Deep Learning for NLP with PyTorch

Oct 28, 2020

Topics

- AI and NLP Introduction
- NLP Tools and Pipeline
    - Word vectors, Tranformers, BERT
- Text Classification, Text Summarization
    - Labs using Pytorch, SpaCy, Gensim, BERT/XLNet

Bio

- **Ravi Ilango**

- Lead Data Scientist, Stealth Startup, SantaClara

- 10+ Years at Apple, Sr Data Scientist at FogHorn Systems, Sr DataScietist at StatesTitle

- Education:
    - BE Mech (Madras University, India)
    - Masters Program in Aero and Production (IIT Madras, India)
    - MBA (Santa Clara University)
    - Graduate Certificate in Data Mining and Machine Learning (Stanford)

- email: ravi.ilango@gmail.com

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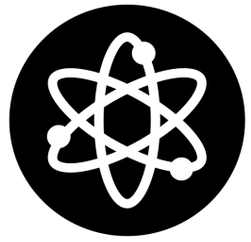


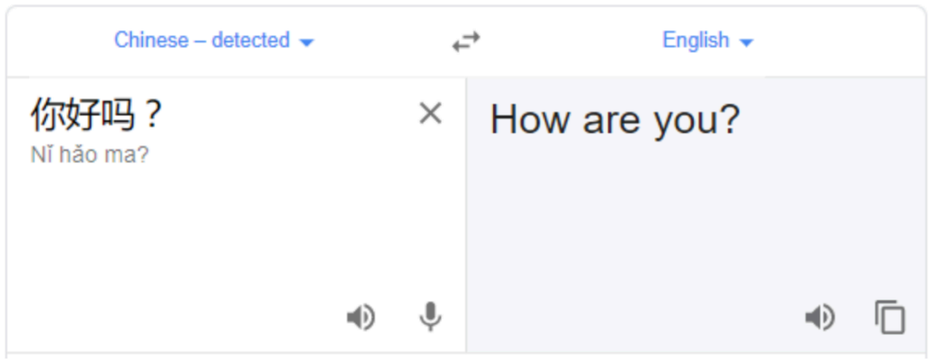
We’re hiring:

https://relyance.ai/careers

NLP Everyday

Google Translate

used by 500 million people every day



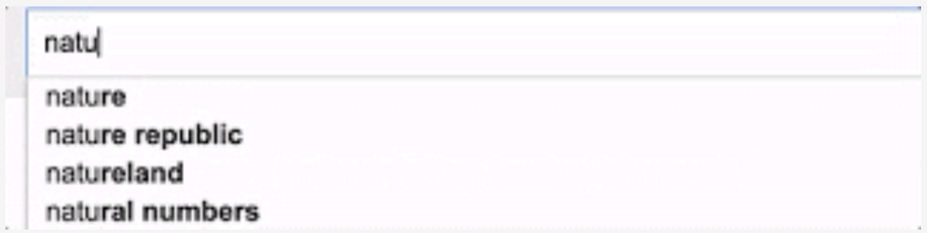
Google Translate from Chinese to English

Chatbot

*Our Financial Consultants use the ask**PRU** chatbot to provide a better service experience to customers.*

Email assistant

Predictive typing suggests the next word in the sentence.



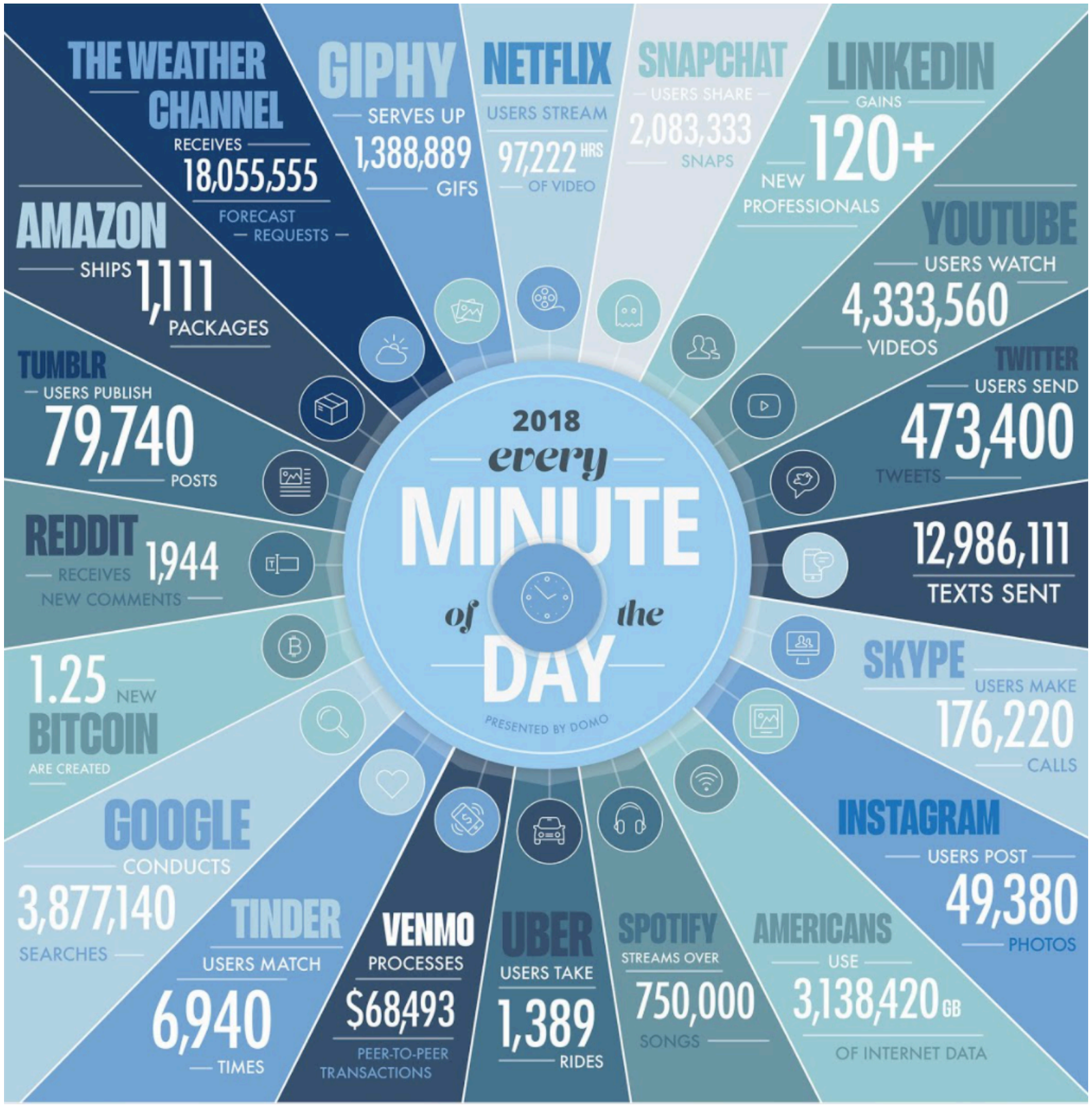
3.5B searches/daily

NLP in business operation

- Achieve efficiencies using machine processing of unstructured tect data

Extract and Summarization

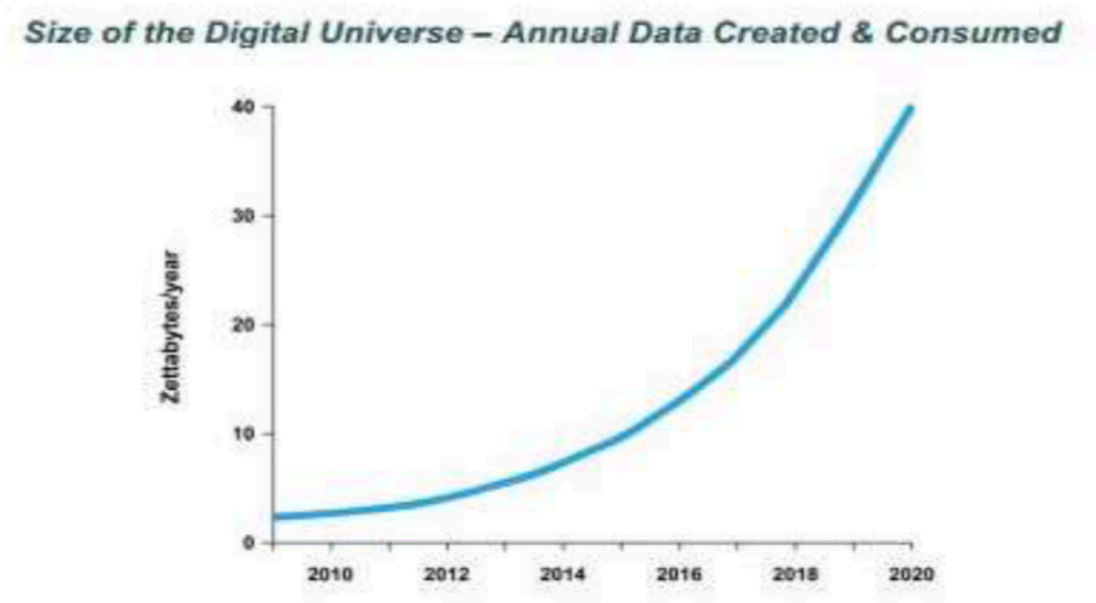
Data production rate



https://www.digitalinformationworld.com/2018/06/infographics-data-never-sleeps-6.html

Text data

- About 80% of data in organizations are in text format
- Harder to analyse than structured data
- Huge amount of textual documents
  - Only in biomedicine 2200 scientific papers are published every day
- Growing exponentially

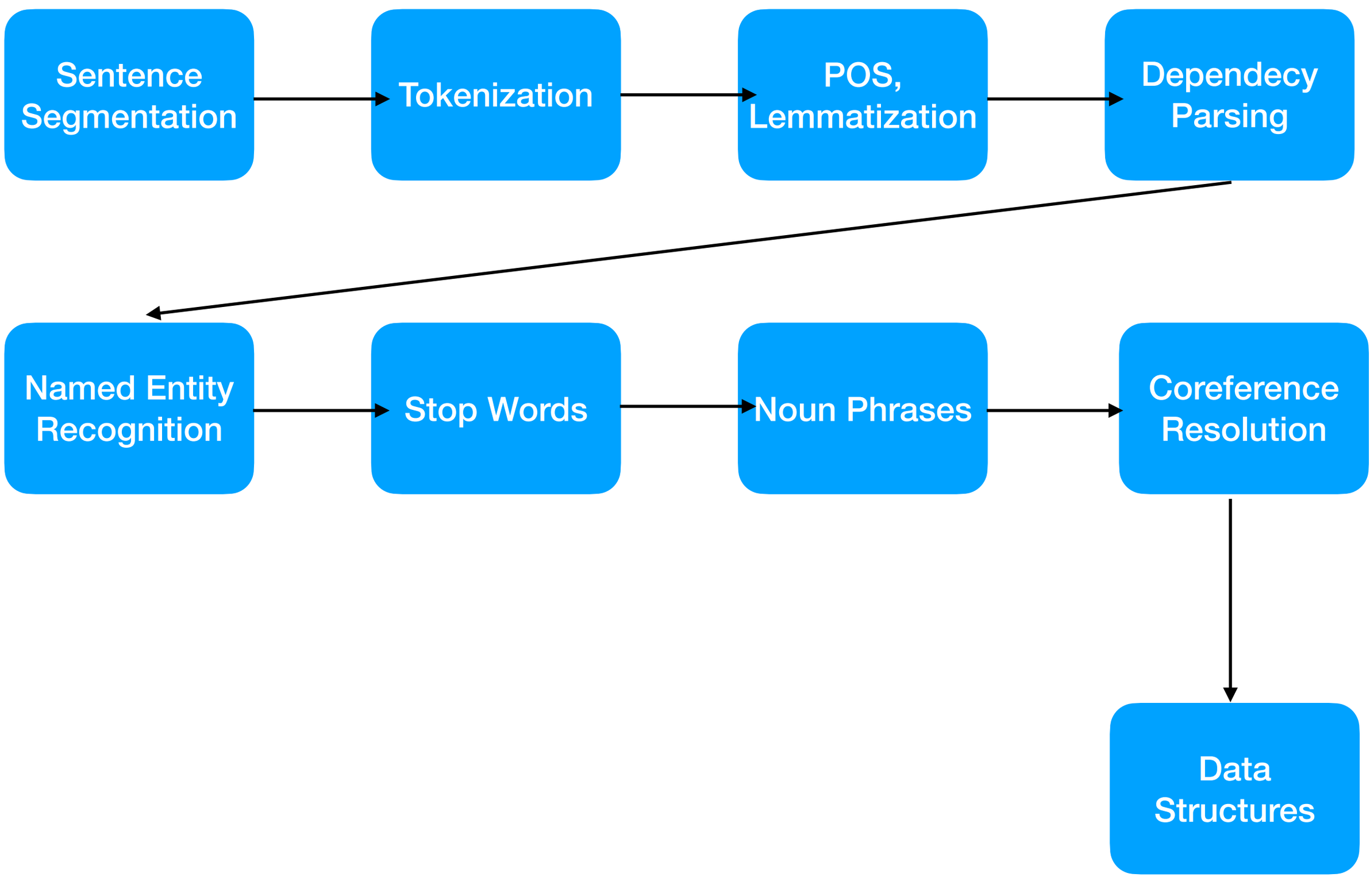


NLP Use Cases in Enterprises

- Text Classification- It is the process of categorizing or tagging text based on its content
  - organizing customer support tickets, customer reviews, emails

- Text Extraction- It is the process of extracting specific information from documents
  - extract key info from business documents (invoices, agreements), emails

NLP Pipeline to produce representative data structures



NLP Data Scientist - (some) tools

python™

Transformers

PyTorch

scikit learn

NLTK

TensorFlow

spaCy

CoreNLP

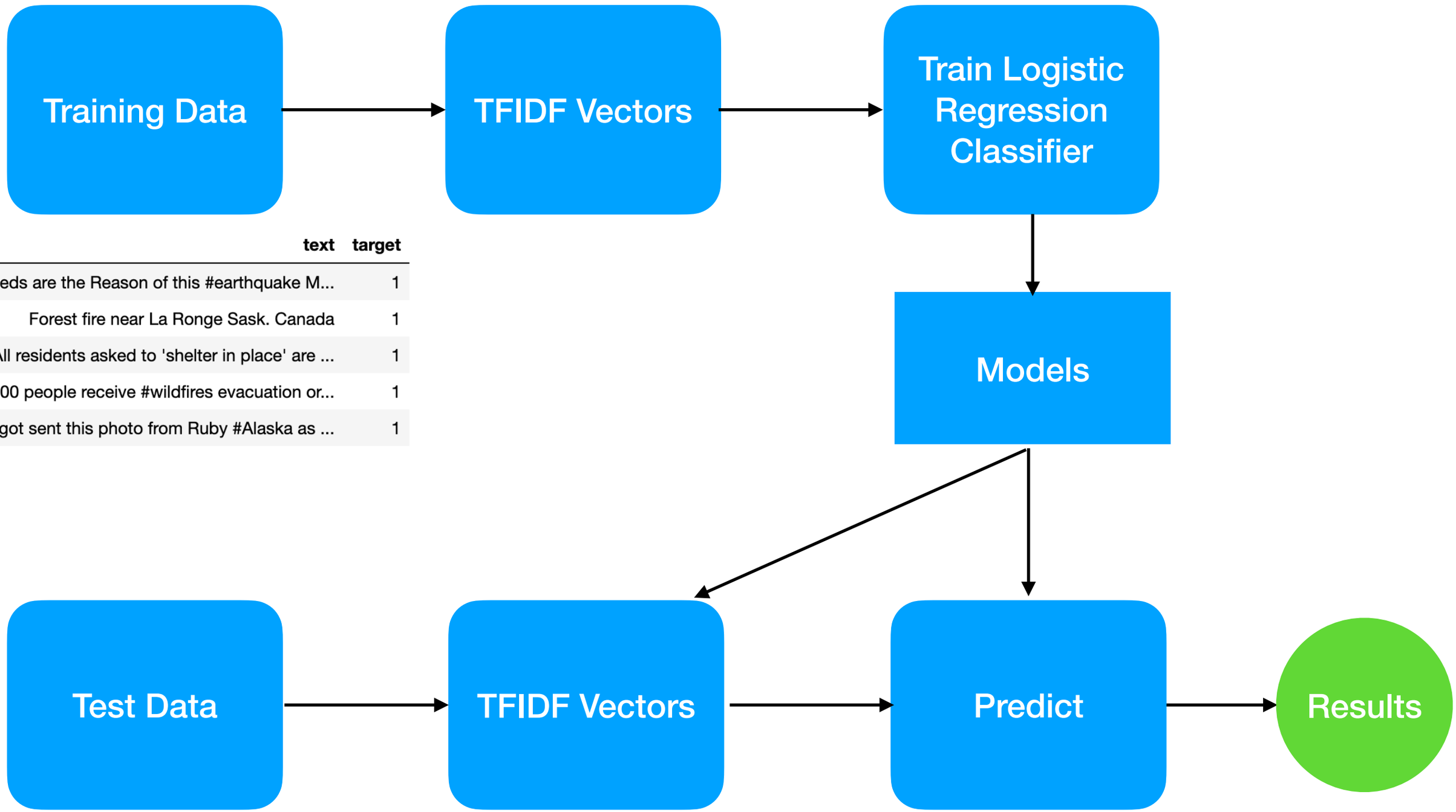
PyText

gensim

NLP Data Scientist - (some) concepts & techniques

- Word vectors, tokenization, document vectorization
- POS (parts of speech), NER
- Document parsing techniques, Regex
- Supervised ML, Classifiers, Deep Learning and how to use word embeddings
- Using Pretrained models

Lab: Disaster Detection



	text	target
	Our Deeds are the Reason of this #earthquake M...	1
	Forest fire near La Ronge Sask. Canada	1
	All residents asked to 'shelter in place' are ...	1
	13,000 people receive #wildfires evacuation or...	1
	Just got sent this photo from Ruby #Alaska as ...	1

Lab 1: Disaster Detection using TFIDF and Logistic Regression

https://colab.research.google.com/github/ravi-ilango/odsc2020_nlp/blob/main/lab1/disaster_detection_tfidf.ipynb

Word Embedding

"You shall know a word by the company it keeps"
(J. R. Firth 1957)

One of the most successful ideas of modern statistical NLP!

government debt problems turning into **banking** crises as has happened in

saying that Europe needs unified **banking** regulation to replace the hodgepodge

these words represent banking

Vector Space Model

- Neural word embeddings
- Combine vector space semantics with the prediction of probabilistic models
- Words are represented as a **dense** vector:

Candy = $\begin{pmatrix} 0.286 \\ 0.792 \\ -0.177 \\ -0.107 \\ 0.109 \\ -0.542 \\ 0.349 \\ 0.271 \end{pmatrix}$

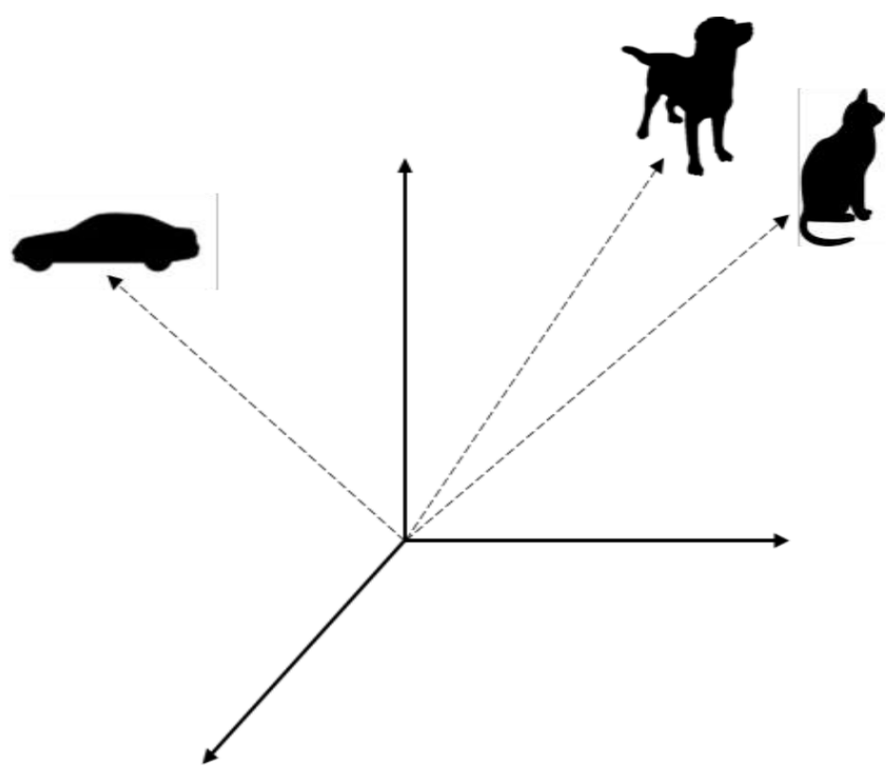
Vector Space Model

Embeddings

The vectors we have been discussing so far are very high-dimensional (thousands, or even millions) and sparse.

But there are techniques to learn lower-dimensional dense vectors for words using the same intuitions.

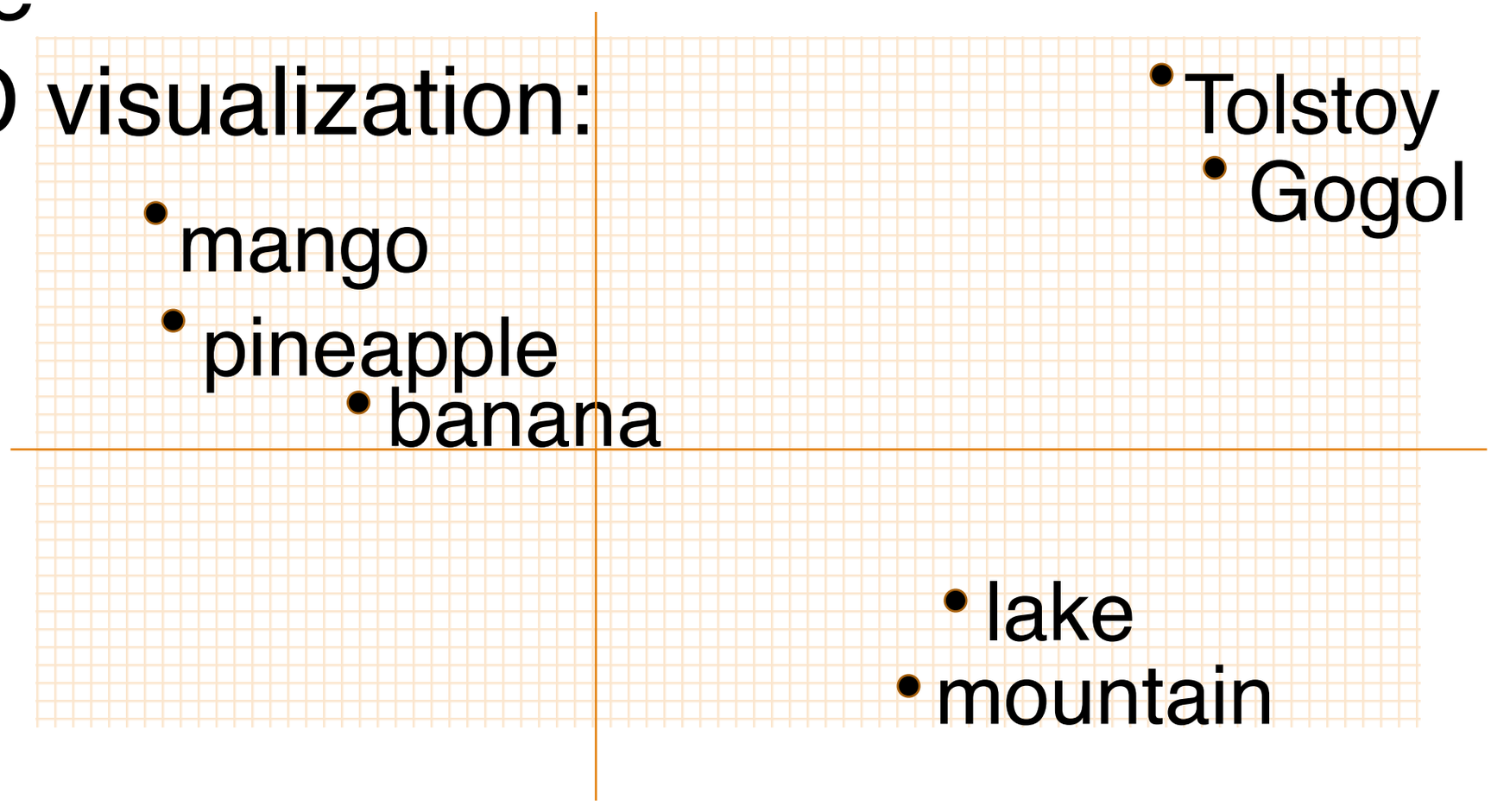
These dense vectors are called embeddings.



Neural word embeddings

A word's meaning is a point in 300-dimensional space

A 2-D visualization:



Embeddings are the core of NLP

Core technology for any NLP task (question answering, machine translation, information retrieval, etc)

- Finding synonyms for words
- Deciding if two sentences have similar meaning

How to learn these "embeddings"?

Push words **together in space** they occur **together in text**

Read millions of words.

When you see:

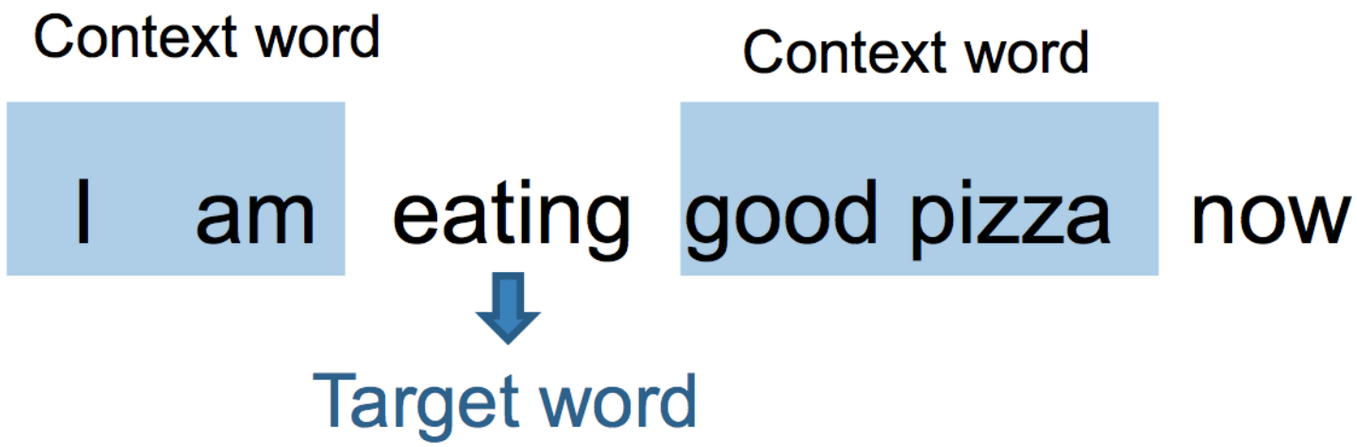
Banana, mango, or pineapple are all delicious…

Move **banana** closer to **mango**

Move **banana** further from **Tolstoy**

Continuous Bag-of-Words Model

- Continuous Bag-of-Words Model
  - Predict target word by the context words
  - Eg: Given a sentence and window size 2

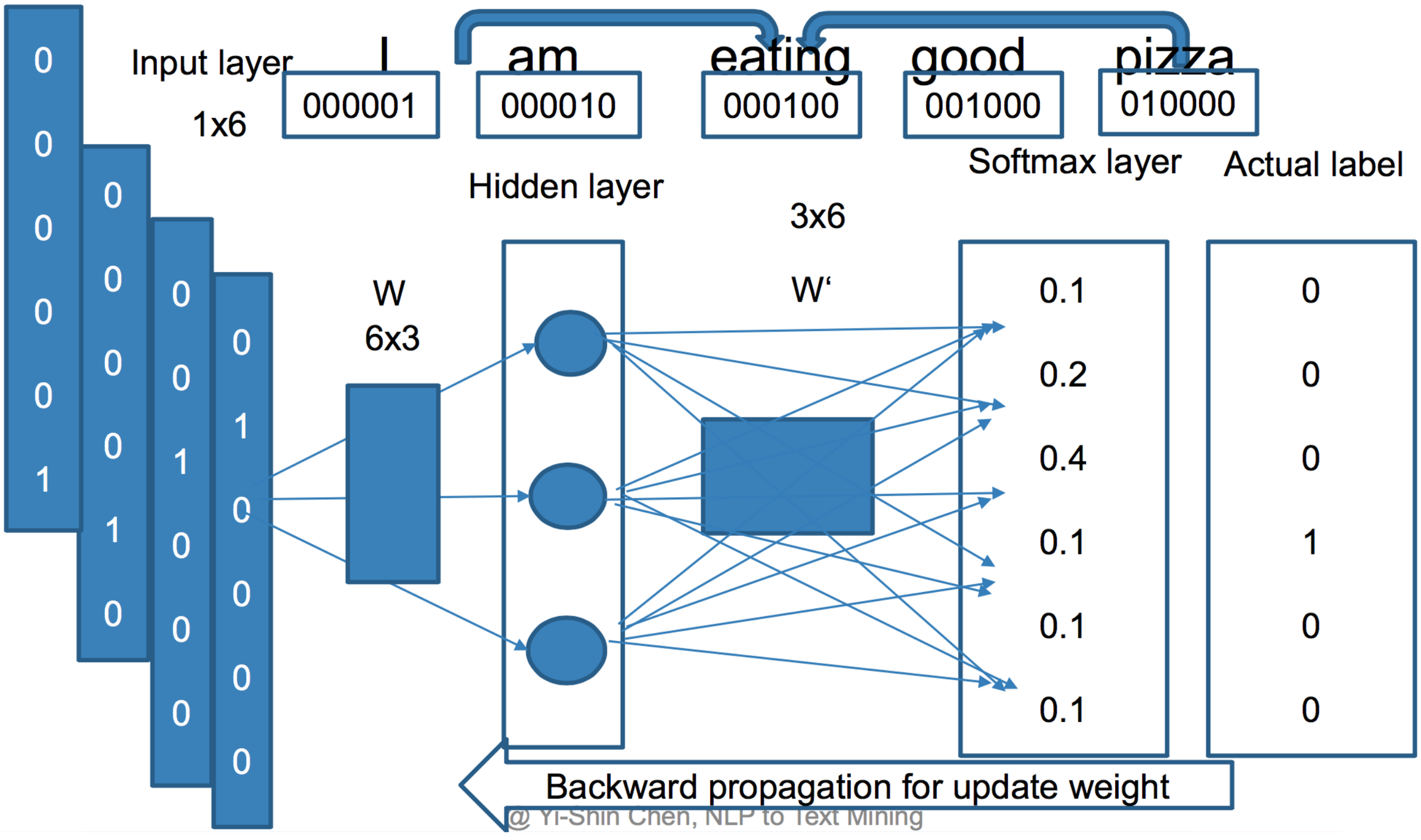


Ex: ([features], label)
([I, am, good, pizza], eating), ([am, eating, pizza, now], good) and so on and so forth.

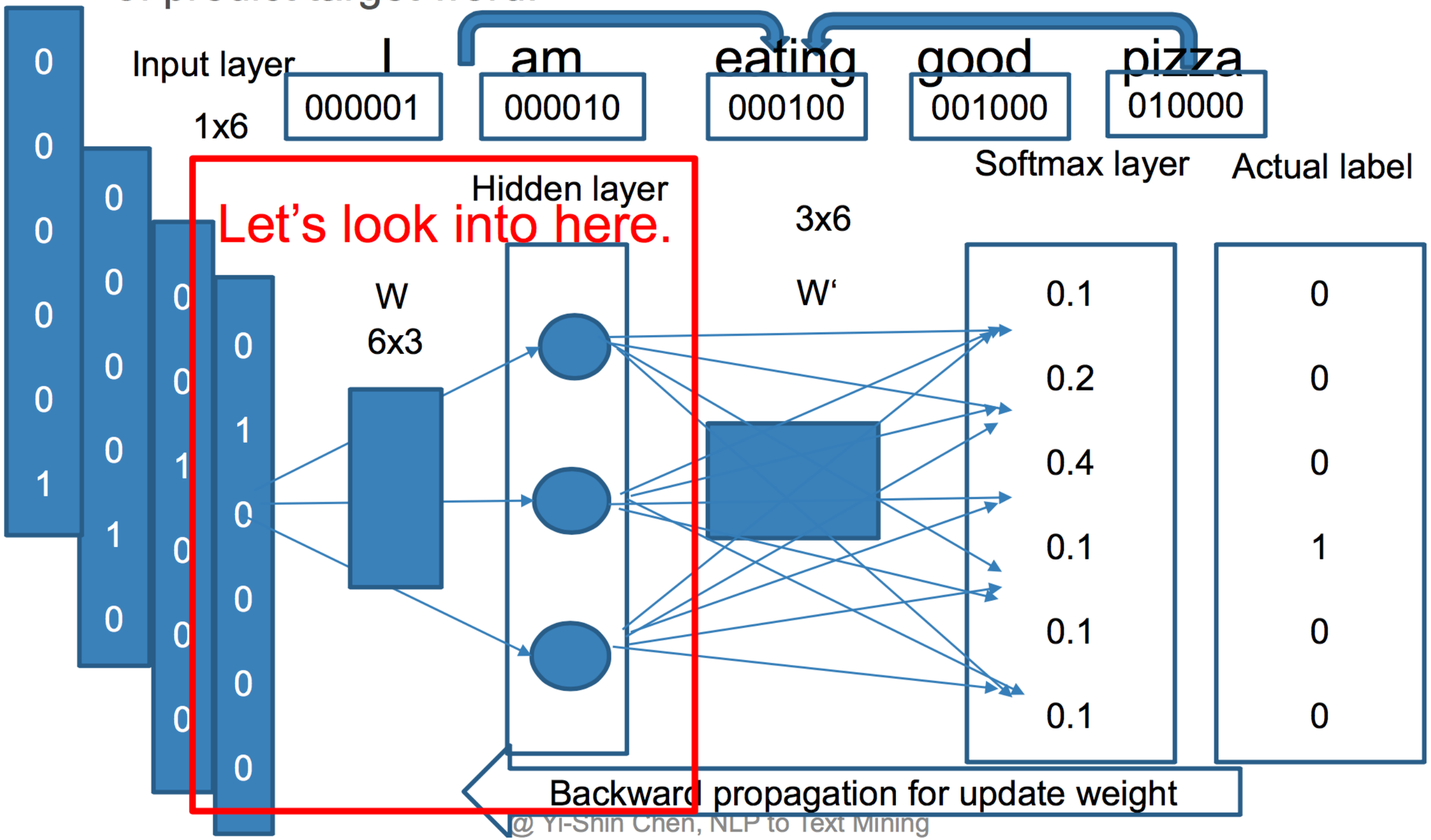
Word Embedding in a Deep Learning network

Continuous Bag-of-Words Model (Contd.)

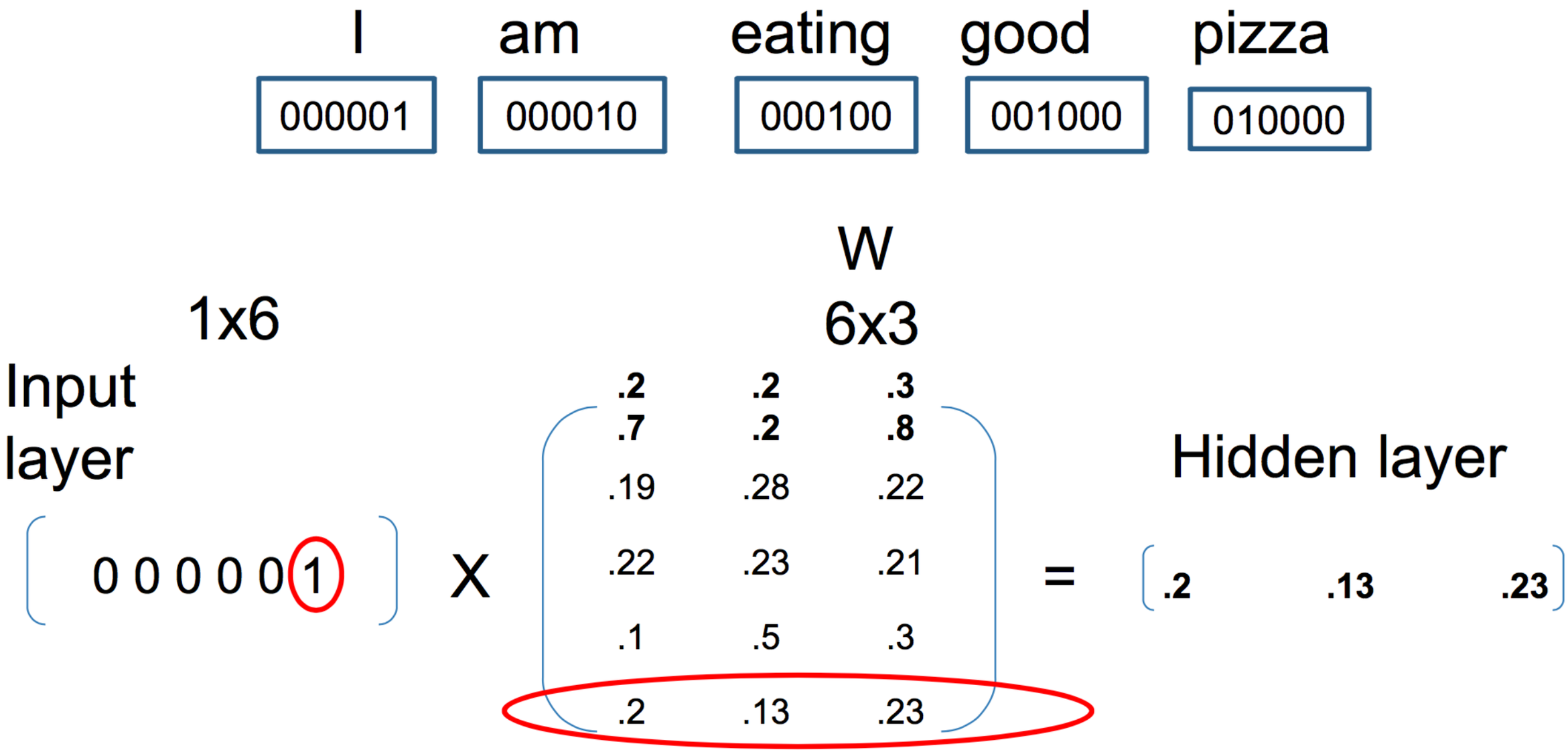
- We train one depth neural network, set hidden layer's width 3.



- The goal is to extract word representation vector instead of prob of predict target word.

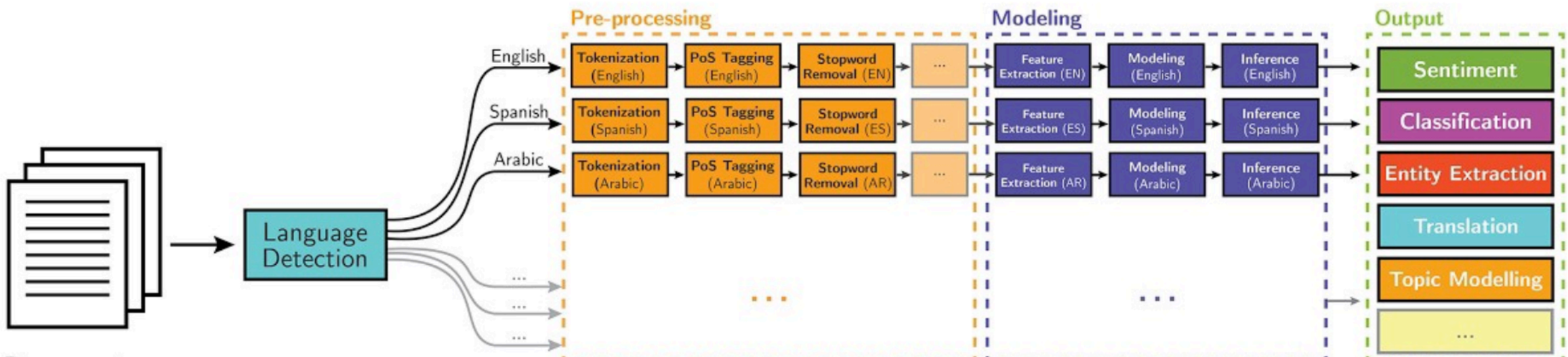


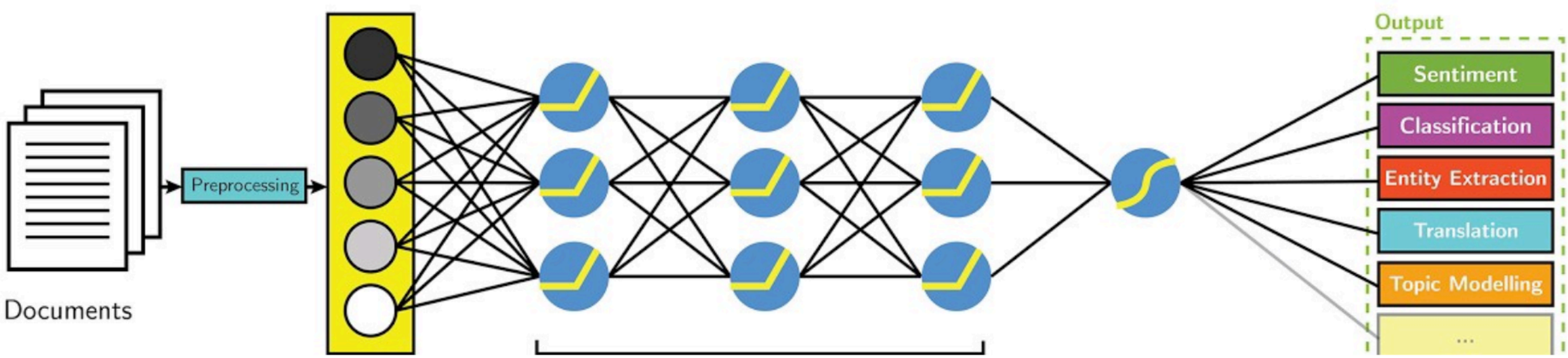
Continuous Bag-of-Words Model (Contd.)



- The output of the hidden layer is just the "word vector" for the input word

NLP


Pre-processing
Modeling
Output
English
Spanish
Arabic
Tokenization (English)
PoS Tagging (English)
Stopword Removal (EN)
Tokenization (Spanish)
PoS Tagging (Spanish)
Stopword Removal (ES)
Tokenization (Arabic)
PoS Tagging (Arabic)
Stopword Removal (AR)
Feature Extraction (EN)
Modeling (English)
Inference (English)
Feature Extraction (ES)
Modeling (Spanish)
Inference (Spanish)
Feature Extraction (AR)
Modeling (Arabic)
Inference (Arabic)
Language Detection
Documents
Sentiment
Classification
Entity Extraction
Translation
Topic Modelling


Deep Learning-based NLP
Preprocessing
Documents
Output
Sentiment
Classification
Entity Extraction
Translation
Topic Modelling

Why Recurrent Neural Network?

Two main limitations of other deep nets are:

- **Data points with dependencies**: ANNs can't deal with sequential or "temporal" data.

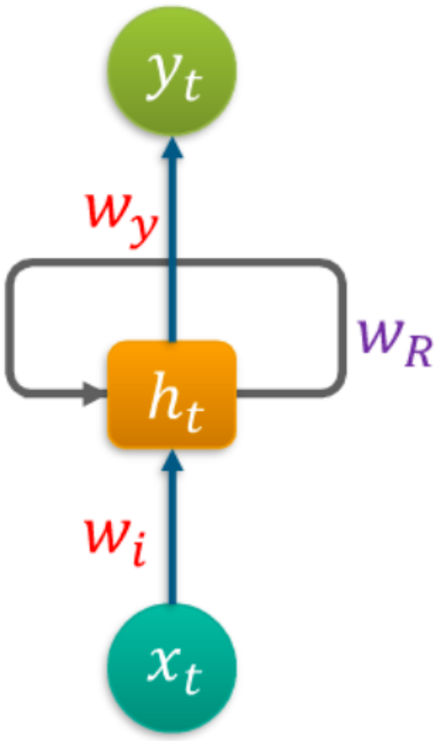
Time Series	Gene Sequences	Sentences	Stock prices

- **Independence**: Traditional neural network assumes that each data point is independent of other data points (inputs are analysed in isolation)

For sequential data the length of the input sequences can vary from example to example. Also In sequences there will be short and long temporal dependencies among the words, thus normal deep networks can't be used for sequential data

Structure of RNN

- The basic elements of a recurrent neuron is given below:



Here, activity $h^{(t)}$ depends on both input $x^{(t)}$ and a recurrent connection with weight w_R

$$h^{(t)} = g_h\left(w_i x^{(t)} + w_R h^{(t-1)} + b_h\right)$$

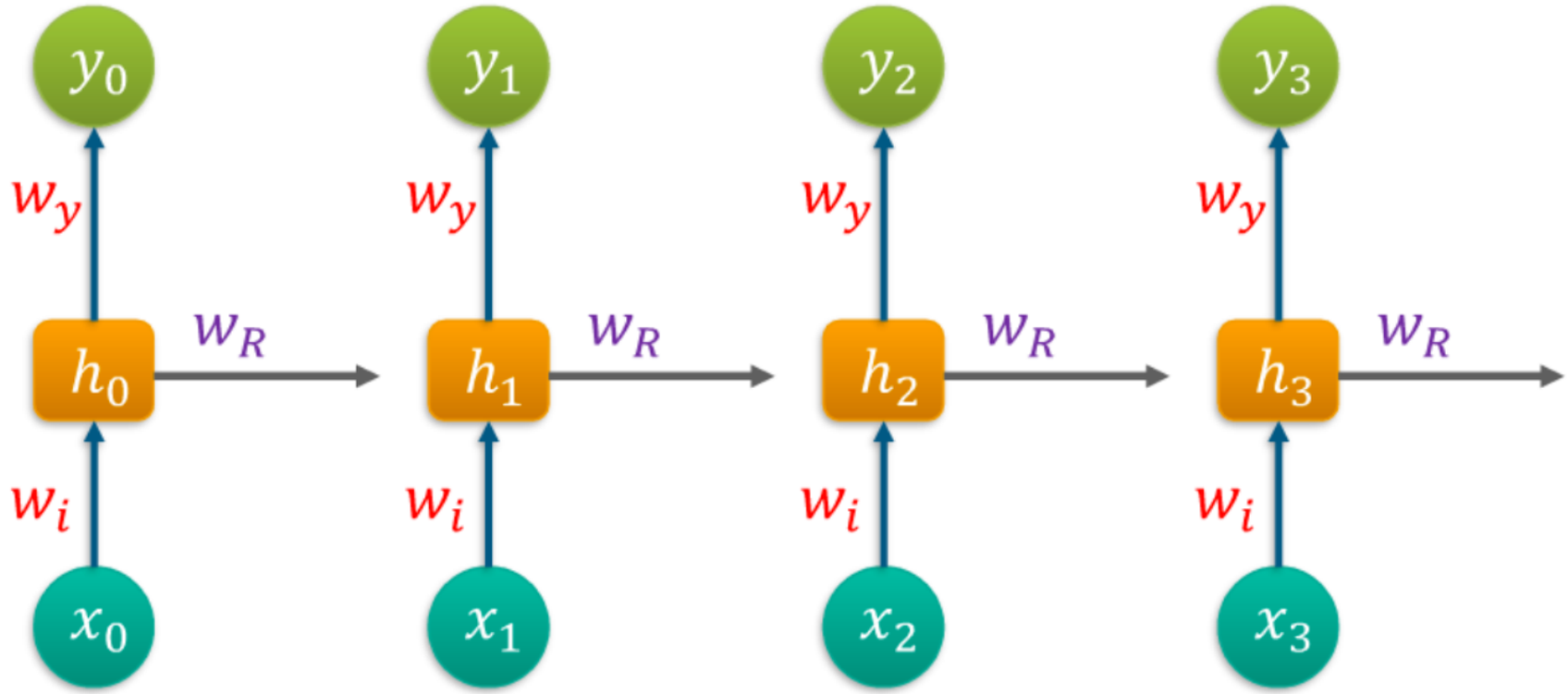
$$y^{(t)} = g_y\left(w_y h^{(t)} + b_y\right)$$

Activity at previous time stamp

Labelling of parameters used

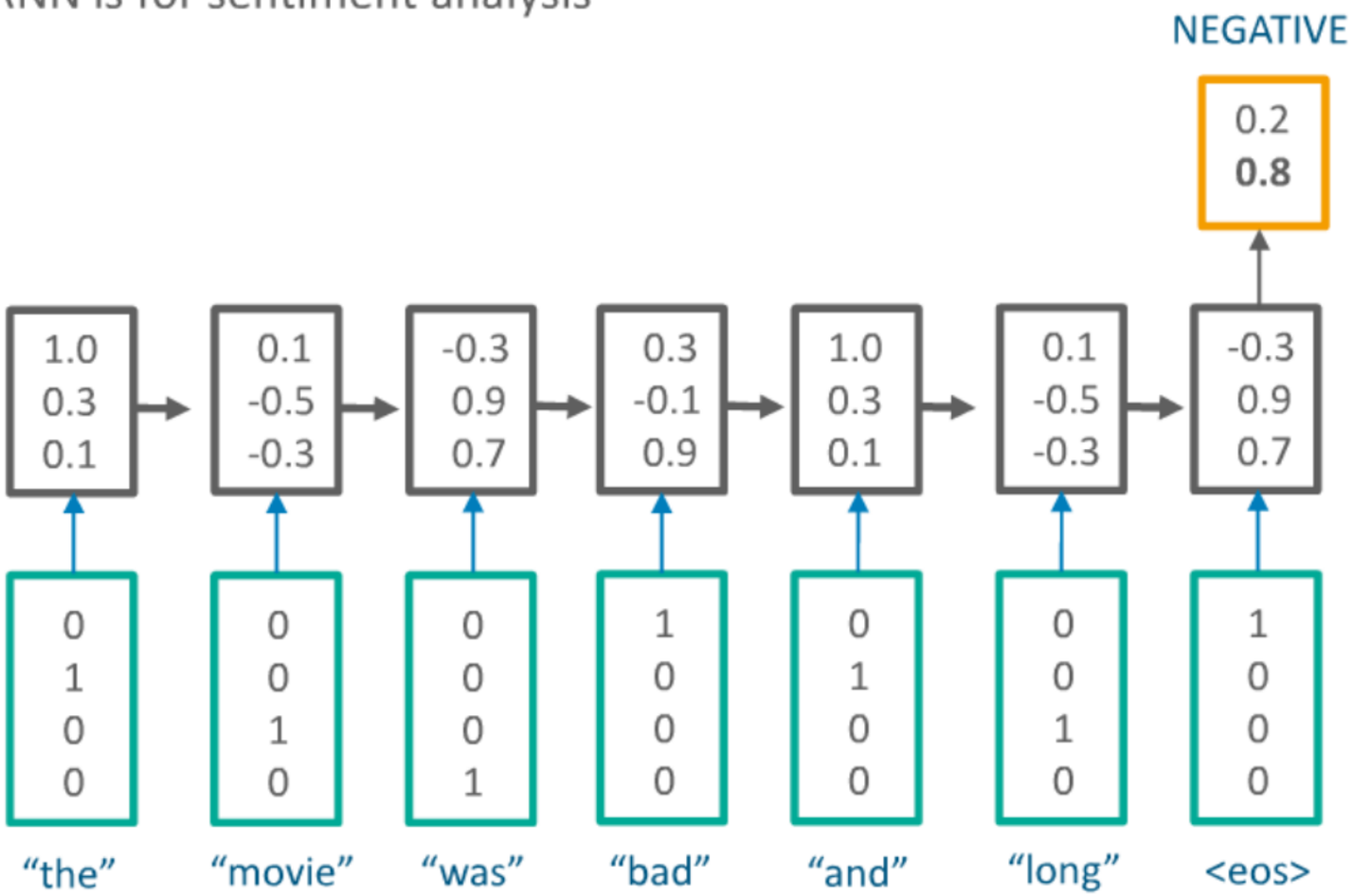
Structure of RNN

- By unrolling an RNN in time, we will get a feed forward network as:



Example

- Another use of RNN is for sentiment analysis



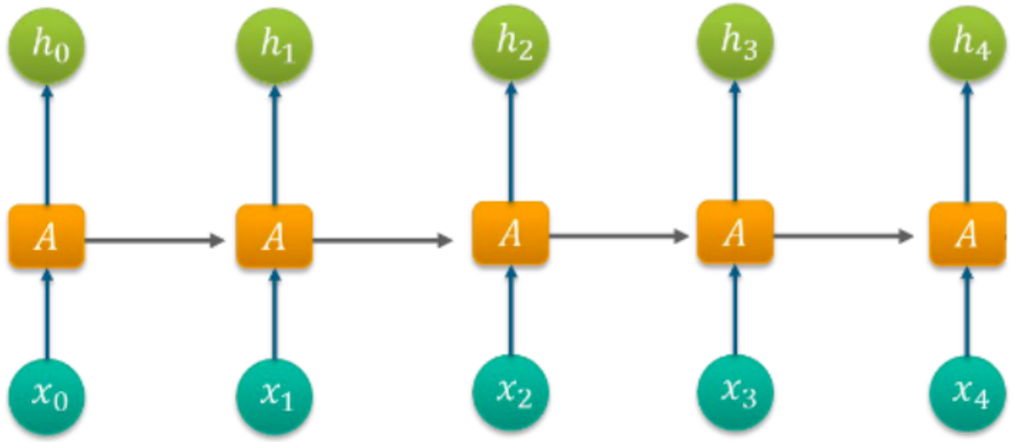
What are LSTMs?

- Long Short Term Memory networks – usually just called “LSTMs” – are a special kind of RNN, capable of **learning long-term dependencies.**
- LSTMs are explicitly designed to avoid the long-term dependency problem. Remembering information for long periods of time is practically their default behaviour.

What are LSTMs?

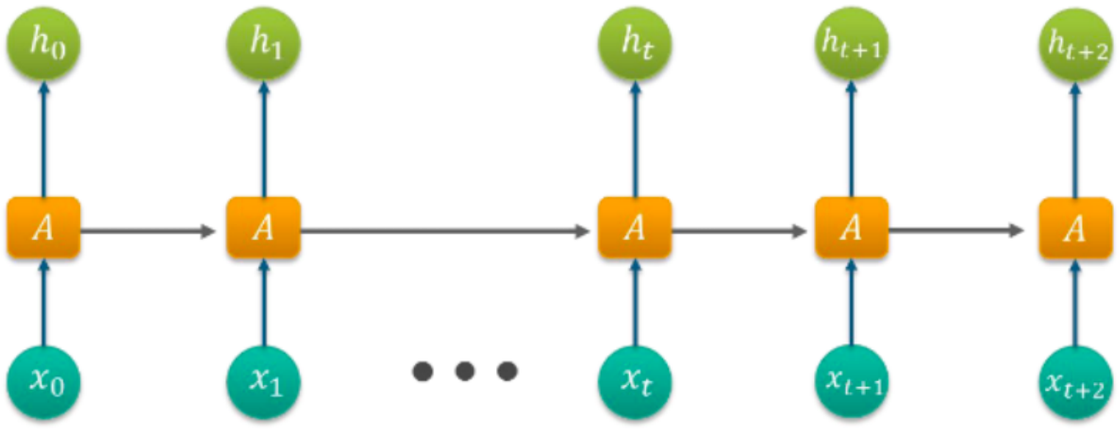
Consider an example where we want to predict the last word of a given text.

- **Short Term Memory**



The clouds are in the ***sky***

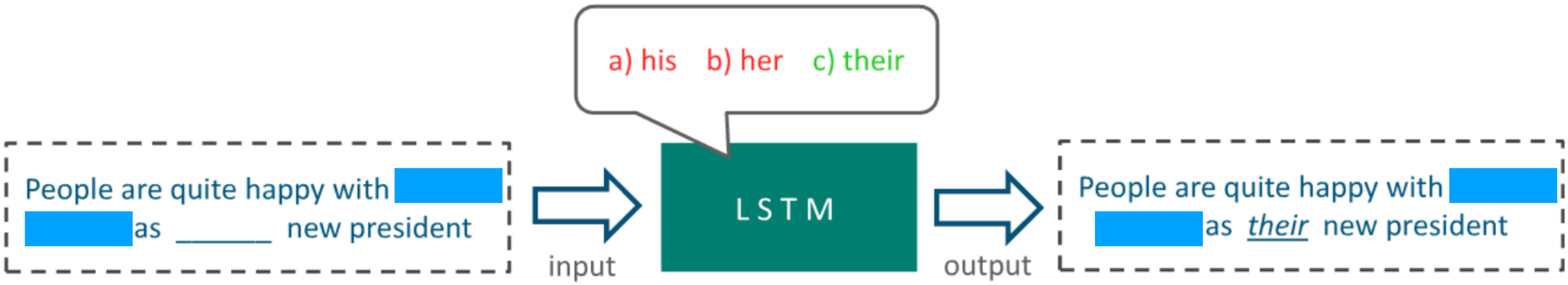
- **Long Term Memory**



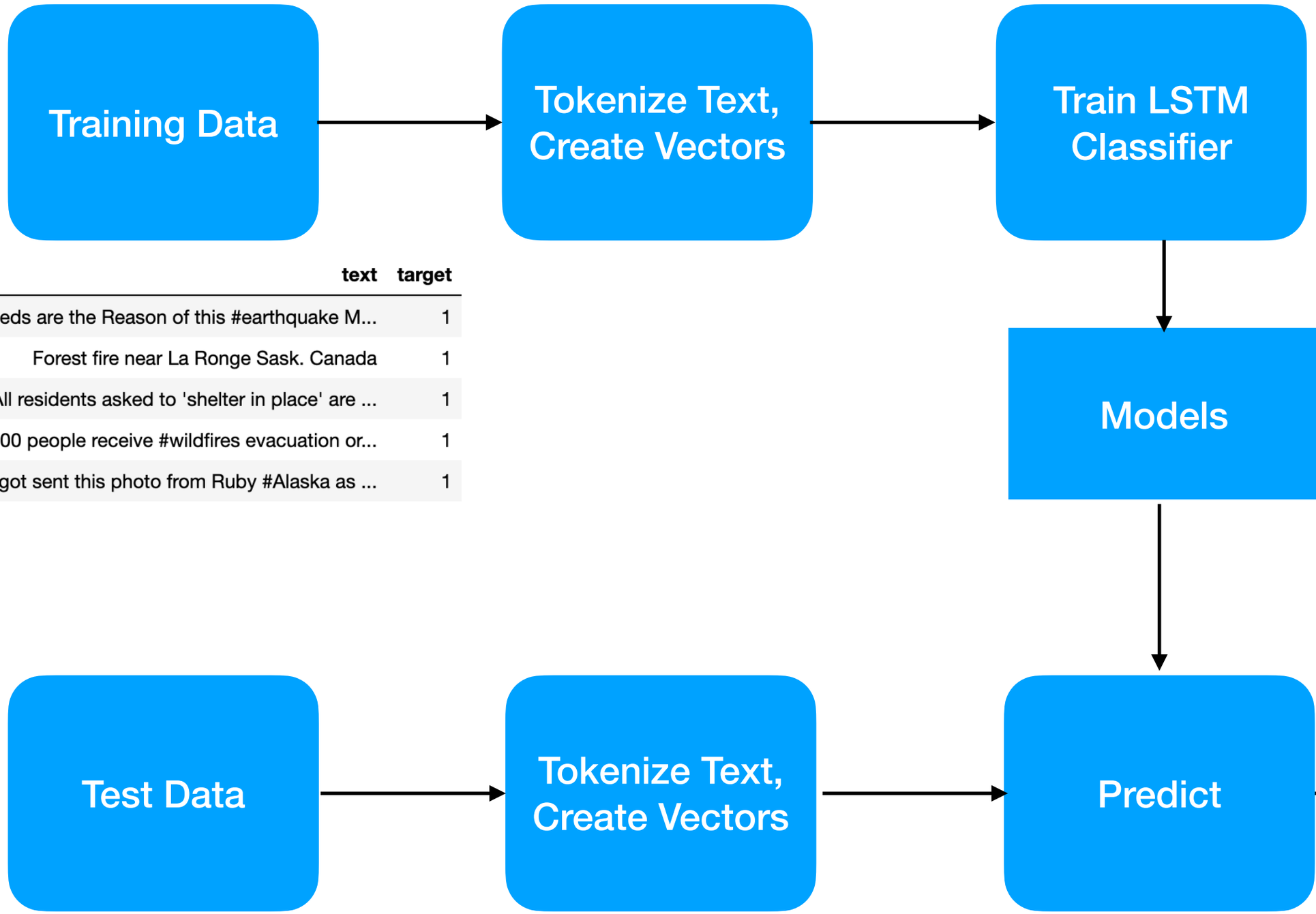
I grew in France… I speak fluent ***French***.

LSTM Working Steps

- For the language model example, since it just saw a subject, it might want to output information relevant to a verb, in case that's what is coming next.
- For example, it might output whether the subject is singular or plural, so that we know what form a verb should be conjugated into if that's what follows next.



Lab: Quora Comment Classifier



text	target
Our Deeds are the Reason of this #earthquake M...	1
Forest fire near La Ronge Sask. Canada	1
All residents asked to 'shelter in place' are ...	1
13,000 people receive #wildfires evacuation or...	1
Just got sent this photo from Ruby #Alaska as ...	1

Lab 2: Text Classification

https://colab.research.google.com/github/ravi-ilango/odsc2020_nlp/blob/main/lab2/quora_classifier_lstm.ipynb

Transformers

- **Transformer:** It applies attention mechanisms to gather information about the relevant context of a given word, and then encode that context in a rich vector that smartly represents the word.

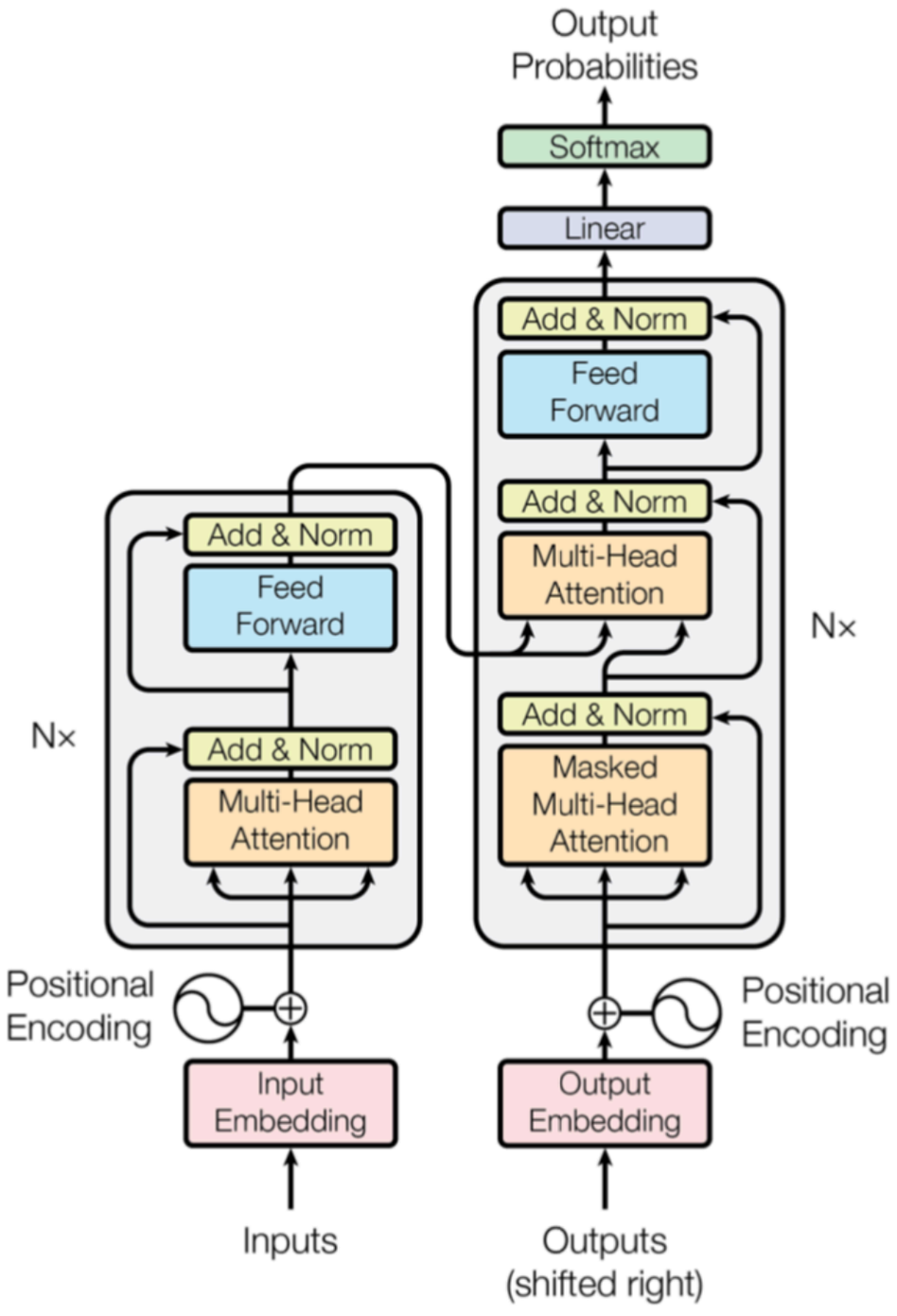


Figure 1: The Transformer - model architecture.

Source: Attention Is All You Need

Transformers

The Transformer presents a new approach, it proposes to extract information from each position and to apply the mechanism of attention in order to connect two distant words, which can then be parallelized, thus accelerating learning. It applies a mechanism of self-attention.

https://medium.com/analytics-vidhya/transformer-vs-rnn-and-cnn-18eeefa3602b
https://arxiv.org/abs/1705.03122

PyTorch-Transformers

- PyTorch-Transformers is a library of state-of-the-art pre-trained models for Natural Language Processing (NLP)

- Contains PyTorch implementations, pre-trained model weights for BERT (Google), GPT (OpenAI), Transformer-XL, XLNet, XML (Facebook) and more …

Transfer Learning

In practice, very few people train an entire Deep Learning Network from scratch (with random initialization), because it is relatively rare to have a dataset of sufficient size. Instead, it is common to pretrain a ConvNet on a very large dataset (e.g. ImageNet, which contains 1.2 million images with 1000 categories), and then use the ConvNet either as an initialization or a fixed feature extractor for the task of interest

Source: http://cs231n.github.io/transfer-learning/

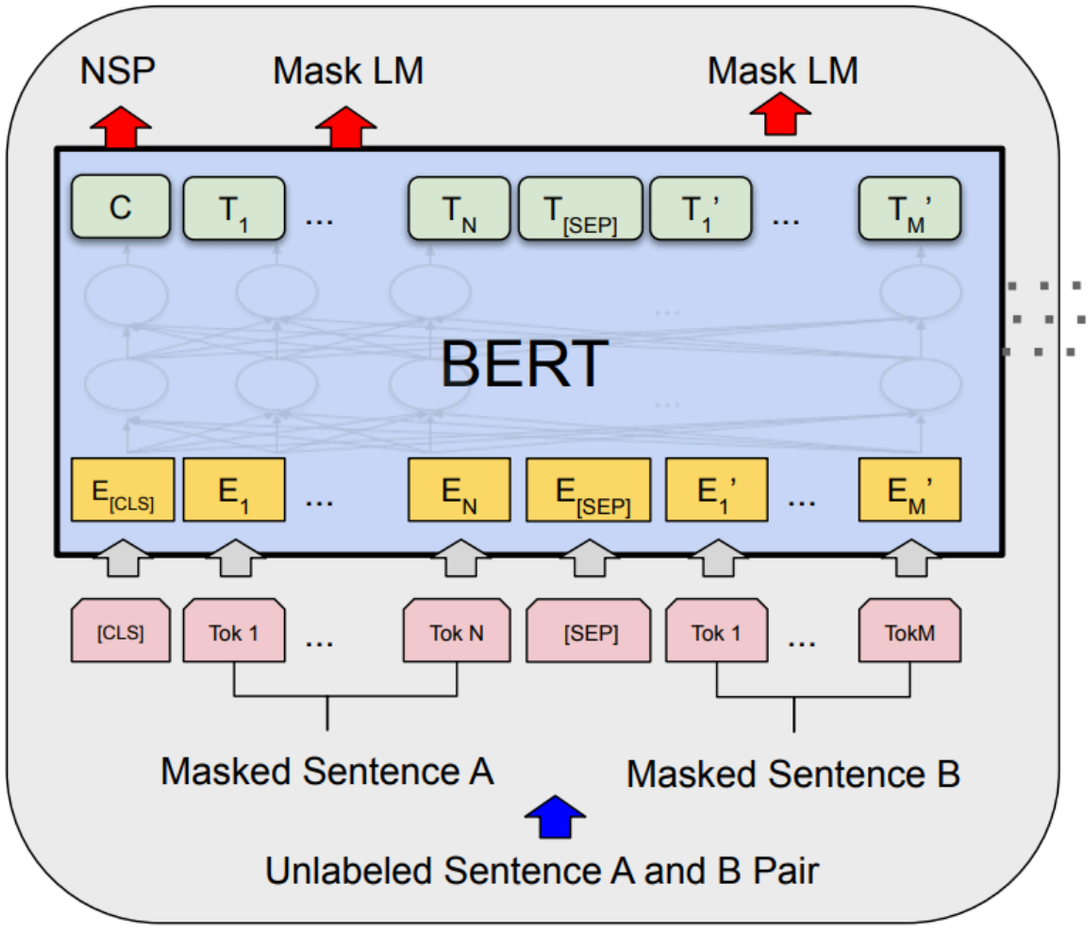
BERT - Bidirectional Encoder Representations from Transformers

Model Details

- Data: Wikipedia (2.5B words) + BookCorpus (800M words)
- Batch Size: 131,072 words (1024 sequences * 128 length or 256 sequences * 512 length)
- Training Time: 1M steps (~40 epochs)
- Optimizer: AdamW, 1e-4 learning rate, linear decay
- `BERT-Base`: 12-layer, 768-hidden, 12-head
- `BERT-Large`: 24-layer, 1024-hidden, 16-head
- Trained on 4x4 or 8x8 TPU slice for 4 days

BERT - Bidirectional Encoder Representations from Transformers

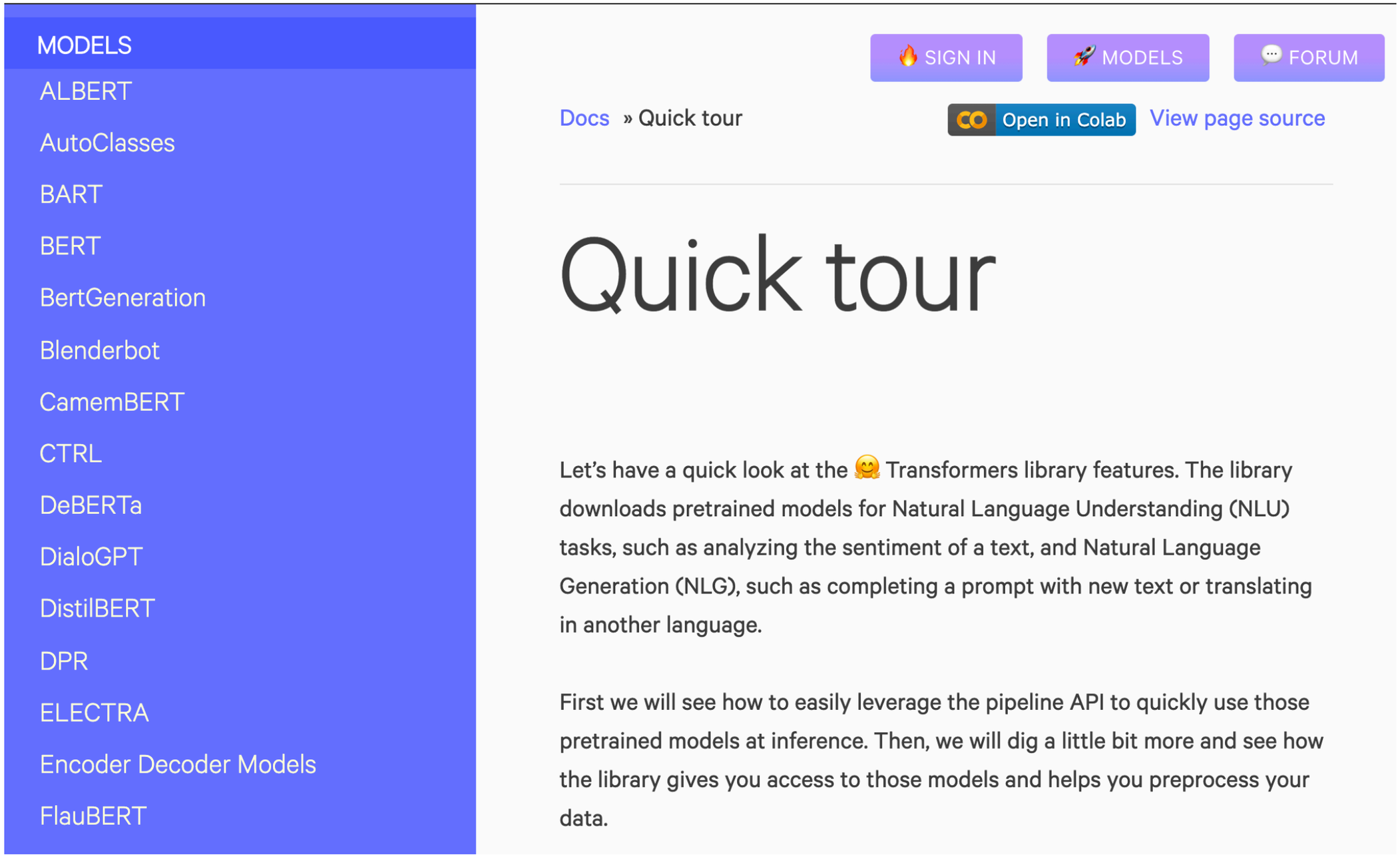
- Pretraining
  - Masked LM
  - Next Sentence Prediction (NSP)
  - Books Corpus (800M words) and English Wikipedia (2,500M words).



Pre-training

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

HuggingFace



https://huggingface.co/transformers/quicktour.html

Lab 3: Disaster Detection using BERT

https://colab.research.google.com/github/ravi-ilango/odsc2020_nlp/blob/main/lab3/disaster_detection_bert.ipynb

Lab 4: Text Classification

https://colab.research.google.com/github/ravi-ilango/odsc2020_nlp/blob/main/lab4/LAB_Sarcasm_Detector.ipynb

https://colab.research.google.com/github/ravi-ilango/odsc2020_nlp/blob/main/lab5/LAB_humor_questions.ipynb

Text Summarization

- Extractive summarization
  - Extract parts of text from the corpus and arrange them to form a summary
  - NLTK Summarizer, Gensim Summarizer
- Abstractive summarization
  - Generate new text using natural language generation

Lab 5: Text Summarization

https://colab.research.google.com/github/ravi-ilango/odsc2020_nlp/blob/main/lab6/TextSummarization.ipynb