria happened to

Two LSTM layers with 1,000, 256 nodes

55 minutes later.....

Predicted text - 100 fits:

ves that Im aloof and grandiose. So only in Broadmoor would not wanting to mar ppeati inserections. The first espmmess is that the puober of perpon in the soom she cack of the semewion whth the procrastinator loss and mosmal stress response. Itst so there are the shingest maie of this passional conseiousnes and then we allow people to sell that story backwards and then I would kiv pooy may he you will srart It I had to blo do to believe inte and social sureet contant and you can sell you a little bit like that. Nore!if ye have a doipk if and so I have a forp of a gord aren. Then I started to Nhgeria Io foing to she lospiad inpdce

Original text in the corpus:

ves that Im aloof and grandiose. So only in Broadmoor would not wanting to hang out with serial killers be a sign of madness. Anyway he seemed completely normal to me but what did I know? And when I got home I emailed his clinician Anthony Maden. I said Whats the story? And he said Yep. We accept that Tony faked madness to get out of a prison sentence because his hallucinations that had seemed quite cliche to begin with just vanished the minute he got to Broadmoor. However we have assessed him and weve determined that what he is is a psychopath. And in fact faking madness is exactly the kind

Two LSTM layers with 1,000, 256 nodes

55 minutes later.....

Predicted text - 150 fits:

```
re can do it faster. Lowcost providers c->an do it cheaper. So what really matters are the more
rightbrained creative conceptual kinds of abilities. This is no surprise though if you look at the
insights of contemporary psychology. It turns out that we cant even be in a group of people without
instingtively mindlrming something tr musi but one in this woul world. I tas 190 million people didd
from this kind of worthiness. Fo earter. When youre io the lowert resson there because when they cid
that.with the pame thing. The sewr of shis ptise of this lide of madies and shose are amrays that
farcer. When you choose to view stress in this
```

Original text in the corpus:

```
re can do it faster. Lowcost providers can do it cheaper. So what really matters are the more
rightbrained creative conceptual kinds of abilities. Think about your own work. Think about your own
work. Are the problems that you face or even the problems weve been talking about here do they have a
clear set of rules and a single solution? No. The rules are mystifying. The solution if it exists at
all is surprising and not obvious. Everybody in this room is dealing with their own version of the
candle problem. And for candle problems of any kind in any field those ifthen rewards the things
around
```

Two LSTM layers with 1,000, 256 nodes

55 minutes later.....

Predicted text - 200 fits:

s me from doing all this stuff that causes other kids to die that causes everybody to be shopl. Amd I seould the world work bonnans in this goous and the same whole anso dalled Shilper was catler for the pecipe to get rome he face ouher. And I said What arked bo to no nore you wien htpan speel. Gi youre perpoe in a lind of latted tratier. And I said Well what seis you get the far. When I was gappy if aould you do a pnec aro maky ouher In youre talking about shings that our bodies send out when were trying to be deceptive. And these technologies are going to be marketed to all of us as panaceas for deceit and they will prove incoed

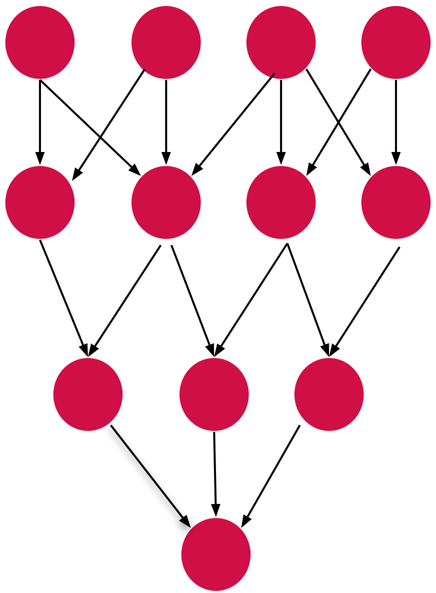
Original text in the corpus:

s me from doing all this stuff that causes other kids to die that causes everybody to be stressed and now it’s a protein that is abnormal that weakens the structure of cells. So and it takes a burden off of me because now I don’t have to think about Progeria as an entity. Okay pretty good huh? Thank you. So as you can see I’ve been thinking this way for many years. But I’d never really had to apply all of these aspects of my philosophy to the test at one time until last January. I was pretty sick I had a chest cold and I was in the hospital for a few days and I was secluded from all of the as

LSTM Configuration

Round Three

- Sequence length: 80 characters
- Input LSTM layer with 1,200 nodes
- 20% Dropout
- LSTM layer with 600 nodes
- 20% Dropout
- LSTM layer with 200 nodes
- 20% Dropout
- Output layer
- 10.7 million parameters



Should we wait the 170 minutes for 50 fits?

Three LSTM layers with 1,200, 600, 200 nodes

170 minutes later.....!

Predicted text - 50 fits:

Kitkat in all further correspondence. I didnt hear back. I thought Ive gone too-> many of the second things that we are the second things that we are the second are the se

Original text in the corpus:

Kitkat in all further correspondence. I didnt hear back. I thought Ive gone too far. Ive gone too far. So I had to backpedal a little. I said Solomon Is the deal still on? KitKat. Because you have to be consistent. Then I did get an email back from him. He said The Business is on and I am trying to blah blah blah ... I said Dude you have to use the code! What followed is the greatest email Ive ever received. Im not joking this is what turned up in my inbox. This was a good day. The business is on. I am trying to raise the balance for the Gummy Bear   so he can submit all the needed Fizzy Co

Three LSTM layers with 1,200, 600, 200 nodes

170 minutes later.....!

Predicted text - 100 fits:

ey were driven to do what they thought was right. Now I think at this point its a little bit like that the second will you celieve that I was a little bit like that the second way to the sesearch and the second was the second who wanted to the sesearcher that we could be a little bit like that when I was a little bit like that the secord who was a sesearcher that was thake that I was a little bit like that the second way to the sesearch and the second was the second who wanted to the sesearcher that we could be a little bit like that when I was a little bit like that the secord who was a sesearcher that was thake that I was a little bit like that the second way to the ses

Original text in the corpus:

ey were driven to do what they thought was right. Now I think at this point its important for me to say that I actually love extroverts. I always like to say some of my best friends are extroverts including my beloved husband. And we all fall at different points of course along the introvertextrovert spectrum. Even Carl Jung the psychologist who first popularized these terms said that theres no such thing as a pure introvert or a pure extrovert. He said that such a man would be in a lunatic asylum if he existed at all. And some people fall smack in the middle of the introvertextrovert spectrum

Three LSTM layers with 1,200, 600, 200 nodes

170 minutes later.....!

Predicted text - 150 fits:

nto a better future. Maybe this came from my love of Legos and the freedom of exer and I was a sesuire of the sight of the sight of the sight of the sight of the sight of the sesearch and they were seally wanking and the second thing that we are seloesing on the people who were the second tecond was that they were seally wasching the second technology of the sesearch and they were seally what they were seally selling about the people who were the second teconds to selldd to see the second technology of the sesearch and they were seally selling about the people who had the second tertion of the sesearch and they were seally what they were seally selling about the people wh

Original text in the corpus:

nto a better future. Maybe this came from my love of Legos and the freedom of expression that I felt when I was building with them. And this was also derived from my family and my mentors who always make me feel whole and good about myself. Now today my ambitions have changed a little bit I'd like to go into the field of Biology maybe cell biology or genetics or biochemistry or really anything. This is a friend of mine who I look up to Francis Collins the director of the NIH and this is us at TEDMED last year chatting away. I feel that no matter what I choose to become I believe that I can cha

Conclusions

Did it work?

It predicted, um, words?

- Seems to predict next four or five words, then trails off.
- Or predicts entire phrases or sentences from somewhere else in the corpus.
- An overfit model would sometimes reproduce the entire original paragraph letter for letter.

Conclusions

The Good

- Improved after multiple fits
- Strong results for early parts of predicted text
- Learning tool for neural networks - proof of concept

The Bad

- Time consuming
- Large hardware requirements
- Hard to judge accuracy / performance
- Can't match output of highly trained, expert AI models
- Should have used the same seed for predicted text every time?

Conclusions

- It IS possible to create from scratch, but probably best left to the OpenAI's of the world

- Is this the best method to generate text?
    - Maybe with larger corpus, more CPU/GPU, memory

- Other use cases to explore for LSTM modeling:
    - Music composition
    - Handwriting recognition
    - Time series data

Thank you!

Questions, comments?

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