

Natural Language Processing Recurrent Neural Networks (RNN)

Artificial Intelligence @ Allegheny College

Janyl Jumadinova

March 22, 2023

Alex Graves, "Supervised Sequence Labelling with Recurrent Neural Networks"

<http://colah.github.io/posts/2015-08-Understanding-LSTMs/>

Natural Language Processing

Understand, interpret and manipulate natural language

Ambiguity makes NLP hard

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- Teacher Strikes Idle Kids

Ambiguity makes NLP hard

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- Red Tape Holds Up New Bridges

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- Juvenile Court to Try Shooting Defendant

Ambiguity makes NLP hard

- Teacher Strikes Idle Kids
- Red Tape Holds Up New Bridges
- Juvenile Court to Try Shooting Defendant
- Local High School Dropouts Cut in Half

Other NLP Difficulties

non-standard English

Great job @justinbieber! Were
SOO PROUD of what youve
accomplished! U taught us 2
#neversaynever & you yourself
should never give up either♥

segmentation issues

the New York-New Haven Railroad
the New York-New Haven Railroad

idioms

dark horse
get cold feet
lose face
throw in the towel

neologisms

unfriend
Retweet
bromance

world knowledge

Mary and Sue are sisters.
Mary and Sue are mothers.

tricky entity names

Where is *A Bug's Life* playing ...
Let It Be was recorded ...
... a mutation on the *for* gene ...

NLP Examples

Question Answering: IBM's Watson

Won Jeopardy on February 16, 2011!

**WILLIAM WILKINSON'S
"AN ACCOUNT OF THE PRINCIPALITIES OF
WALLACHIA AND MOLDOVA"
INSPIRED THIS AUTHOR'S
MOST FAMOUS NOVEL**



Bram Stoker

Information Extraction

Hi Janyl,

Subject: curriculum meeting
Date: November 1, 2016

Event: Curriculum mtg
Date: Nov-1-2016
Start: 10:00am
End: 11:00am
Where: CC 103

Hi Janyl, we've now scheduled the curriculum meeting.
It will be in CC 103 tomorrow from 10:00-11:00.

-Chris

Create new Calendar entry

Low-level information extraction

Google



google headquarters

🔍

All Maps Images Videos News More ▾ Search tools

About 731,000,000 results (0.53 seconds)

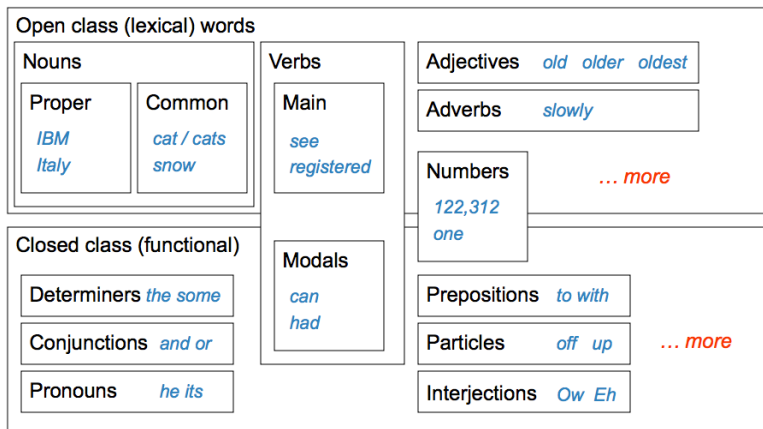
Google / Headquarters



Mountain View, CA

The image shows a Google search result for "google headquarters". The search bar at the top contains the text "google headquarters" and a magnifying glass icon. Below the search bar, there are tabs for "All", "Maps", "Images", "Videos", "News", "More", and "Search tools". The "All" tab is selected. Below the tabs, it says "About 731,000,000 results (0.53 seconds)". The main content area shows a result for "Google / Headquarters". It features two images: an aerial view of Mountain View, CA, and a map of the San Jose area with Mountain View highlighted. The map shows major highways like I-880, I-680, and I-205, and cities like Menlo Park, Palo Alto, Sunnyvale, Santa Clara, and San Jose. The text "Mountain View, CA" is displayed below the images.

Parts of Speech (POS)



POS Tagging

- **Input:** Plays well with others
- **Ambiguity:** NNS/VBZ UH/JJ/NN/RB IN NNS
- **Output:** Plays/VBZ well/RB with/IN others/NNS

<https://www.anc.org/penn.html> Penn Treebank Tag-set



Named Entity Recognition (NER)

A very important sub-task: find and **classify** names in text

The decision by the independent MP **Andrew Wilkie** to withdraw his support for the minority **Labor** government sounded dramatic but it should not further threaten its stability. When, after the **2010** election, **Wilkie**, **Rob Oakeshott**, **Tony Windsor** and the **Greens** agreed to support **Labor**, they gave just two guarantees: confidence and supply.

Person
Date
Location
Organization

Sentiment Analysis

**GoPro HERO5 Black**
\$399.00  [In Stock](#). Ships from and sold by Amazon.com. Gift-wrap available.

Customer Reviews
★★★★☆ 95
3.9 out of 5 stars

5 star 59%

4 star 7%

3 star 10%

2 star 6%

1 star 18%

Share your thoughts with other customers

Write a customer review

See all verified purchase reviews

Top Customer Reviews

★★★★★ **Awesome Upgrade**

By [Devon Stephens](#) [WALL OF JAM](#) [TOP 50 REVIEWER](#) on October 4, 2016

Style Name: Basic

First Impressions: This review will be updated as I get more of a chance to play with this camera. I received it Oct 4th so still plenty of playing around to do! So far I have added 1 additional con, updated some of the pros, and added a few pros... I will continue to update!

Short Review: I have owned GoPro cameras since the Hero 2... I have recently been introduced to other brands that work just as well but I am loyal to GoPro and had to try out the new hero 5... I am glad I did because GoPro is now on top of their game again and this is now the best Action Camera I have ever owned!... I used to hate all in one designs (Waterproofing being built into the camera) but I actually feel it works very well with this camera and provides much greater protection! No more "Naked" GoPros getting broken! (I have broke a few)

While the Hero 5 doesn't really have any major improvements in resolution or shooting specs, the improvements that have been made in design and software actually work well and really make the photo and videos appear much better! The most notable improvements include built in stabilization that works very well and much better audio! Audio is where action cameras have always been lacking, but GoPro has made a huge improvement here. GoPro has also improved their user interface which is a great improvement. Old models took a little while to learn, but not the Hero 5... I haven't seen an action camera this easy to use ever! So even though GoPro has carried over the same sensor from the Hero 4, this camera is very much worth the improvements

Pros:

- 1.) Video Quality - Is outstanding. The software changes they made, actually make the video quality look much better even though the same sensor was carried over

2. [Read more](#)

21 [Comments](#) | 177 people found this helpful. Was this review helpful to you? [Report abuse](#)

★★★★☆ **All the Pros, Cons and the Oks for this GoPro (H&R)**

By [Honest Reviewer](#) on October 3, 2016

Style Name: Basic

Pros:

- Waterproof all the way. All ports are covered so there is no fear of them being submerged in the dirt.
- Design itself has smoother edges and overall has a professional feel.
- Voice command that beeps when you speak one of the 12 commands. It also takes into account your accent if you're in the US, UK, AUS, etc.

Get XFINITY® Internet
No term contract

XFINITY Internet
Not started at
\$19.99 a month / 12 months [Switch from X](#)

[xfinity](#)

At feedback

Most Recent Customer Reviews

★★★★★ **Videos are great, photos are ok**

Videos are great, photos are ok. Took it to Zion National Park, was able to get some great videos of my hikes and took a ton of pictures. [Read more](#)

Published 12 hours ago by [David Fattal](#)

★★★★★ **Buy it.**

Awsome product, easy transaction, no worries. Funny part about it was the entire box was in Spanish but provided English directions inside. Not I even read the book. [Read more](#)

Published 14 hours ago by [Jeremy T.](#)

★★★★★ **so small yet so powerful**

so small yet so powerful. I love this it thing. I also got a GoPro Jaws Clamp Mount that works really well together. this is my first gopro and I am very impressed. [Read more](#)

Published 18 hours ago by [Molloy](#)

★★★★☆ **Single shot shutter too slow**

Single shot shutter speed too slow. 1/30 sec shutter speed is too slow for hand held portraits let alone sports and action shots minimum is 1/60th and best is 1/125 or even 1/250. [Read more](#)

Published 19 hours ago by [T. Rogers](#)

★★★★☆ **Horrible connectivity, awful tech support**


Can't connect to one of the latest and most popular android phones, despite hours of different tries, getting a ridiculously horrible, clueless technical support from gopro. [Read more](#)

Published 1 day ago by [Guy Z.](#)

★★★★☆ **Total disappointment for a longtime Goopro Fanboy**

I have been hyped about the gopro, yet I ended up in total disappointment. My gf bought me the camera as a gift. [Read more](#)

Published 1 day ago by [Edward Sheng](#)



Janyl Jumadinova

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March 22, 2023

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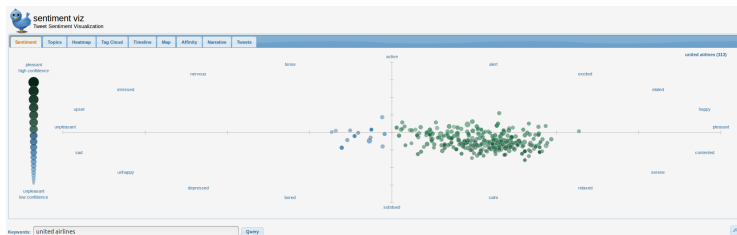
Sentiment Extraction

2016 Election



Source: Washington Post

Sentiment Analysis



- <https://www.nltk.org/howto/sentiment.html>
- <https://nlp.stanford.edu/sentiment/>
- <https://textblob.readthedocs.io/en/dev/>

Machine Translation

The screenshot shows the Google Translate web interface. At the top is the Google logo. Below it, the 'Translate' button is visible. The source language is set to 'English - detected' and the target language is 'Kyrgyz'. The input text is 'Happy Monday', which has been translated to 'бактылуу Дүйшөмбү' (Baktyлуу Düyshömbü). The interface includes a 'Turn off instant translation' toggle, a 'Suggest an edit' button, and a 'baktıluu Düyshömbü' link below the translation. The bottom of the interface shows a navigation bar with various icons.

Language Technology

Spam detection

Spam detection

Let's go to Agra! ✓

Buy VIAGRA ... ✗

Part-of-speech (POS) tagging

ADJ ADJ NOUN VERB ADV

Colorless green ideas sleep furiously.

Named entity recognition (NER)

PERSON ORG LOC

Einstein met with UN officials in Princeton

Sentiment analysis

Best roast chicken in San Francisco! 🍗

The waiter ignored us for 20 minutes. 🙄

Coreference resolution

Carter told Mubarak he shouldn't run again.

Word sense disambiguation (WSD)

I need new batteries for my *mouse*.

Parsing

I can see Alcatraz from the window!

Machine translation (MT)

第13届上海国际电影节开幕...

The 13th Shanghai International Film Festival...

Information extraction (IE)

You're invited to our dinner party, Friday May 27 at 8:30

Party May 27
add

Question answering (QA)

Q. How effective is ibuprofen in reducing fever in patients with acute febrile illness?

Paraphrase

XYZ acquired ABC yesterday

ABC has been taken over by XYZ

Summarization

The Dow Jones is up

The S&P500 jumped

Housing prices rose

Economy is good

Dialog

Where is Citizen Kane playing in SF?

Castro Theatre at 7:30. Do you want a ticket?

GPT Models

Start with the basics

Quickstart tutorial

Learn by building a quick sample app

Examples

Explore some example tasks

Build an application



Chat Beta

Learn how to use chat-based language models



Text completion

Learn how to generate or edit text



Embeddings

Learn how to search, classify, and compare text



Speech to text Beta

Learn how to turn audio into text



Image generation Beta

Learn how to generate or edit images



Code completion Limited beta

Learn how to generate, edit, or explain code



Fine-tuning

Learn how to train a model for your use case

<https://platform.openai.com/overview>


Chat GPT

<https://chat.openai.com>



Give a general introduction of GPT models with an example to Artificial Intelligence students in the Department of Computer Science at Allegheny College.



Sure, I'd be happy to introduce GPT models to Artificial Intelligence students at Allegheny College!  

GPT stands for "Generative Pre-trained Transformer" and refers to a family of natural language processing models developed by OpenAI. These models are pre-trained on massive amounts of text data and can then be fine-tuned for specific natural language processing tasks, such as language translation, question answering, and text completion.

One of the most well-known GPT models is GPT-3, which has 175 billion parameters and is currently one of the largest language models in existence. GPT-3 has been shown to excel at a variety of natural language tasks, from generating coherent and grammatically correct sentences to translating between languages and answering complex questions.

For example, suppose you wanted to use GPT-3 to generate a new piece of text that continues a given prompt. Here's an example of how you might do that:

Prompt: "The sun was setting over the horizon, casting a warm orange glow across the sky. As I watched, I felt..."

GPT-3 continuation: "a sense of peace wash over me. It was as if all of the worries and stress of the day were being carried away on the gentle breeze. I closed my eyes and breathed in deeply, savoring the moment of stillness and tranquility."

In this example, GPT-3 has generated a coherent and grammatically correct sentence

- From Google: <https://bard.google.com/>
- From Microsoft: <https://www.bing.com/new>

Microsoft Bing

Write a story for children about a dog who lives on the moon

ALL CHAT IMAGES VIDEOS MAPS NEWS MORE

About 104,000,000 results Any time Open links in new tab

Try these creator prompts:

- Summary
- Joke
- Blog post
- Story

Here's what I generated for you

Okay, here is a story for children about a dog who lives on the moon:

Luna was a very special dog. She was born on the moon, where her parents were part of a team of astronauts who were exploring the lunar surface. Luna loved the moon, because it was her home. She enjoyed bouncing around in the low gravity, digging holes in the dust, and chasing the moon rocks that rolled down the craters.

Luna was curious about everything, and she always wanted to learn new things. She liked to listen to the stories that her parents and the other astronauts told her about Earth, the blue planet that shone brightly in the sky. She wondered what it was like to see the sun, the stars, the clouds, and the oceans. She wondered what it was like to smell the flowers, to feel the wind, and to hear the birds. She wondered what it was like to meet other dogs, and to play with them.

One day, Luna decided that she wanted to go to Earth. She asked her parents if they could take her with them on their next mission, but they said no.

NLP Pre-Processing

Basic Text Processing

Word tokenization

Every NLP task needs to do text normalization:

- ① **Segmenting/tokenizing words in running text**
- ② Normalizing word formats
- ③ Segmenting sentences in running text

Basic Text Processing

Normalization

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- ② **Normalizing word formats**
- ③ Segmenting sentences in running text

Issues in Tokenization

- Finland's capital → Finland Finlands Finland's
- what're, I'm, isn't → What are, I am, is not
- Hewlett-Packard → Hewlett Packard
- state-of-the-art → state of the art
- Lowercase → lower-case lowercase lower case
- San Francisco → one token or two?

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Normalization:

merging of different forms of a token into a canonical normalized form.

- ex.: "Mr.", "Mr", "mister", and "Mister" into a single form.

Basic Text Processing

Stemming

Every NLP task needs to do text normalization:

- ① Segmenting/tokenizing words in running text
- ② Normalizing word formats
- ③ **Segmenting sentences in running text**

Stemming

- Reduce terms to their stems in information retrieval
- **Stemming** is crude chopping of affixes language dependent
- Example: **automate(s)**, **automatic**, **automation** all reduced to **automat**.

*for example compressed
and compression are both
accepted as equivalent to
compress.*



for exampl compress and
compress ar both accept
as equal to compress

Porter's Algorithm

Most common English stemmer.

Step 1a

sses	→ ss	caresses	→ caress
ies	→ i	ponies	→ poni
ss	→ ss	caress	→ caress
s	→ ∅	cats	→ cat

Step 1b

(*v*)ing	→ ∅	walking	→ walk
		sing	→ sing
(*v*)ed	→ ∅	plastered	→ plaster
...			

Step 2 (for long stems)

ational	→ ate	relational	→ relate
izer	→ ize	digitizer	→ digitize
ator	→ ate	operator	→ operate
...			

Step 3 (for longer stems)

al	→ ∅	revival	→ reviv
able	→ ∅	adjustable	→ adjust
ate	→ ∅	activate	→ activ
...			

Sentence Segmentation

- !, ? are relatively unambiguous

Sentence Segmentation

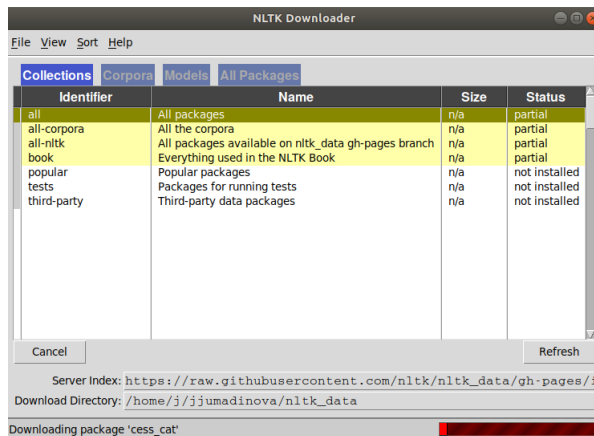
- !, ? are relatively unambiguous
- Period "." is quite ambiguous
 - Sentence boundary
 - Abbreviations like Inc. or Dr.
 - Numbers like .02 or 4.3

Sentence Segmentation

- !, ? are relatively unambiguous
- Period "." is quite ambiguous
 - Sentence boundary
 - Abbreviations like Inc. or Dr.
 - Numbers like .02 or 4.3
- Build a binary classifier
 - Classifiers: hand--written rules, regular expressions, or machine--learning

NLTK

```
$ python3  
$ import nltk  
$ nltk.download()
```



NLTK Basic Pre-Processing

Tokenize using Python

- ① `urllib` module to crawl the webpage
- ② BeautifulSoup to clean the text with html tags
- ③ convert text into tokens using `split()` function

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Remove Stop Words

- ① get english stop words from `nlTK`
- ② remove stop words before plotting

NLTK Basic Pre-Processing

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Remove Stop Words

- ① get english stop words from `nlk`
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Frequency Analysis

- ① `nlk's FreqDist` to calculate the frequency distribution
- ② `plot` function to produce a graph

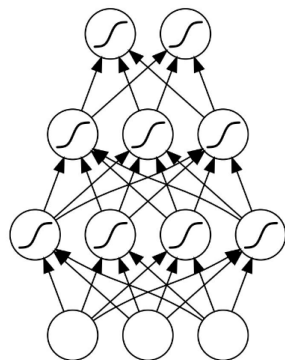
Word2Vec Model

- **Word2Vec** is used to learn vector representations of words, “word embeddings”.
- This is typically a pre-processing step, where the learned vectors are fed into a discriminative model (such as RNN).
- Word2vec is a computationally-efficient predictive model for learning word embeddings from raw text.

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- Word2vec is a computationally-efficient predictive model for learning word embeddings from raw text.
 - (1) *Continuous Bag-of-Words model* (CBOW): predicts target words from context words.
 - (2) *Skip-Gram model*: predicts source context words from target words.

Recurrent Neural Networks



Output Layer



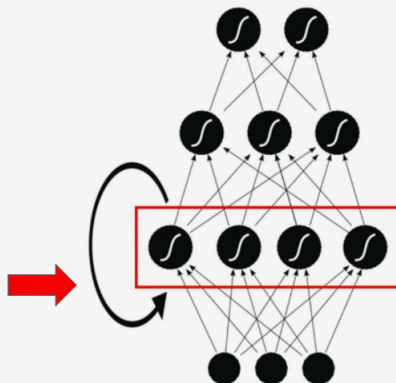
The output depends
ONLY on the current
input.

Hidden Layers

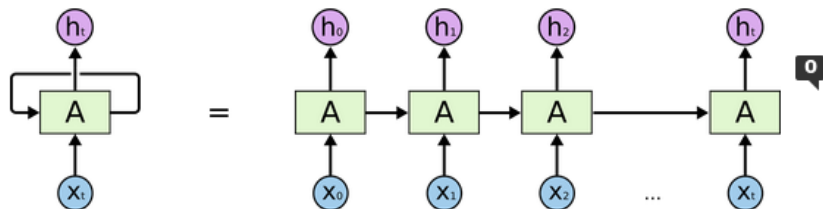
Input Layer

Recurrent Neural Networks

The hidden layers and the output depend from previous states of the hidden layers



Recurrent Neural Networks

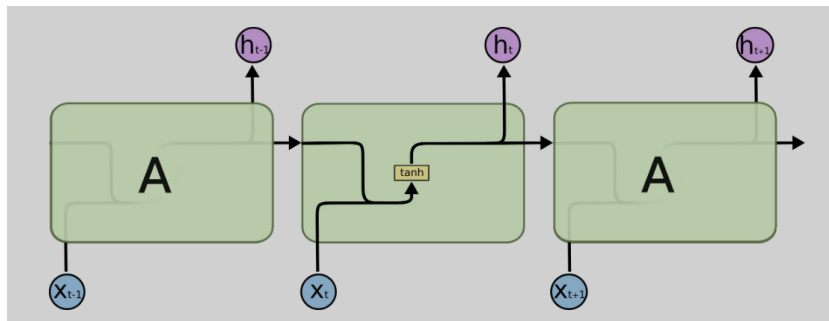


An unrolled recurrent neural network.

Based on an encoder-decoder scheme, using Seq2Seq model.

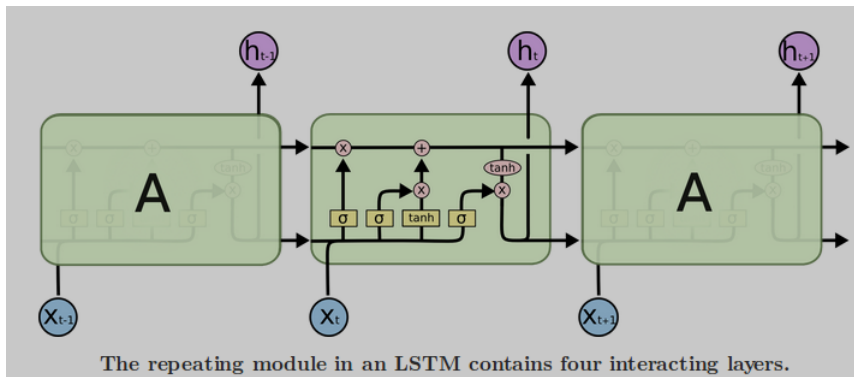
Long Short-Term Memory (LSTM)

Based on a standard RNN whose neuron activates with tanh

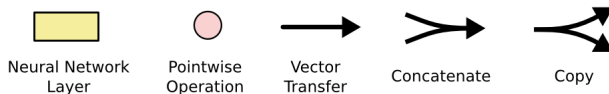


Cristopher Olah, "Understanding LSTM Networks" (2015)

Long Short-Term Memory (LSTM)



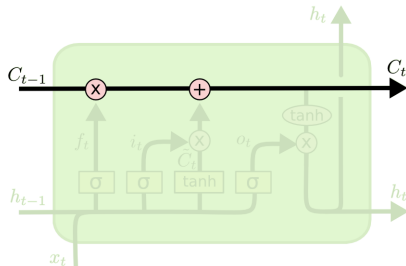
Long Short-Term Memory (LSTM)



- Each line carries an entire vector from the output of one node to the inputs of others.
- Pointwise operations are operations such as vector addition.
- Yellow boxes are learned neural network layers.
- A “Copy” line denote its content being copied and the copies going to different locations.

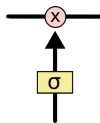
Long Short-Term Memory (LSTM)

The **cell state** runs through the entire chain, with only some minor linear interactions.



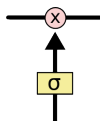
Long Short-Term Memory (LSTM)

The **gate** structures allow to remove or add information to the cell state.



Long Short-Term Memory (LSTM)

The **gate** structures allow to remove or add information to the cell state.



Disadvantage of RNN/LSTM

- Suffer from memory-bandwidth limited problems.
- Alternative? Transformer architecture (replace recurrence/convolution with attention).

- TensorFlow Recurrent Neural Networks
- Text Generation with Recurrent Neural Networks