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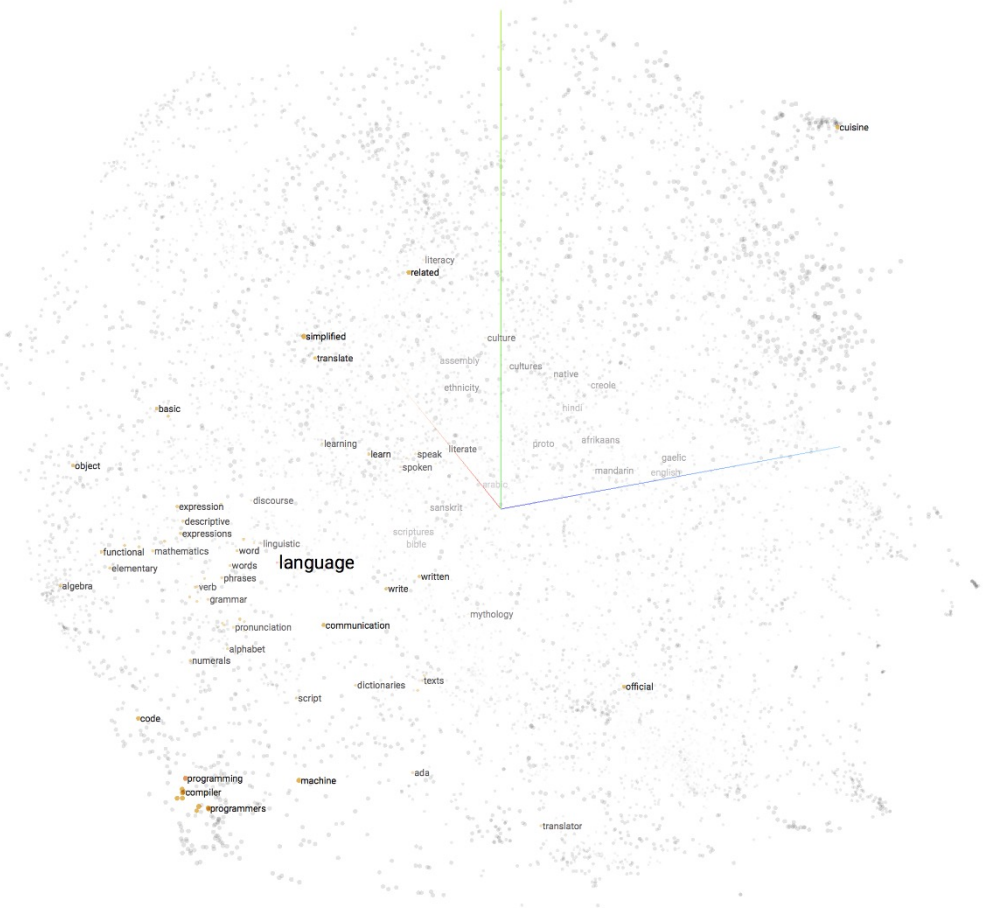

Machine Learning for Natural Language Processing

Prof. Dr. Andreas Hotho, Albin Zehe, Konstantin Kobs

Organisational: Dates

- **Lecture**
  - Begin: 15. April
  - Thursday, 12:15 – 13:45

- **Exercises**
  - Tuesday, 10:15 – 11:45 (starting 27. April)
  - Wednesday, 12:15 – 13:45 Uhr (starting 28. April)
  - online

- **Exam**
  - Will be announced
    Registration via WueStudy

Organisational: Zoom

- All lectures and exercises via Zoom

- Microphone: off
- Camera: on, if possible (helps via visual feedback!)

- Questions: Via chat or Zoom's hand raising feature

Organisational

- Exercise:
  - **independent work** on the exercises (in small groups of 3-4 persons)
  - **questions** can be asked to the assistant
  - **no general repetition** of the lecture material
  - **no presentation** of the sample solution (sample solution will be provided later)
- Necessary for this
  - independent lecture post-processing **before the exercise**
  - be active by your own

Organisational

- **Why this exercise concept?**
  - it is more effective to actively work on the lecture‘s content
  - **recognising connections** in the material
  - learning structured thinking and independent working
  - learning to **work in teams**
  - learning to explain (as tutor and as participant)
  - **exam training** 😉
  - *“Your personal strengths are initiative, willingness to comunicate and cooperate, and teamwork.“*

(Typical job ad text)

Organisational

Contacts:

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- Konstantin Kobs: kobs@informatik.uni-wuerzburg.de (Raum B114)

Information in WueCampus:

- https://wuecampus2.uni-wuerzburg.de/moodle/course/view.php?id=45164

- There, you can find:
  - current announcements (!)
  - slides
  - exercise sheets
  - literature recommendations
  - dates

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WHAT WE DO

Text analysis & Knowledge Graphs

- Digital Humanities
- Social-Media-Analysis
- Structured Knowledge (KG)

AI-Security & Fraud Detection

- Fraud detection in ERP systems
- Detection of hacker attacks
- Explainable AI

Recommender systems

- Deep Learning
- Product recommendations in webshops
- Supporting medical diagnosis
- Reference management support

Environmental Data Science

- Time Series Analysis
- Climate models
- Analysis of bee behavior
- Estimation of air quality

Organisational: Praktikum Machine Learning

- „**Praktikum Machine Learning**“ as practical addition to the lecture
- Separate course
- 5 ECTS
- Content:
  - Applying the techniques learned in the lecture
  - Practical work on large text datasets
  - Testing new ideas and solving problems, maybe resulting in a *published paper*

- Every **winter term:** *NLP* centric task
- **Summer term (this term):** *Recommendation* and *Timeseries Analysis*

Organisational: Praktikum Machine Learning

Praktikum: Machine Learning for Recommendation

This year: RecSys Challenge 21

Goal: Predict Tweet engagement as Like, retweet, quote, and reply

Data: Large-scale dataset of twitter with information about tweets and users

Kick-Off: Thursday, 22.04. 2pm

Link will be published on our website

Praktikum: Machine Learning for Time Series Analysis

This year: Stabilos Ubicomp 2021 Challenge

Goal: Predict mathematical equation from pencil movement captured by sensors

Data: Time-based sensor data of the pencil

Kick-Off: 15.04. (today) 4pm

Link is on our website

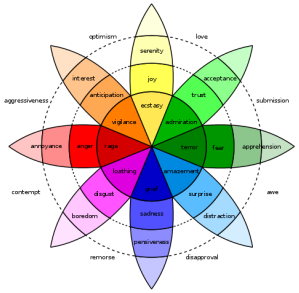
What is this lecture about?

Machine Learning for Natural Language Processing

- We will cover recent topics in **Machine Learning**…
  - Currently mostly neural network-based methods
- … in the specific context of **Natural Language Processing**
  - How are different network types used in natural language processing?

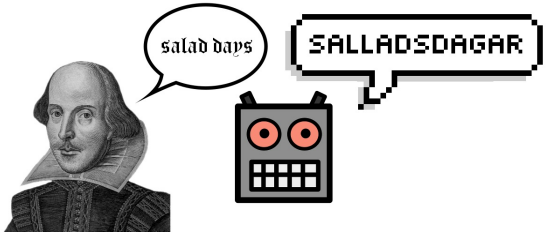
Example Uses of Natural Language Processing

- Sentiment Analysis



- Text Generation

- Machine Translation

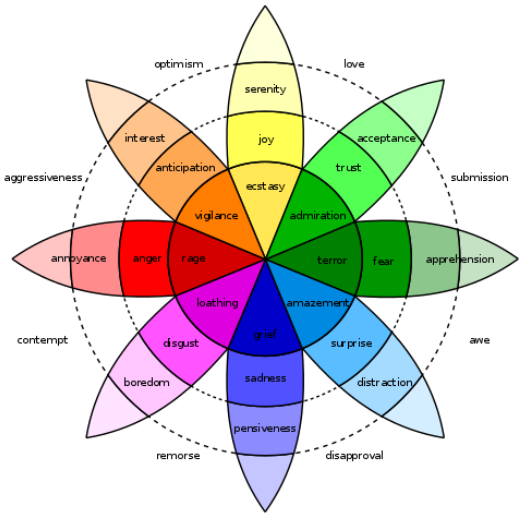


Sentiment Analysis

- Determining positive or negative connotation in text
- Interesting for all kinds of texts
  - Product Reviews

    I really enjoyed reading this book! It was just boring.
  - Political Comments

    I do not agree with this statement at all.
  - Characterising plot development in stories



Sentiment Analysis

- Challenges
  - Negations

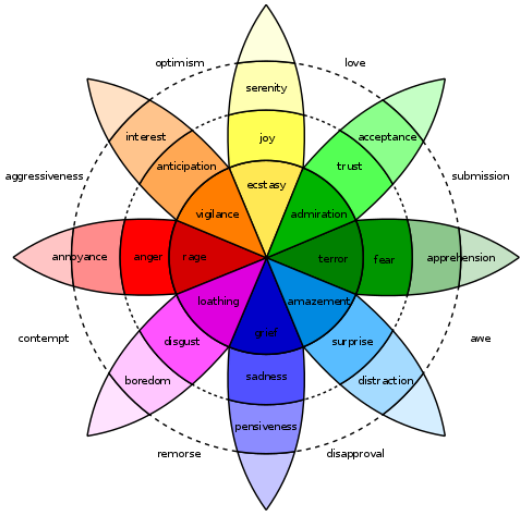
This may or may not be a positive sentence.

I won‘t ever stop being happy about this.

  - Irony/Sarkasm

Isn‘t this just awesome.

  - …



Text Generation/Language Modelling

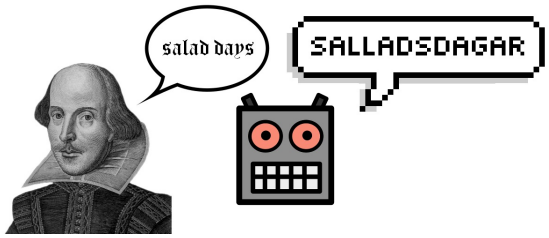
- Generate sentences that are grammatically correct and make sense
- Useful for chatbots, automated helpdesks, …
- … and for fun ☺

`` I've warned you , Snivellus , '' said Dumble- dore happily to a thunderstruck Umbridge .

- Perfect text generator → Passes Turing Test!

Machine Translation

- Given a text in one language, provide a translation to another language
- Combines many hard problems
  - Determine the meaning of the source text
    - Words with multiple meanings
    - Possibly wrong grammar/spelling
  - Generate text in the target language
    - Finding the right words
    - Creating a sentence that makes sense!
- Popular example: Google Translate
  - Based on neural networks

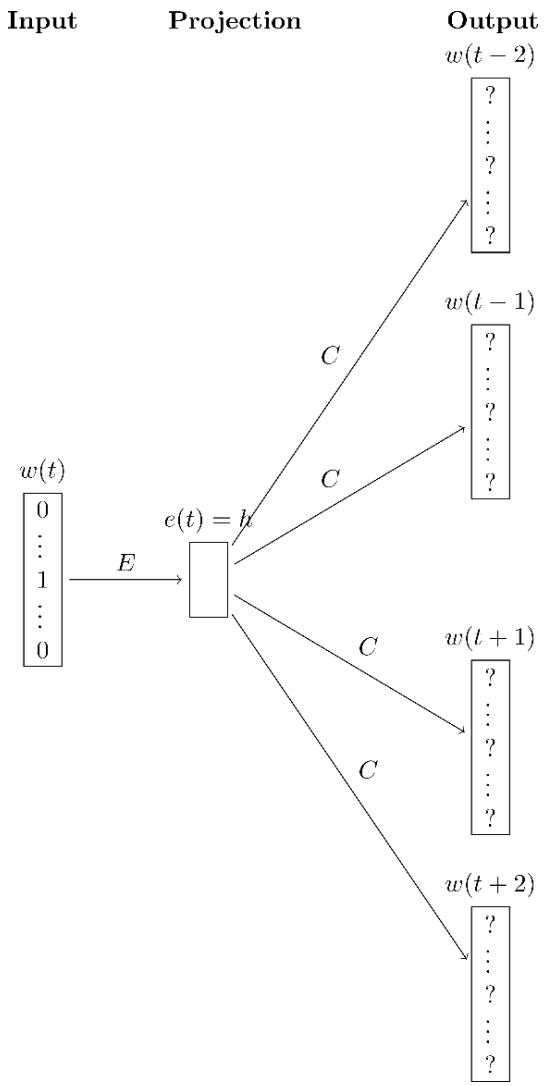


Overview

1. Representing Words
2. Neural Network Basics
3. Implementing Neural Networks in PyTorch
4. Modelling the Text Stream
   a) „The new n-grams“ – Convolutional Neural Networks
   b) Sentences as a sequence — RNNs and their Applications
5. Seq2Seq models and Attention
6. Transformer — Is Attention All You Need?
7. Representing Words Part 2 — Context
8. Representing Words Part 3 — World Knowledge
9. Applications

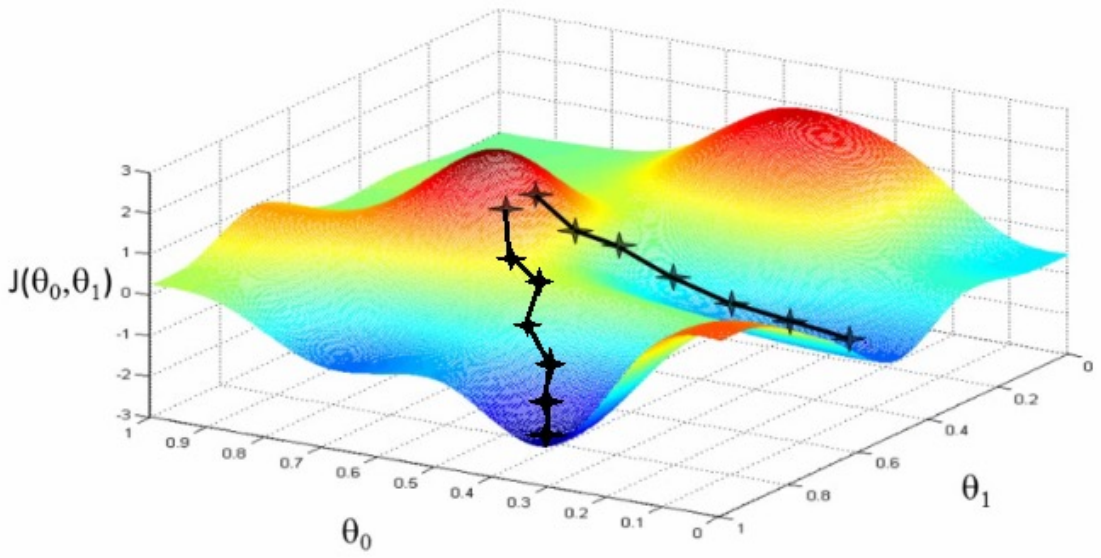
Representing Words

- Words = basic units in NLP!
- Classic word representations have their limitations
  - How to represent words with similar meanings?
- (Neural) Word Embeddings can solve some of these issues
- Example: Word2Vec



Neural Network Basics

- Basic Optimisation
  - Backpropagation
  - Gradient Descent
- Implementation in PyTorch



http://blog.datumbox.com/wp-content/uploads/2013/10/gradient-descent.png

Modelling Sentences – RNNs and their Applications

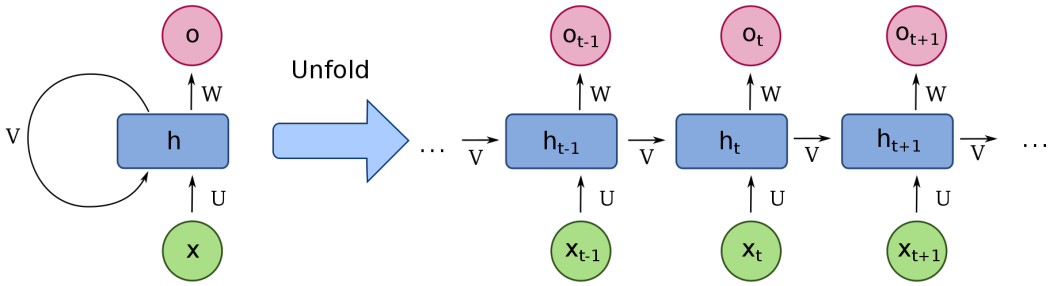
- Modelling words is not enough
- How to represent sentences or longer texts?

→ Recurrent Neural Networks model sequential data!

→ A sentence is a sequence of words

→ A sentence is a sequence of characters

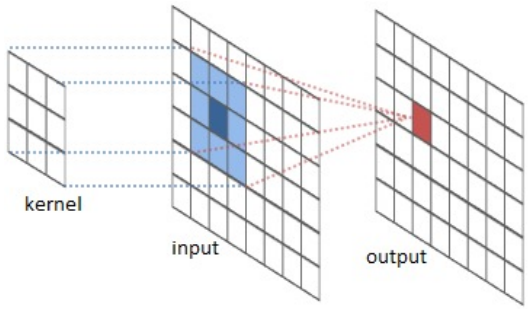
→ …



https://commons.wikimedia.org/wiki/File:Recurrent_neural_network_unfold.svg

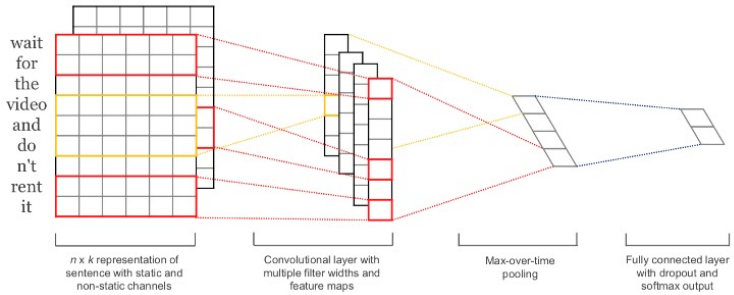
„The new n-grams“ – Convolutional Neural Networks in NLP

- RNNs are a natural choice for NLP (sequential data)
- CNNs work very well, too!
- CNNs are based on „filters“/“kernels“, i.e. local groups of input tokens
- Originally from computer vision



http://intellabs.github.io/RiverTrail/tutorial/

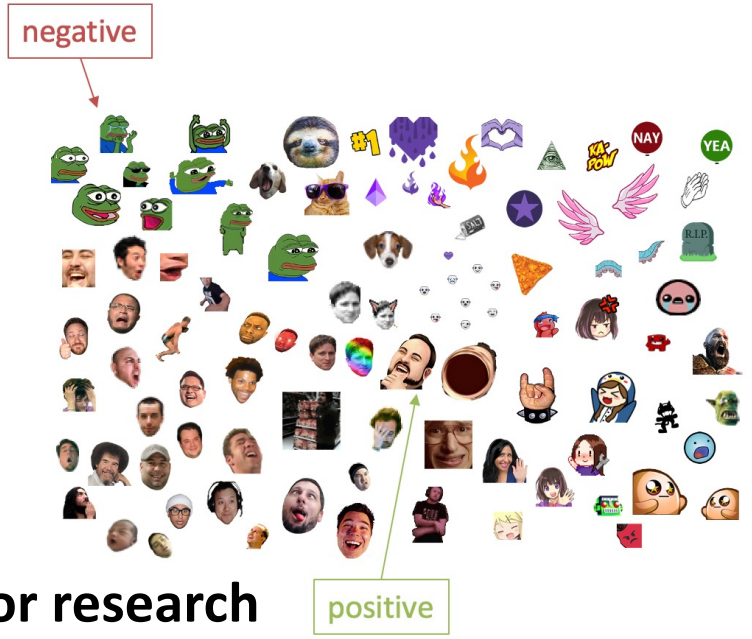
- Can be seen as analogous to n-grams, which traditionally work very well



[Kim, 2014]

Our Work with Convolutional Neural Networks in NLP

Sentiment Analysis on Twitch.tv chat messages



Konstantin Kobs, Albin Zehe, Armin Bernstetter, Julian Chibane, Jan Pfister, Julian Tritscher, and Andreas Hotho. 2020.
Emote-Controlled: Obtaining Implicit Viewer Feedback Through Emote-Based Sentiment Analysis on Comments of Popular Twitch.tv Channels.
Trans. Soc. Comput. 3, 2, Article 7 (April 2020), 34 pages.
DOI:https://doi.org/10.1145/3365523

Finding fitting conferences or journals for research papers

BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding

We introduce a new language representation model called BERT, which stands for Bidirectional Encoder Representations from Transformers. . . .

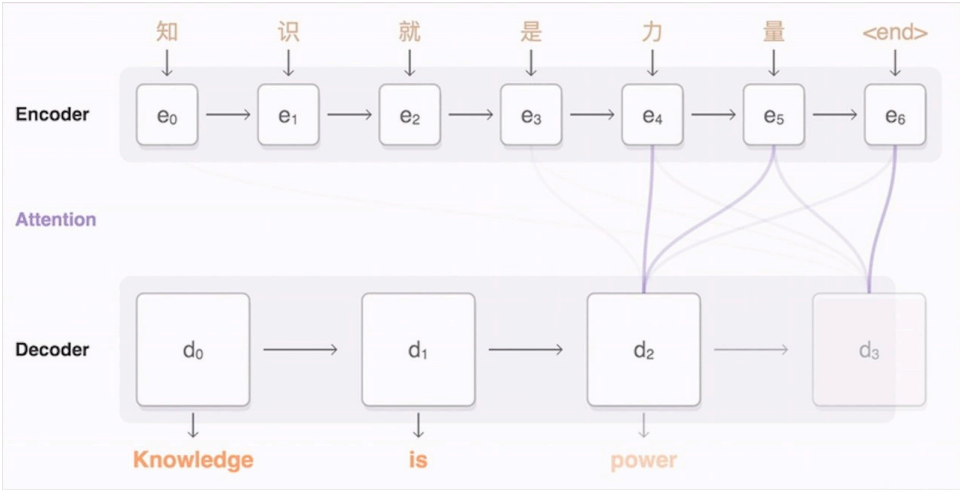
→ NAACL

Kobs, K., Koopmann, T., Zehe, A., Fernes, D., Krop, P., & Hotho, A. (2020, November). Where to Submit? Helping Researchers to Choose the Right Venue. In *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: Findings* (pp. 878-883).

Seq2Seq Models and Attention

- Encoder – Decoder – Architectures
  - Encoder takes the source text and builds an internal representation
  - Decodes generates target text based on this internal representation

- Great progress in the past years
  - Attention mechanisms help to focus on the most relevant words at any given position
  - Neural machine translation overtakes traditional machine translation



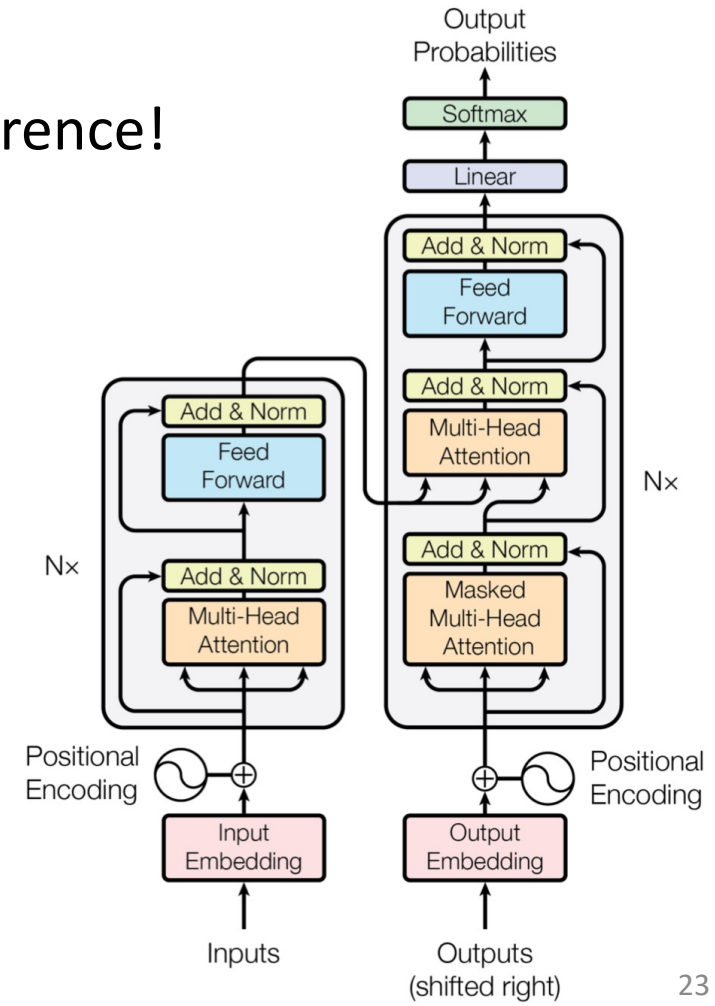
https://github.com/google/seq2seq

Transformer — Is Attention All You Need?

- A novel neural network architecture based on attention

- Encoder-Decoder structure, but no recurrence!
  - Parallelizable → faster to train
- The encoded sentence is as long as the input sentence
  - Capturing more information of input
  - „Transforms“ the input into an encoded form

- Many state-of-the-art improvements!



Representing Words Part 2 — Context

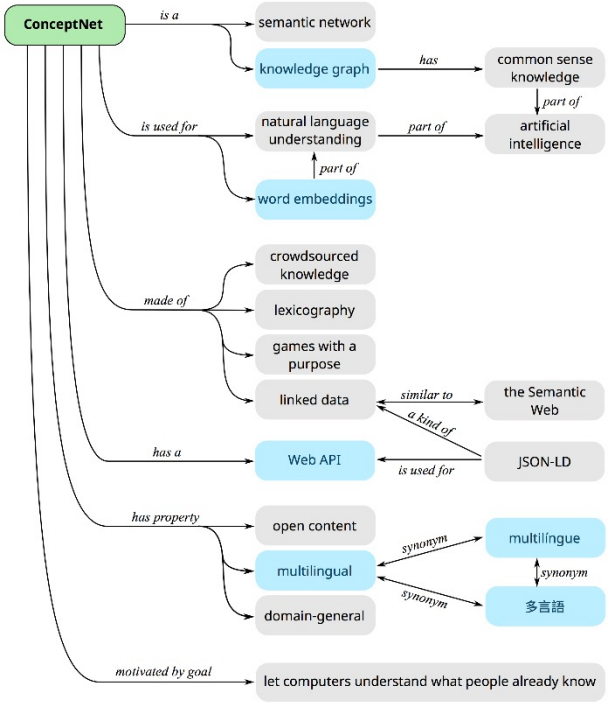
- Many words have a different meaning depending on the context they are used in
  - e.g. „stick“, „bank“, ...
- Idea: Also consider the context a word is used in to calculate its word representation
  - Using RNNs: e.g. ELMo
  - Using Transformers: e.g. BERT

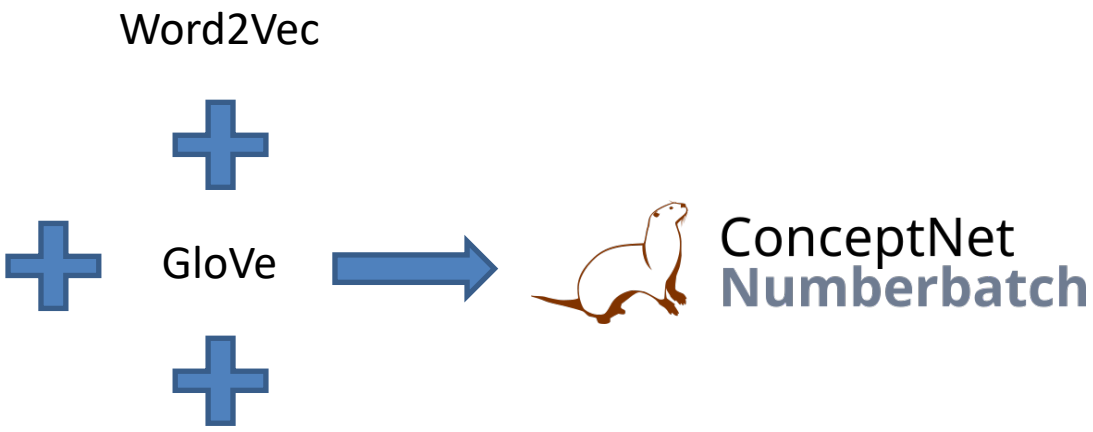
Source

Source

Representing Words Part 3 — World Knowledge

- Word2Vec still has shortcomings
- Idea: Integrating **world knowledge → e.g. Conceptnet Numberbatch**





https://github.com/commonsense/conceptnet-numberbatch/blob/master/conceptnet-numberbatch.png

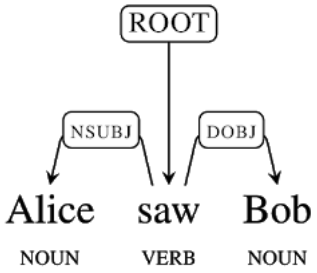
Our Work with World Knowledge in NLP

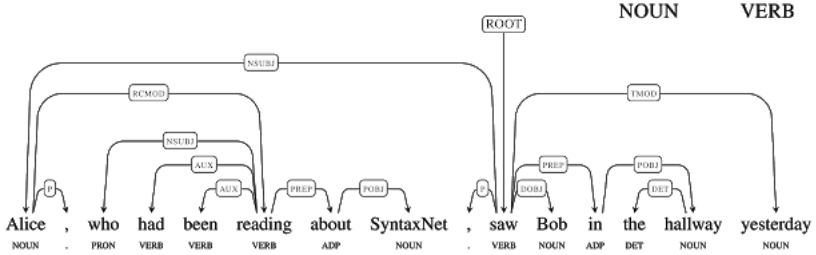
- Language Models contain world knowledge based on knowledge captured in texts it was trained on
- Can we improve a Knowledge Graph using this knowledge?
- Can we then improve word embeddings using an improved Knowledge Graph?

Omeliyanenko, J., Zehe, A., Hettinger, L., & Hotho, A. (2020, November). LM4KG: Improving Common Sense Knowledge Graphs with Language Models. In *International Semantic Web Conference* (pp. 456-473). Springer, Cham.

Applications

- SyntaxNet
  - Part-of-speech (POS) tagging: Noun, verb, ...
  - Dependency parsing: „Alice“ is the subject of „saw“, ...
  - Generally a very complex task





- GPT-3
  - A very complex and big **(175 billion parameters!) language model** using the transformer architecture
  - Objective: Given a text, predict the next word
  - Very convincing output
  - Can solve many tasks without further training, e.g. question answering, machine translation, ...

https://twitter.com/quasimondo/status/1284509525500989445

The importance of being on twitter

by Jerome K. Jerome
London, Summer 1897

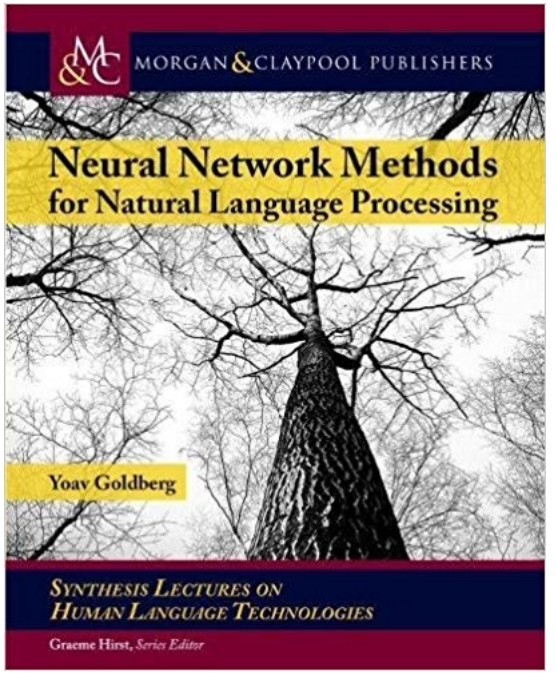
It is a curious fact that the last remaining form of social life in which the people of London are still interested is Twitter. I was struck with this curious fact when I went on one of my periodical holidays to the sea-side, and found the whole place twittering like a starling-cage. I called it an anomaly, and it is.

I spoke to the sexton, whose cottage, like all sexton's cottages, is full of antiquities and interesting relics of former centuries. I said to him, "My dear sexton, what does all this twittering mean?" And he replied, "Why, sir, of course it means Twitter."
"Ah!" I said, "I know about that. But what is Twitter?"

"It is a system of short and pithy sentences strung together in groups, for the

Literature

Neural Network Methods in Natural Language Processing, 2017 by Yoav Goldberg (Author), Graeme Hirst (Editor)



A Primer on Neural Network Models for Natural Language Processing, Yoav Goldberg

https://www.jair.org/media/4992/live-4992-9623-jair.pdf

Other Resource: Twitter

NLP moves very fast nowadays → Follow researchers on Twitter for new interesting papers and discussions

Some recommendations

- Sebastian Ruder: @seb_ruder
- Chris Manning: @chrmanning
- Yoav Goldberg: @yoavgo
- Emily M. Bender: @emilymbender
- Andrej Karpathy: @karpathy
- Anna Rogers: @annargrs
- ...