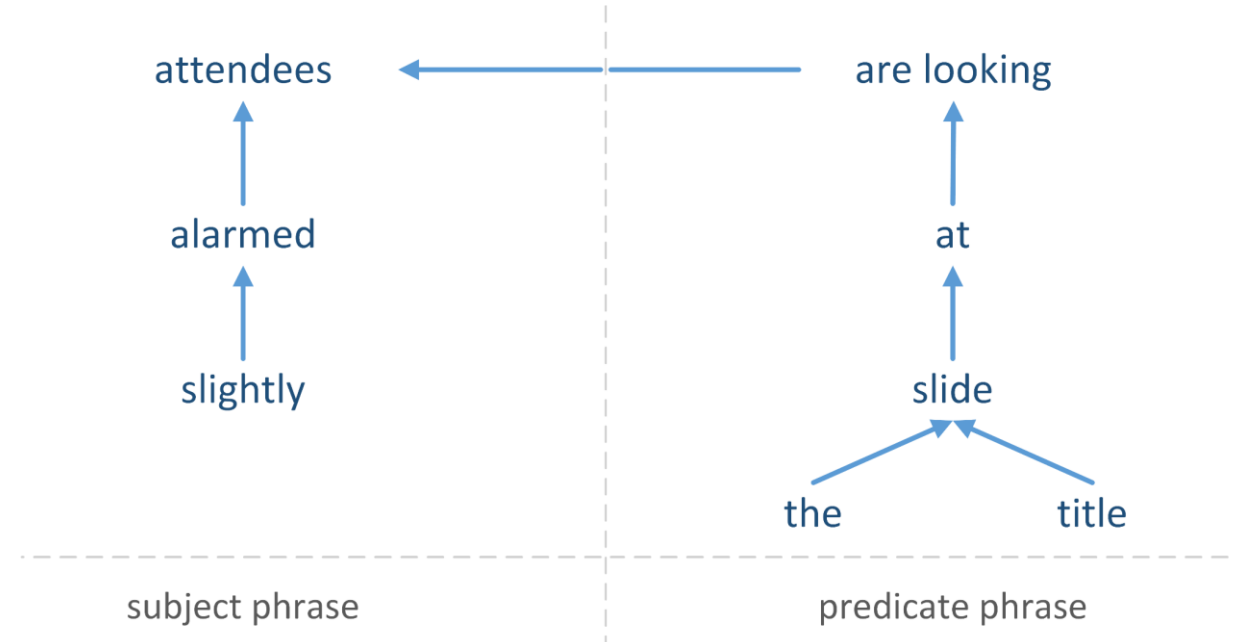


Do androids read about electric sheep?

Machine reading comprehension algorithms

Marek Grzenkowicz

Roche Global IT Solution Centre





Marek Grzenkiewicz

C64 BASIC → ... → ETL → Hadoop → **Python / Data analytics**

 @chopeen  marek.grzenkiewicz@roche.com



Roche Global IT Solution Centre (RGITSC)

Offices in Warsaw and Poznan

 it.roche.pl  instagram.com/it.roche.pl

1. Natural language processing
 - What is it?
 - Why is it important?
 - Basic NLP operations [demo] 🙌
2. My vision
3. Do androids read?
 - Fundamental skills
 - The state of research
4. Summary

Reading between the lines

Reading between the lines

Bob? Who's Bob?



My friend Alice is a great developer.
Unfortunately, Bob isn't.

A blue speech bubble with a tail pointing towards the bottom left.

Bob is not my friend

An orange speech bubble with a tail pointing towards the bottom right.

Bob is not a great
developer

Reading between the lines

Charlie is 6

Roche

Charlie can already write, so he must be at least 6!

6 six years old

6 feet tall

Reading between the lines

Charlie is 6

Roche

Charlie plays basketball, so he must be at least 6!

6 six years old

6 feet tall

Reading between the lines

How's the water?

Roche

Chuck: How did you like the Canary Islands?

Frank: It was nice – sunny, not too humid.
The water was a bit cold though.

Water in the ocean
was cold

Water in the shower
was cold

Reading between the lines

Nothing is certain



Let me tell you how it will be
There's one for you, nineteen for me
'Cause I'm the taxman, yeah, I'm the taxman
The Beatles - Taxman

The Beatles were
required to pay a
95% tax

Before 1971, 1 pound = 20 shillings
(and 1 shilling = 12 pence)

Altogether there
were 20 forms to be
filled

Reading between the lines

Album 1, side 1, track 1



She was born in November 1963
The day Aldous Huxley died

Sheryl Crow – Run Baby Run

Aldous Huxley

From Wikipedia, the free encyclopedia

Aldous Leonard Huxley (26 July 1894 – 22 November 1963) was an English writer and philosopher.^{[1][2][3][4]} He wrote nearly fifty books^{[5][6]}—both novels and non-fiction works—as well as wide-ranging essays, narratives, and poems.

John F. Kennedy

From Wikipedia, the free encyclopedia

(Redirected from [John Fitzgerald Kennedy](#))

"*JFK*", "*John Kennedy*", and "*Jack Kennedy*" redirect here. For other uses, see *JFK (disambiguation)*, *John Kennedy (disambiguation)*.

John Fitzgerald Kennedy (May 29, 1917 – November 22, 1963), often referred to by initials **JFK** and **Jack**, was an American politician who served as the 35th [president of the United States](#) from January 1961 until his

Natural language processing

Natural language processing

Selected areas and tasks



Syntax

Lemmatization
Stemming

POS tagging
Text segmentation

Speech

Speech-to-text
(recognition)

Text-to-speech
(generation)

Semantics

Machine translation
Optical character recognition (OCR)

Natural language understanding (NLU)
Natural language generation (NLG)

Named entity recognition (NER)
Sentiment analysis

Topic modelling
Word sense disambiguation



For millions of years, mankind lived just like the animals.

Then something happened which unleashed the power of our imagination. **We learned to talk** and we learned to listen.

Stephen Hawking

Natural language processing


Publication overload



5 000+ life sciences and biomedical journals

813 598 citations in FY 2017

2 000+ articles daily



Only a fraction
of available
knowledge and
data is used

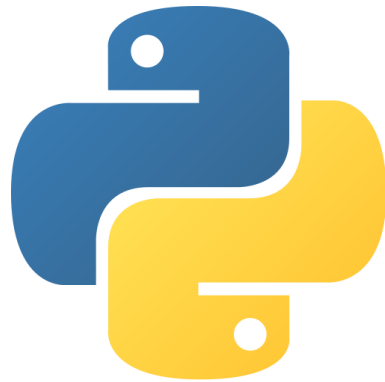
Sub-optimal results

- Research
- Drug development
- Patient treatment
- Software development

Source: [MEDLINE/PubMed Resources - Detailed Indexing Statistics: 1965-2017](#)

Natural language processing

Basic NLP operations [demo]



spaCy

My vision

My vision

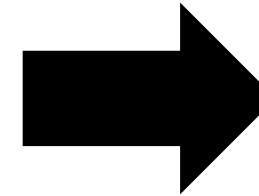
Tailored reading recommendations



High-level
requirements for
a novel project



1000's of articles and
research papers



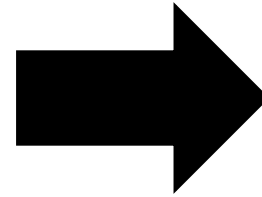
Recommended
materials

My vision

Text summarization (Pharma)



Audit protocols
Observation notes
FDA inspection forms



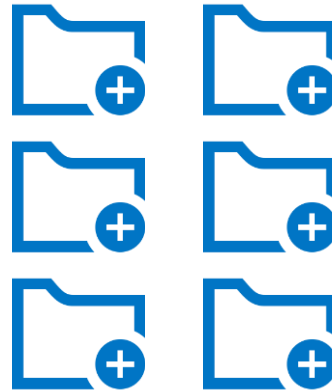
Executive summary slide for
the annual meeting

My vision

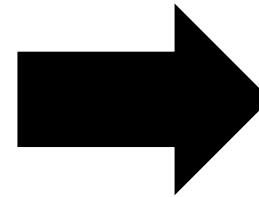
Decision support system for complaint handling (Diagnostics)



Complaint
handling manual



New complaint
cases



PRI	PSI
NORMAL	NORMAL
NORMAL	PRI

Suggested case
classification

PRI = Potentially Reportable Incident, **PSI** = Potential Safety Issue

Do androids read?

Reading comprehension

Definition

Reading comprehension is the ability to:

1. process text,
2. understand its meaning,
3. integrate with what the reader already knows.

Reading comprehension

Fundamental skills



Knowing **meaning of words**

Understanding meaning of words
from discourse context

Ability to identify the main thought
of a passage

Ability to **answer questions**
answered in a passage

Ability to recognize the **literary
devices** used in a passage and
determine its tone

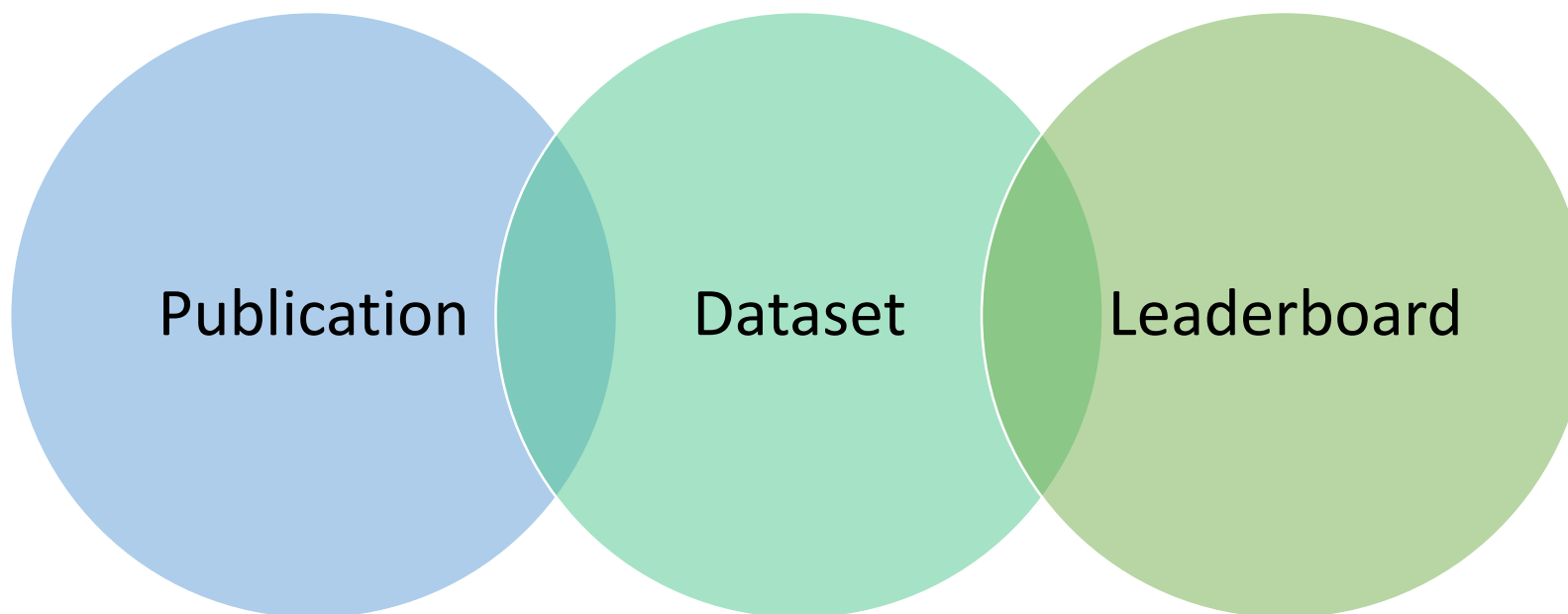
Information integration

- real-world knowledge
- common sense

Reading comprehension

Current research

1. Stanford Question Answering Dataset (SQuAD)
2. Reading Comprehension with Multiple Hops (QAngaroo)
3. NarrativeQA Reading Comprehension Challenge

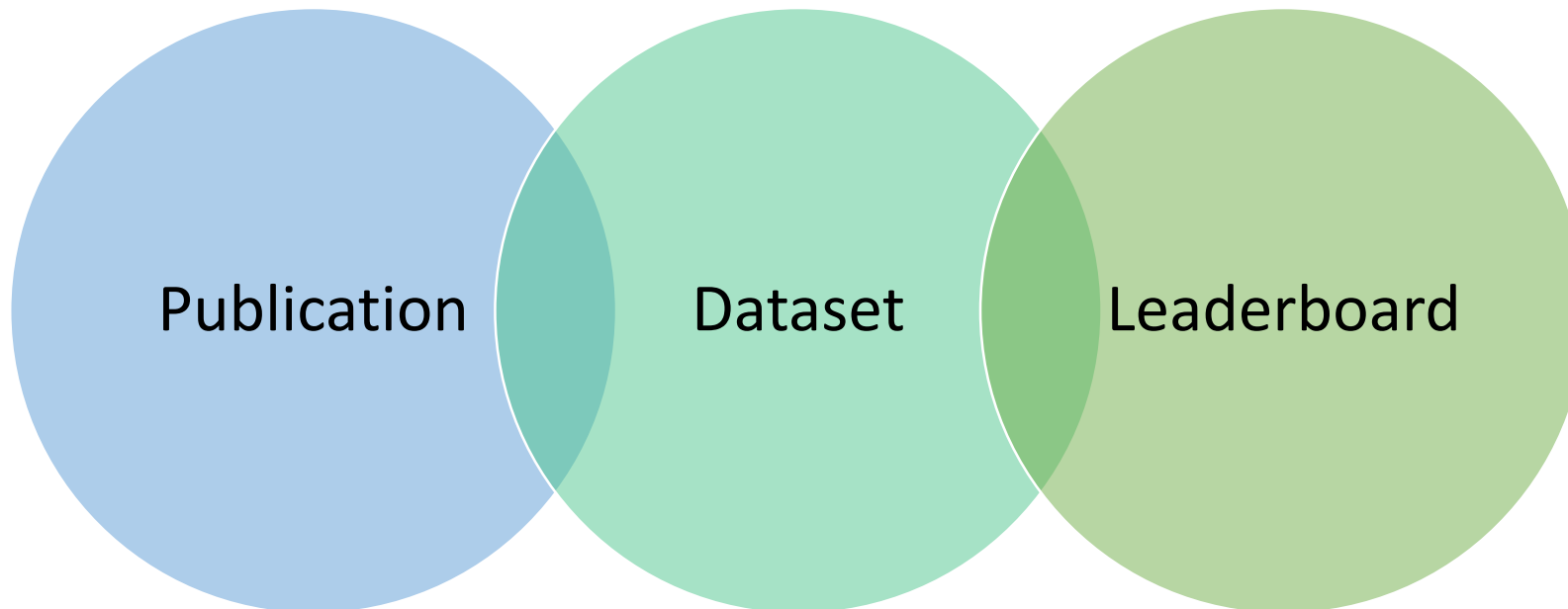


Reading comprehension

Current research



1. **Stanford Question Answering Dataset (SQuAD)**
2. Reading Comprehension with Multiple Hops (QAngaroo)
3. **NarrativeQA Reading Comprehension Challenge**



SQuAD dataset



SQuAD v1.1

- 100,000+ question-answer pairs
- extracted from 500+ Wikipedia articles

SQuAD v2.0

- v1.1 combined with 50,000+ new, unanswerable questions



Document: The heat required for boiling the water and supplying the steam can be derived from various sources, most commonly from burning combustible materials with an appropriate supply of air in a closed space (called variously combustion chamber, firebox). In some cases the heat source is a nuclear reactor, geothermal energy, solar energy or waste heat from an internal combustion engine or industrial process. In the case of model or toy steam engines, the heat source can be an electric heating element.

Question: What is the usual source of heat for boiling water in the steam engine?

Document: The heat required for boiling the water and supplying the steam can be derived from various sources, most commonly from **burning combustible materials** with an appropriate supply of air in a closed space (called variously combustion chamber, firebox). In some cases the heat source is a nuclear reactor, geothermal energy, solar energy or waste heat from an internal combustion engine or industrial process. In the case of model or toy steam engines, the heat source can be an electric heating element.

Question: What is the usual source of heat for boiling water in the steam engine?

Answer: burning combustible materials



	Correct answers (exact match)
Human performance	86.83 %
Best model (Sep 2019)	89.73 %

Results for SQuAD v2.0

SQuAD dataset

Limitations



- ❌ Limited lexical and topical diversity
- ❌ The documents are short (i.e. paragraphs of text)
- ❌ Each answer is a span of text from a single document (→ QAngaroo)
- ❌ Shallow pattern matching may suffice to produce correct answers (→ NarrativeQA)

NarrativeQA dataset



- 1,500+ documents
 - books (Project Gutenberg)
 - movie scripts (Internet Movie Script Database and other websites)
- 45,000+ question-answer pairs

Example

Full story snippet:

As he spins around one of the attackers jams all eight inches of his bayonet blade into Jacob's stomach. Jacob screams. It is a loud and piercing wail.

...

A doctor leans his head in front of the lamp and removes his mask. His expression is somber. He shakes his head. His words are simple and final.

DOCTOR: He's gone.

The doctor steps away. A nurse rudely pulls a green sheet over his head. The doctor turns to one of the aides and throws up his hands in defeat.

Question: What is the fatal injury that Jacob sustains which ultimately leads to his death?

Example

Full story snippet:

As he spins around one of the attackers **jams all eight inches of his bayonet blade into Jacob's stomach**. Jacob screams. It is a loud and piercing wail.

...

A doctor leans his head in front of the lamp and removes his mask. His expression is somber. He shakes his head. His words are simple and final.

DOCTOR: **He's gone.**

The doctor steps away. A nurse rudely pulls a green sheet over his head. The doctor turns to one of the aides and throws up his hands in defeat.

Question: What is the fatal injury that Jacob sustains which ultimately leads to his death?

Answer: a bayonet wound



	BLEU-1	BLEU-4	METEOR	ROUGE-L
Human performance	44.43	19.65	24.14	57.02
Best model (Dec 2017)	19.09	2.11	4.37	14.03

Results for models processing full stories



	BLEU-1	BLEU-4	METEOR	ROUGE-L
Human performance	44.43	19.65	24.14	57.02
Best model (Dec 2017)	19.09	2.11	4.37	14.03
Best model (Jan 2019)	48.70	20.98	21.95	54.74

Results for models processing full stories

NarrativeQA dataset

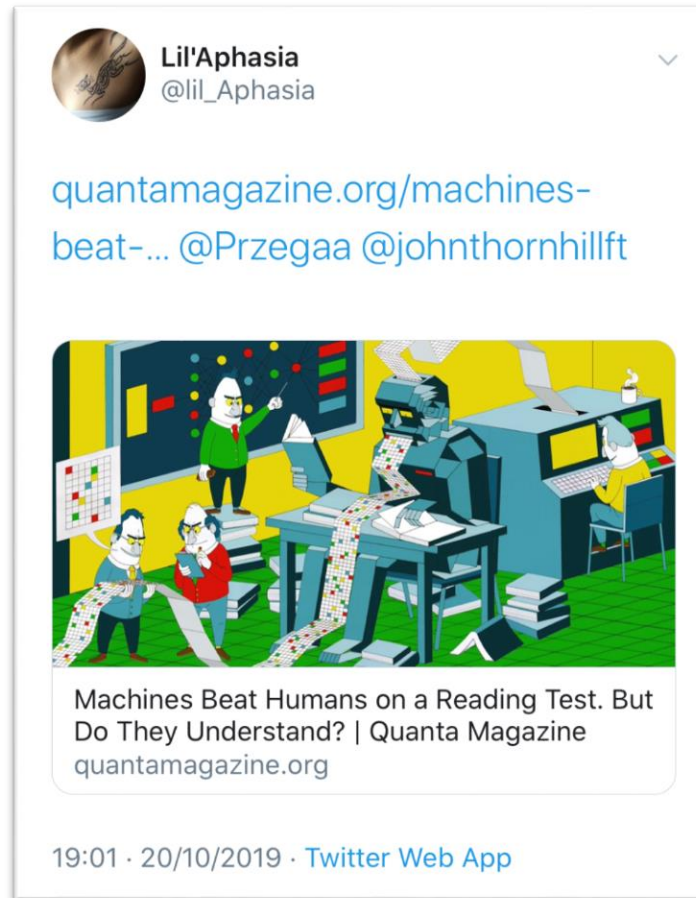
Summary

- ❌ No integration of external information
 - ❌ Every question can be answered using a single document
- ✅ Decreasing performance gap between humans and machines – impressive progress made in less than two years
- ❌ These models don't generalize well
 - ❌ Researches fine-tune their models to get to the top of the leaderboard

Summary

Reading comprehension

Erase and rewind?



- ❑ General Language Understanding Evaluation (**GLUE**)
- ❑ Still **no real understanding** of the language
- ❑ Models learn to **cheat** at standardized NLP tests
- ❑ Datasets must be checked for **bias** and **repetitive examples**
- ❑ New datasets with **adversarial examples** (SuperGLUE)

Source: [Machines Beat Humans on a Reading Test. But Do They Understand?](https://www.quantamagazine.org/machines-beat-humans-on-a-reading-test-but-do-they-understand-20191020/)

Reading comprehension

Do androids read about electric sheep?

~~No.~~

Not yet.



Slides, code, papers, datasets, leaderboards, etc.

<https://go.roche.com/reading>

Doing now what patients need next