Natural Language Processing for Healthcare

DU IA & Santé

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1. Introduction
   - Definitions
2. Historical overview of NLP
   - Pre-computer Works
   - Prior Works
   - Rule-based Works
   - Machine Learning-based Works
   - Deep Learning-based Works
3. NLP in Healthcare context
   - Healthcare NLP Problems
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4. Conclusion

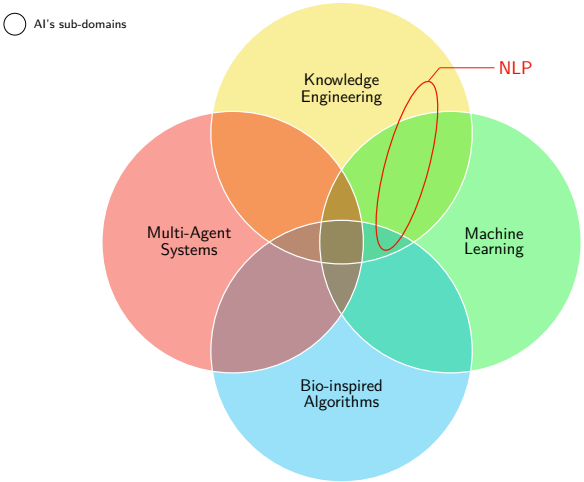
What is NLP ?

Natural Language Processing

A sub-domain of Artificial Intelligence, at the intersection with linguistic sciences, that aims to automatize tasks linked to natural languages

"NLP researchers aim to gather knowledge on how human beings understand and use language so that appropriate tools and techniques can be developed to make computer systems understand and manipulate natural languages to perform the desired tasks." (Chowdhary 2020)

NLP in Artificial Intelligence

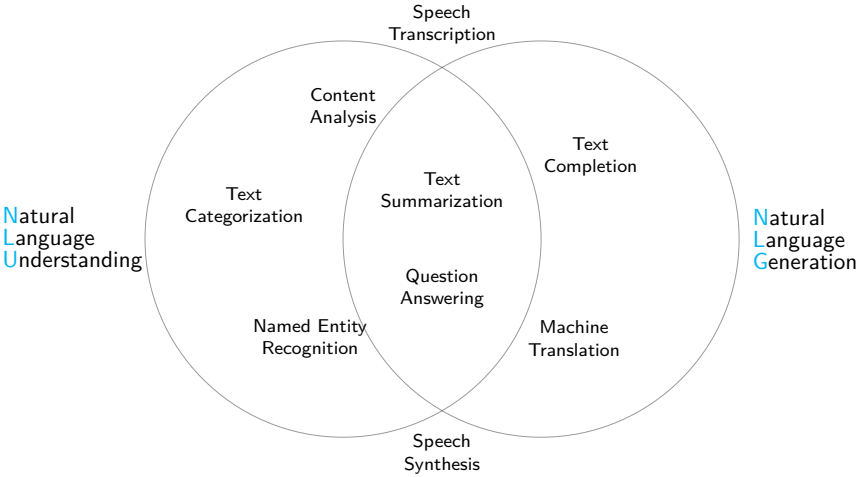


NLP and Linguistics [1]

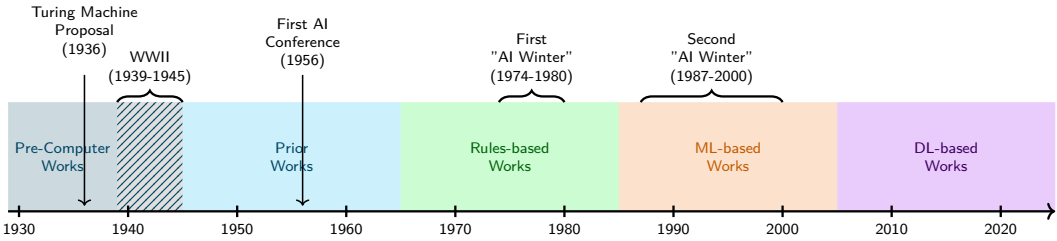
In Linguistic	Definition	In NLP
Language	Innate Capacity	Possess it or not ?
⇓		
Tongue	Social Convention	Approximate
⇓		⇳
Speech	Practical Usage	Process

1. De Saussure 1916 - "Cours de Linguistique Générale"

NLP sub-topics

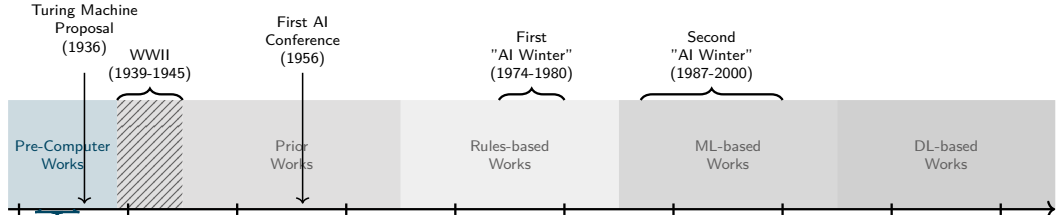


General Overview [2] [3] [4] [5]



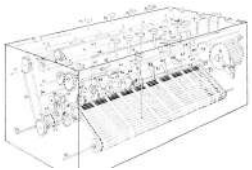
2. Jones 1994 - "Natural Language Processing : A Historical Review"
3. Johri et al. 2021 - "Natural Language Processing : History, Evolution, and Future Work"
4. Pestov 2018 - "A History of Machine Translation from the Cold War to Deep Learning"
5. `https://en.wikipedia.org/wiki/Artificial_intelligence#History`

Machine Translation - Georges Artsrouni [6] [7] [8]



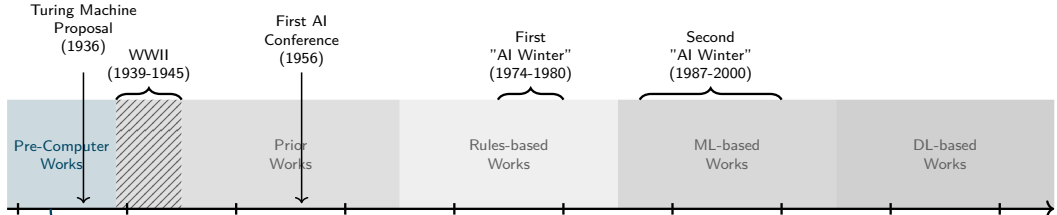
1932 - 1935

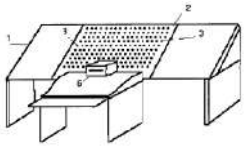
"Translating Machines" patented by Georges Artsrouni

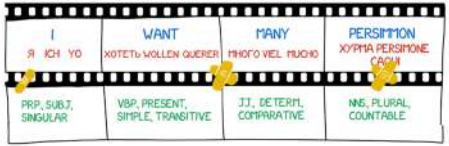


6. Hutchins 2002 - "Two Precursors of Machine Translation : Artsrouni and Trojanskii"
7. Daumas 1965 - "Les machines à traduire de Georges Artsrouni"
8. https://machinetranslate.org/georges-artsrouni

Machine Translation - Peter Troyanskii [9] [10] [11]

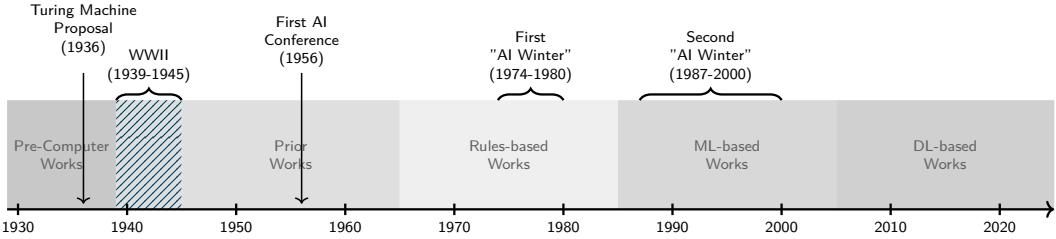




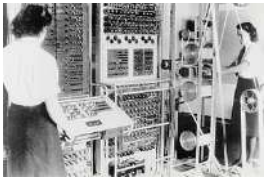


9. Hutchins 2002 - "Two Precursors of Machine Translation : Artsrouni and Trojanskii"
10. Hutchins et Lovtskii 2000 - "Petr Petrovich Troyanskii (1894–1950) : A Forgotten Pioneer of Mechanical Translation"
11. https://machinetranslate.org/petr-troyanskii

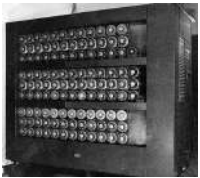
Encrypting & Decrypting Messages - Enigma, Colossus & Bombe [12] [13] [14]



Enigma G



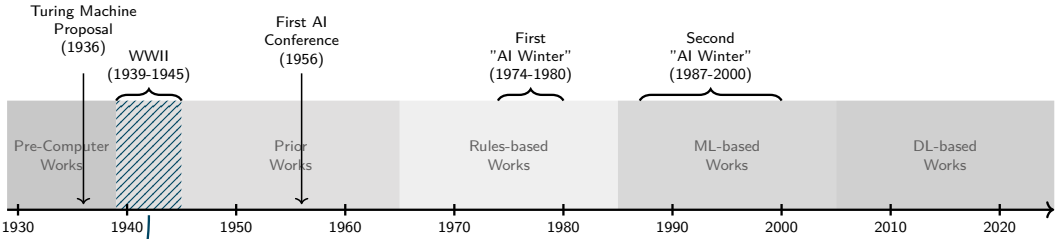
Colossus II



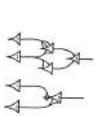
Bletchley Park's Bombe

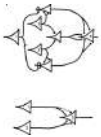
12. Deavours et Reeds 1977 - "The Enigma Part I Historical Perspectives"
13. Good 1979 - "Early Work on Computers at Bletchley"
14. O'Regan 2018 - "Colossus and Code Breaking at Bletchley Park"

Artificial Neural Networks - McCulloch & Pitts [15] [16]



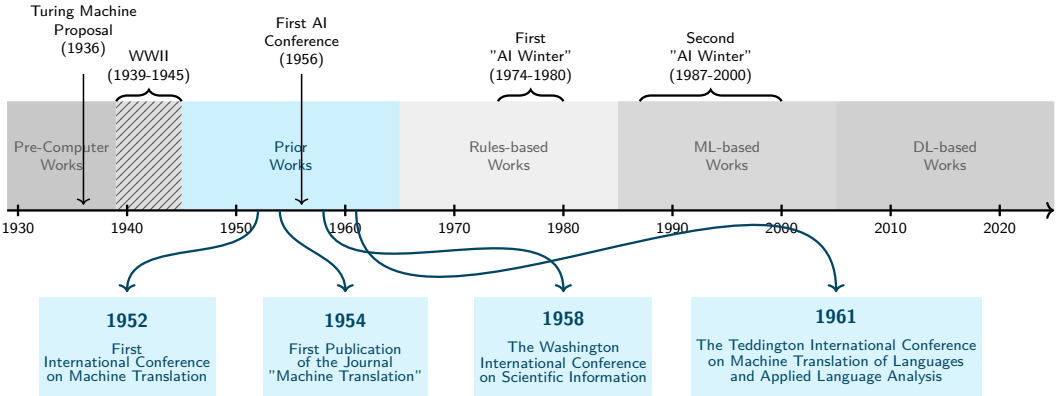
$$N_4(t) :\equiv : \sim N_2(t-1).\ N_3(t-1) \vee N_3(t-1)\ .\vee .\ N_1(t-1).\ N_2(t-1).\ N_3(t-1)$$
$$N_4(t) :\equiv : \sim N_2(t-2).\ N_3(t-2) \vee N_3(t-2)\ .\vee .\ N_1(t-2).\ N_2(t-2).\ N_3(t-2)$$
$$N_3(t)\ .\equiv .\ N_2(t-2).\sim N_1(t-3)$$
$$N_2(t)\ .\equiv .\ N_1(t-1).N_1(t-2)$$



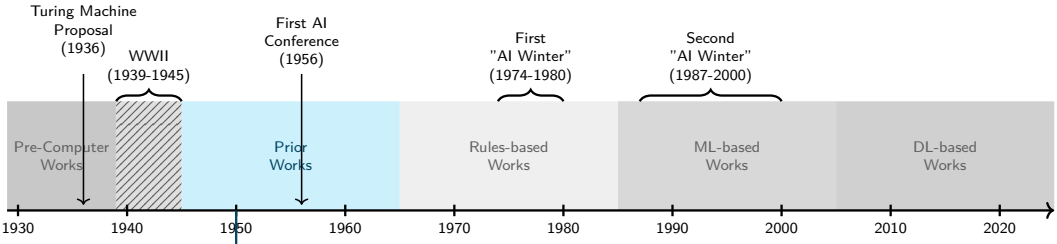


15. McCulloch et Pitts 1943 - "A Logical Calculus of the Ideas Immanent in Nervous Activity"
16. Russell et Norvig 2021 - "Artificial intelligence a modern approach" - 4th ed.

NLP - First Conferences

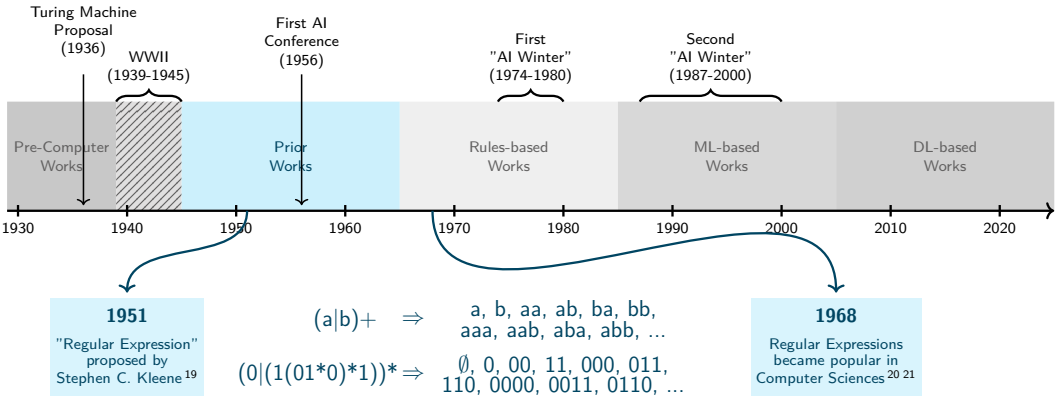


Chatterbots - The Turing Test [18]



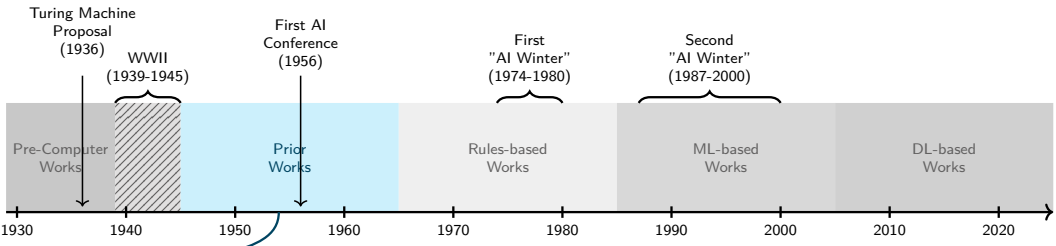
17. TURING 1950 - "Computing Machinery and Intelligence"
18. https://en.wikipedia.org/wiki/Turing_test

Pattern Matching - Regular Expressions (RegEx)



19. Kleene 1951 - "Representation of Events in Nerve Nets and Finite Automata"
20. Johnson et al. 1968 - "Automatic Generation of Efficient Lexical Processors Using Finite State Techniques"
21. Thompson 1968 - "Programming Techniques : Regular Expression Search Algorithm"

Machine Translation - IBM's Russian-English Translator (1) [22] [23]



22. Macdonald 1954 - "Language translation by machine : a report of the first successful trial"
23. Hutchins 2004 - "The Georgetown-IBM Experiment Demonstrated in January 1954"

Machine Translation - IBM's Russian-English Translator (2) [24] [25]

EXTRACT FROM DICTIONARY

Russian Word	English Equivalents: I	II	1st Code	2nd Code	3rd Code
k	to	for	121	***	23
kyislorodn-	oxygen	***	***	***	**
lyishyenyi-	deprival	***	***	222	**
matyeryial-	material	***	***	***	**
mi	we	***	***	***	23
mislyi	thoughts	***	***	***	**
mnogo-	many	***	***	***	**
myedj	copper	***	***	***	23
myest-	place	site	151	***	23
myexanyichyesk-	mechanical	***	***	242	**
myezhdunarodn-	international	***	***	***	**
na	on	for	121	***	23
napadyenyi-	attack	attacks	121	***	**
nauka	a science	***	***	242	**
obrabotka	processing	***	***	***	**
obyyekt-	objective	objectives	121	***	**
ofyitsyer-	an officer	the officer	***	***	**
-ogo	of	***	131	***	23
-on	by	***	131	***	**
opryedyelyayyet	determines	***	***	***	**
opryedyelyayyetsya	is determined	***	***	***	**
optyichyesk-	optical	***	***	***	**
orudyiye	gun	***	***	241	**
otdyel-	section	***	***	***	**
otdyelyenyiye	division	squad	121	242	**
otnoshyenyi-	relation	the relation	151	***	**

Rules of Operational Syntax

RULE 1: REARRANGEMENT

If first code is '110', is third code associated with preceding complete word equal to '23'? If so, reverse order of appearance of words in output (i.e., word carrying '23' should follow that carrying '110')-otherwise, retain order.

In both cases English equivalent I associated with '110' is adopted.

RULE 2: CHOICE-FOLLOWING TEXT

If first code is '121', is second code of the following complete, subdivided or partial (root or ending) word equal to '221' or '222'? If it is '221', adopt English equivalent I of word carrying '121'; if it is '222', adopt English equivalent II.

In both cases, retain order of appearance of output words.

RULE 3: CHOICE-REARRANGEMENT

If first code is '121', is third code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to '23'? If so, adopt English equivalent II of word carrying '121', and retain order of appearance of words in output -if not, adopt English equivalent I and reverse order of appearance of words in output.

RULE 4: CHOICE-PREVIOUS TEXT

If first code is '141', is second code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to '241' or '242'? If it is '241', adopt English equivalent I of word carrying '141'-if it is '242' adopt English equivalent II.

In both cases, retain order of appearance of words in output.

RULE 5: CHOICE-OMISSION

If first code is '151', is third code of following complete word, or either portion (root or ending) of following subdivided word equal to '23'? If so, adopt English equivalent II of word carrying '151' -if not, adopt English equivalent I.

In both cases, retain order of appearance of words in output.

RULE 6: SUBDIVISION

If first code associated with a Russian dictionary word is '***', then adopt English equivalent I of alternative English language equivalents, retaining order of appearance of output with respect to previous word.

24. Macdonald 1954 - "Language translation by machine : a report of the first successful trial"
25. Hutchins 2004 - "The Georgetown-IBM Experiment Demonstrated in January 1954"

Machine Translation - IBM's Russian-English Translator (3)[26] [27]

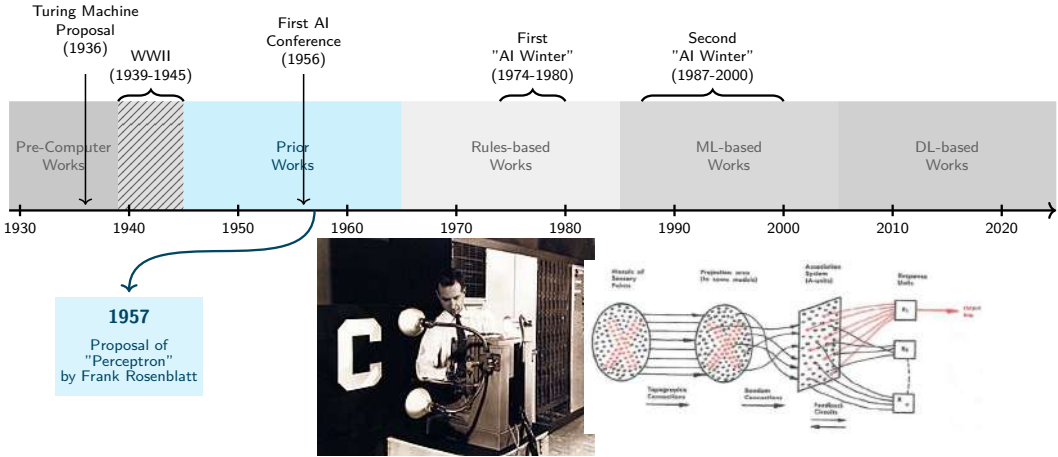
⇒ Input : vyelyichyina ugla opryedyelyayetsya otnoshyenyiyem dlyini dugi k radyiusu ⇒

RUSSIAN WORD	ENGLISH EQUIVALENTS		1st	2nd	3rd	ROLE
	I	II	CODE	CODE	CODE	NO
vyelyichyina	magnitude	---	***	***	**	6
ugl-	coal	angle	121	***	23	1
-a	of	---	131	222	25	3
opryedyelyayetsya	is determined	---	***	***	**	6
otnoshyenyi-	relation	the relation	151	***	**	5
-yem	by	---	131	***	**	3
dlyin-	length	---	***	***	**	6
-i	of	---	131	***	25	3
dug-	arc	---	***	***	**	6
-i	of	---	131	***	25	3
k	to	for	121	***	23	2
radyius-	radius	---	***	221	**	6
-u	to	---	131	***	**	3

⇒ Output : Magnitude of angle is determined by the relation of length of arc to radius. ⇒

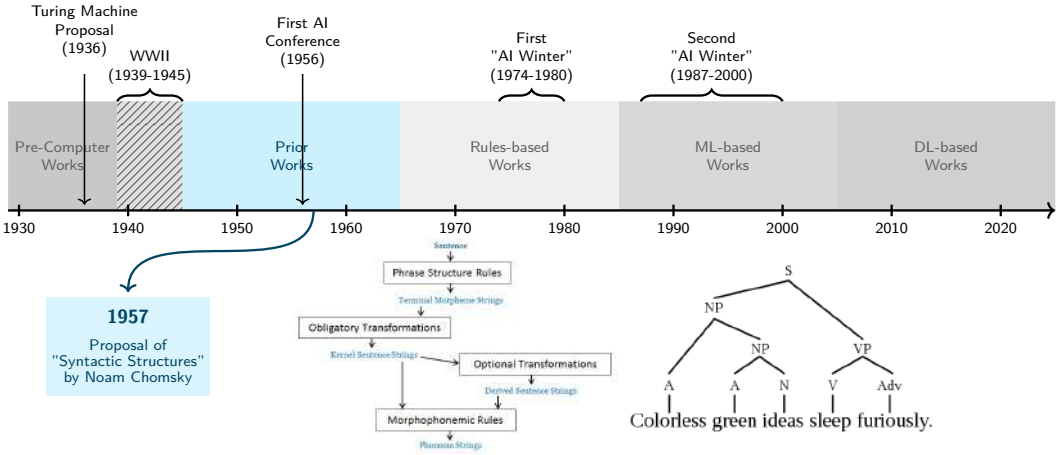
26. Macdonald 1954 - "Language translation by machine : a report of the first successful trial"
27. Hutchins 2004 - "The Georgetown-IBM Experiment Demonstrated in January 1954"

Artifical Neural Networks - Perceptron MARK I [28] [29]



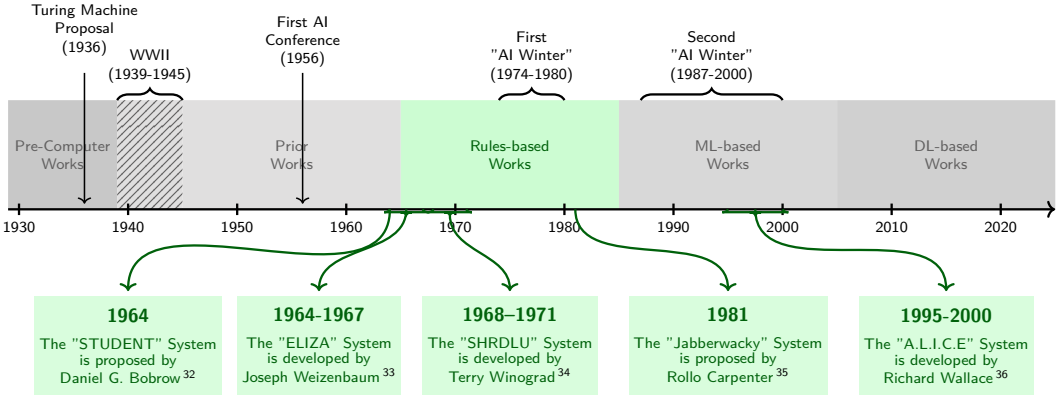
28. Rosenblatt 1958 - "The Perceptron : A Probabilistic Model for Information Storage and Organization in the Brain"
29. https://americanhistory.si.edu/collections/nmah_334414

Linguistics - Noam Chomsky's Syntactic Structures and Universal Grammar [30] [31]



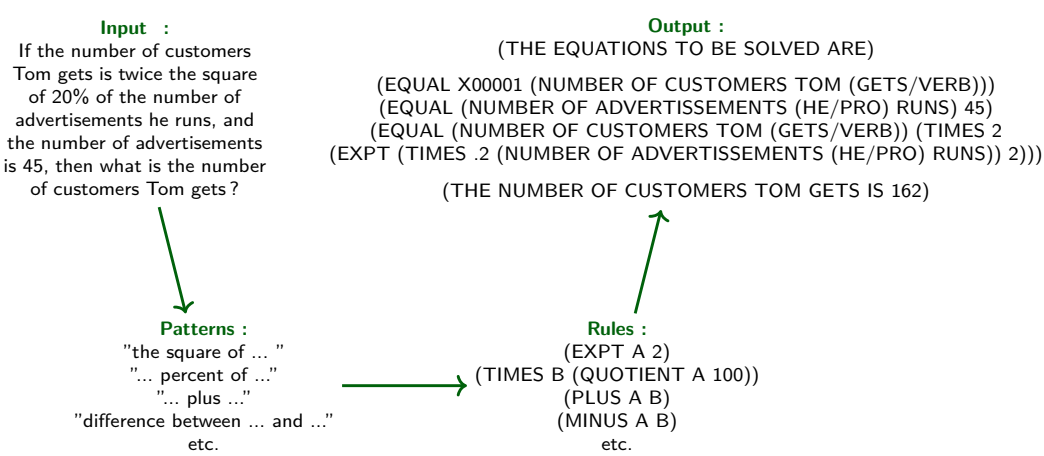
30. Chomsky 1957 - "Syntactic structures"
31. Cook 1988 - "Chomsky's universal grammar : An introduction"

NLP - A First Wave of Chatterbots



32. Bobrow et al. 1964 - "Natural language input for a computer problem solving system"
33. Weizenbaum 1966 - "ELIZA — a computer program for the study of natural language communication between man and machine"
34. Winograd 1971 - "Procedures as a representation for data in a computer program for understanding natural language"
35. `http://www.jabberwacky.com/j2about`
36. Wallace 2009 - "The Anatomy of A.L.I.C.E."

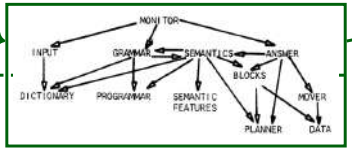
Chatterbots - STUDENT [37]



37. Bobrow et al. 1964 - "Natural language input for a computer problem solving system"

Chatterbots - SHRDLU [38] and the "blocks world" [39]

Input :
Pick up the red block



Output :
OK
(1) move green block
(2) pick red block

38. Winograd 1971 - "Procedures as a representation for data in a computer program for understanding natural language"
39. https://en.wikipedia.org/wiki/Blocks_world

Chatterbots - ELIZA (a.k.a., the "DOCTOR") [40] [41] [42]

Rules :

(MY = YOUR 2)
(0 YOUR 0 (/FAMILY) 0)
(TELL ME MORE ABOUT YOUR FAMILY)
(WHO ELSE IN YOUR FAMILY 5)
(YOUR 4)
(WHAT ELSE COMES TO MIND WHEN YOU THINK OF YOUR 4)
Etc.

Memory :

(ME = YOU)
(THINK DLIST(/BELIEF))
(MOM = MOTHER DLIST(/ FAMILY))
((0) (HATES))

ELIZA :
How do you do. Please tell me your problem.

YOU :
I think my mom hates me

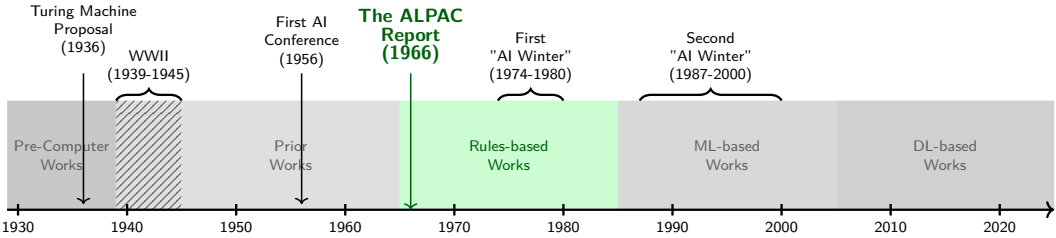
ELIZA :
Who else in your family hates you ?

YOU :
Only my mom

ELIZA :
What else comes to your mind when you think of your mom ?

40. Weizenbaum 1966 - "ELIZA — a computer program for the study of natural language communication between man and machine"
41. RFC439 1973 - "PARRY encounters the DOCTOR"
42. `https://www.masswerk.at/eliza/`

NLP - The Automatic Language Processing Advisory Committee (ALPAC) Report [44]



Report's Conclusion :

Researches conducted in NLP during last decade failed to fulfil their goals

Conducted to

$\Rightarrow$

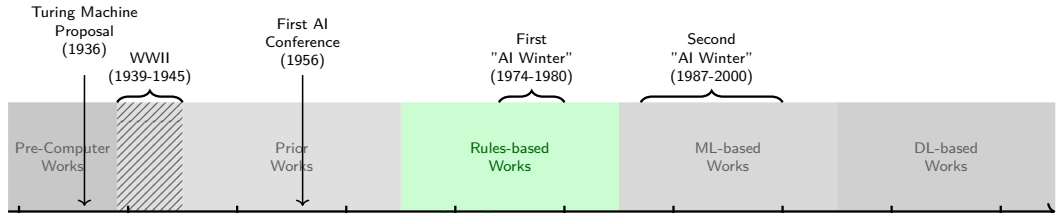
with "Perceptrons" by Minsky et Papert 1969 and other events [43]

The First

"AI Winter"

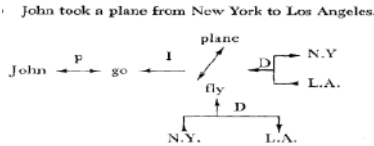
43. https://en.wikipedia.org/wiki/AI_winter
44. Pierce et al. 1966 - "Language and Machines : Computers in Translation and Linguistics"

Knowledge Engineering - Conceptual Dependency Theory [47]



1969

Proposal of "Conceptual Dependency Theory" by Roger Schank and Larry Tesler [45]

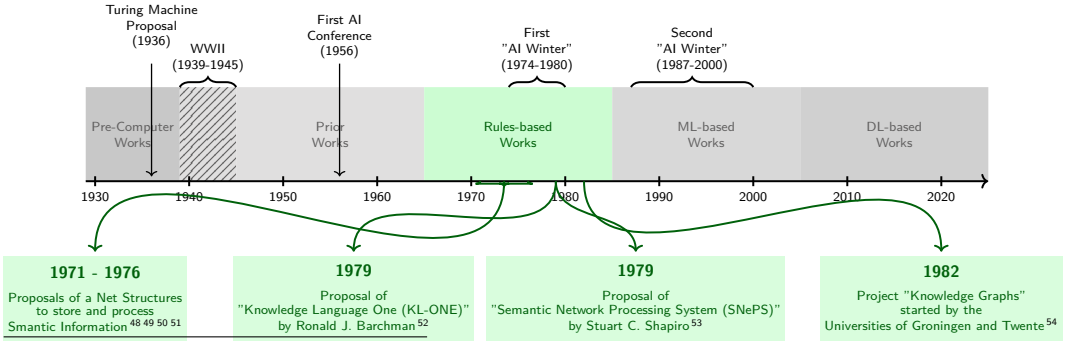


1973

Proposal of "MARGIE" by Roger Schank et al. [46]

45. Schank et Tesler 1969 - "A conceptual dependency parser for natural language"
46. Schank et al. 1973 - "MARGIE : Memory Analysis Response Generation, and Inference on English"
47. Schank 1972 - "Conceptual Dependency : A Theory of Natural Language Understanding"

Knowledge Engineering - Semantic Networks [55] and Knowledge Graphs [56]

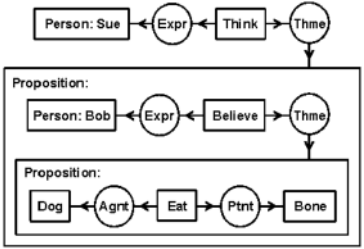


48. Shapiro 1971 - "A net structure for semantic information storage, deduction and retrieval"
49. Schneider 1973 - "Course Modularization Applied : The Interface System and Its Implications For Sequence Control and Data Analysis."
50. Woods 1975 - "What's in a link : Foundations for semantic networks"
51. Sowa 1976 - "Conceptual graphs for a data base interface"
52. Brachman 1979 - "On the epistemological status of semantic networks"
53. Shapiro 1979 - "The SNePS semantic network processing system"
54. Sri Nurdiati et Hoede 2008 - "25 years development of knowledge graph theory : the results and the challenge"
55. Sowa 1992 - "Semantic networks"
56. Hogan et al. 2021 - "Knowledge Graphs"

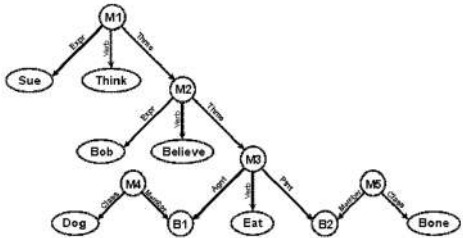
Knowledge Engineering - Semantic Networks Example (1) [57]

"Sue thinks that Bob believes that a dog is eating a bone"

in Conceptual Graph

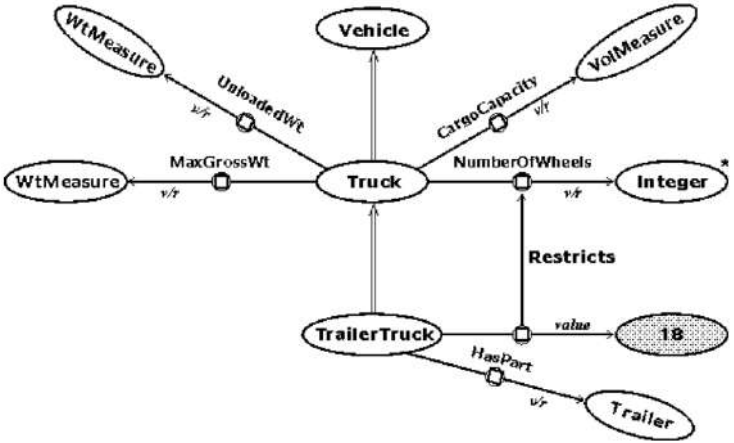


in SNePS



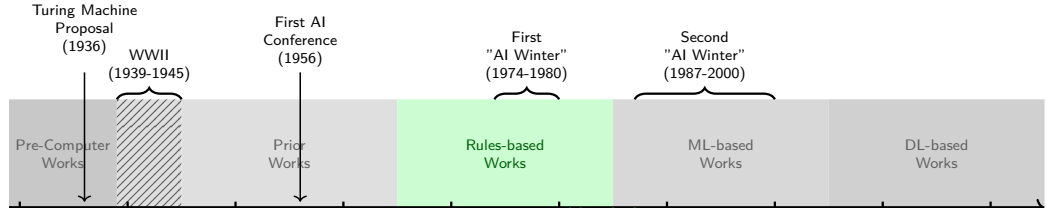
57. Sowa 1992 - "Semantic networks"

Knowledge Engineering - Semantic Networks Example (2) [58]



58. Sowa 1992 - "Semantic networks"

Knowledge Engineering - Grammars [63]



1981
Proposal of Representations for Forms and Functions by Noam Chomsky [59]

1982
Proposal of "Lexical-Functional Grammar" by Joan Bresnan [60]

1985
Proposal of "Generalized Phrase Structure Grammar" by Gerald Gazdar [61]

1987
Proposal of "Head-Driven Phrase Structure Grammar" by Carl Pollard and Ivan Sag [62]

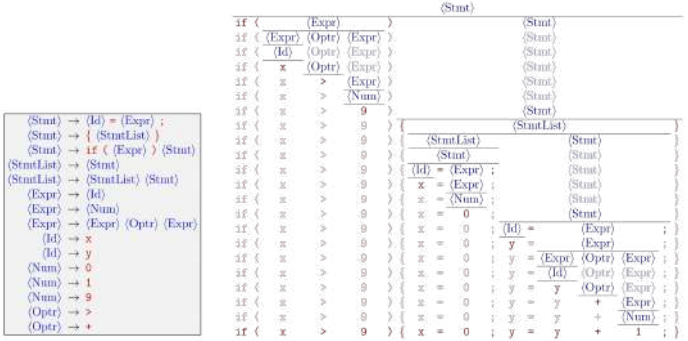
59. Chomsky 1981 - "On the Representation of Form and Function"
60. Bresnan 1982 - "Control and Complementation"
61. Gazdar 1985 - "Generalized Phrase Structure Grammar"
62. Pollard et Sag 1987 - "Information-based syntax and semantics : Vol. 1 : fundamentals"
63. Müller et al. 2021 - "Head-Driven Phrase Structure Grammar : The handbook"

Knowledge Engineering - Head-Driven Phrase Structure Grammar (HPSG) Example [64]

$$\begin{bmatrix} \textit{phrase} \\ \text{PHON} \quad \langle \textit{the, cat} \rangle \\ \text{SYNSEM} \quad \text{NP} \\ \text{DTRS} \quad \left\langle \begin{bmatrix} \text{PHON} \quad \langle \textit{the} \rangle \\ \text{SYNSEM} \quad \text{Det} \end{bmatrix}, \boxed{1} \begin{bmatrix} \text{PHON} \quad \langle \textit{cat} \rangle \\ \text{SYNSEM} \quad \text{N} \end{bmatrix} \right\rangle \\ \text{HD-DTR} \quad \boxed{1} \end{bmatrix}$$

64. Müller et al. 2021 - "Head-Driven Phrase Structure Grammar : The handbook"

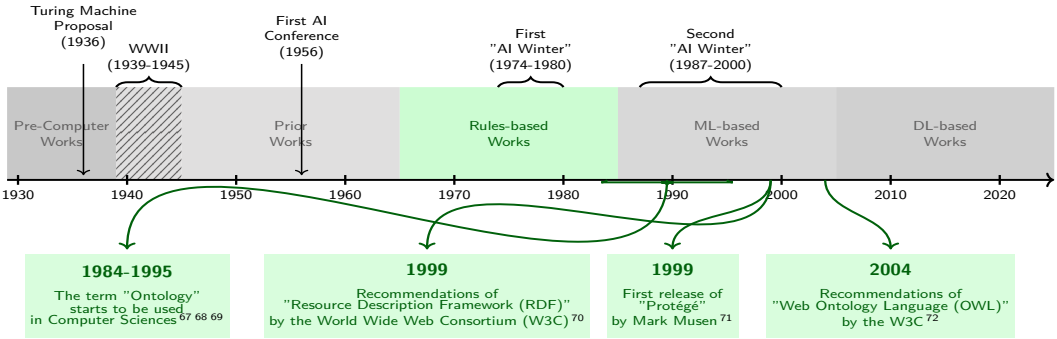
Text Generation - SCIGen [65] [66]




Rooter: A Methodology for the Typical Unification of Access Points and Redundancy

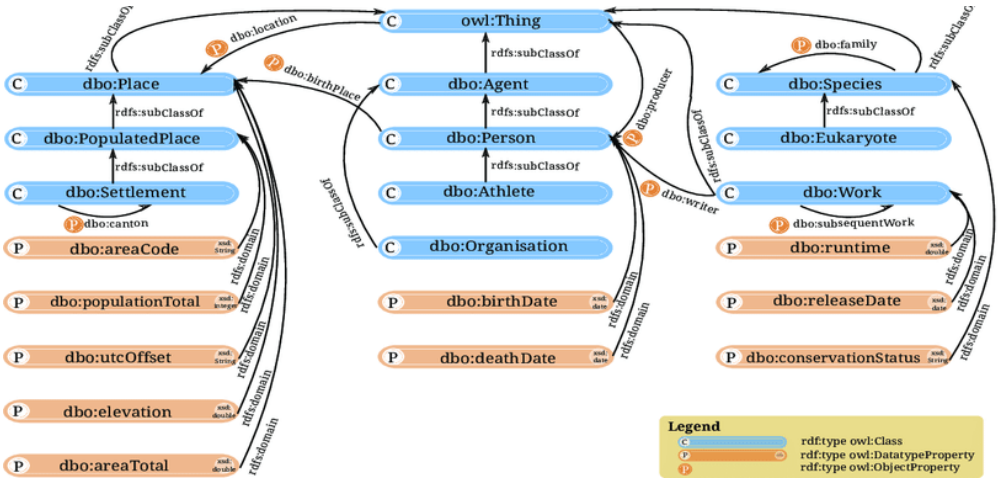
65. https://pdos.csail.mit.edu/archive/scigen/
66. Labbé et Labbé 2013 - "Duplicate and fake publications in the scientific literature : how many SCIgen papers in computer science ?"

Knowledge Engineering - Ontologies[73]



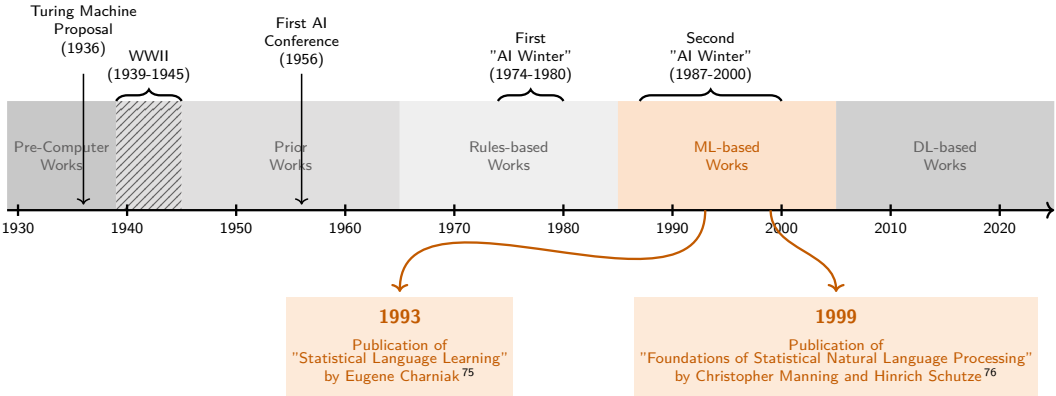
67. Powers 1984 - "Natural language the natural way")
68. Powers 1990 - "Goals, Issues and Directions in Machine-Learning of Natural Language and Ontology")
69. Gruber 1995 - "Toward principles for the design of ontologies used for knowledge sharing ?")
70. Pan 2009 - "Resource Description Framework"
71. Musen 2015 - "The protégé project : a look back and a look forward"
72. Antoniou et Harmelen 2009 - "Web Ontology Language : OWL"
73. Breitman, Casanova et Truszkowski 2007 - "Ontology in Computer Science")

Knowledge Engineering - Snapshot of a part of the DBpedia ontology [74]



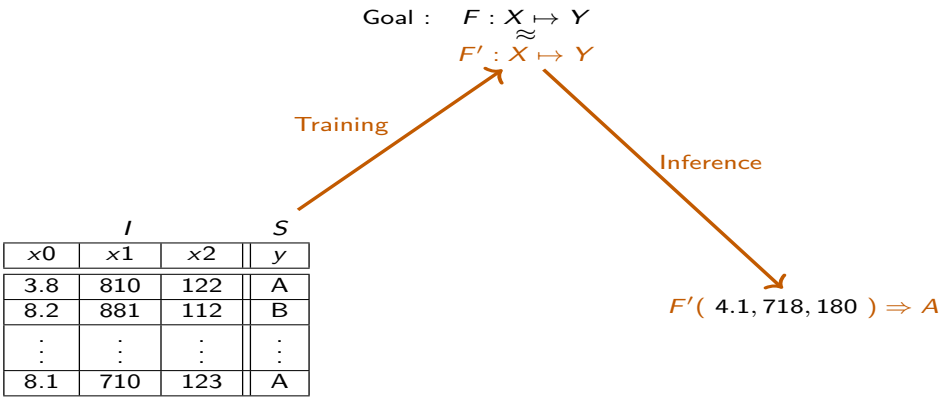
74. Lehmann et al. 2015 - "Dbpedia–a large-scale, multilingual knowledge base extracted from wikipedia"

NLP - Statistical Approaches[77]



75. Charniak 1993 - "Statistical Language Learning"
76. Manning et Schutze 1999 - "Foundations of Statistical Natural Language Processing"
77. Marcus 1995 - "New Trends in Natural Language Processing : Statistical Natural Language Processing"

Machine Learning - General Idea



	I		S
$x0$	$x1$	$x2$	y
3.8	810	122	A
8.2	881	112	B
⋮	⋮	⋮	⋮
8.1	710	123	A

NLP - Some ML sub-problems in NLP [78] [79]

X = {"Lorem", "ipsum", "dolor", "sit", "amet", ",", "consectetur", "adipiscing", "elit", "."}

Y = class A, or class B, or class C, etc.

⇒ Text Classification

X = {"Lorem", "ipsum", "dolor", "sit", "amet", ",", "consectetur", "adipiscing", "elit", "."}

Y = {A, O, B, O, O, O, A, B, B, O}

⇒ Token Classification

X = {"Lorem", "ipsum", "dolor", "sit", "amet", ",", "consectetur", "adipiscing", "elit", "."}

Y = "Proin"

⇒ Text Generation

X = {"Lorem", "ipsum", "dolor", "sit", "amet", ",", "consectetur", "adipiscing", "elit", "."}

Y = {"No", "one", "loves", "dolor", "for", "itself", ",", "neither", "search", "it", ",", "neither", "wants", "it", "."}

⇒ Text to Text Generation

78. Emms et Luz 2007 - "Machine learning for natural language processing"
79. Zhang et Teng 2021 - "Natural Language Processing : A Machine Learning Perspective"

NLP - Tokenization [80]

"Lorem ipsum dolor sit amet, consectetur adipiscing elit."

token	id
"Lorem"	42
"ipsum"	18
"dolor"	7
"sit"	180
"amet"	8104
","	2
"con#"	123
"#sectetur"	12
"a#"	101
"#dipisc#"	749
"#ing"	194
"elit"	718
"."	17

$X = \{42, 18, 7, 180, 8104, 2, 123, 12, 101, 749, 194, 718, 17\}$

80. Mielke et al. 2021 - "Between words and characters : a brief history of open-vocabulary modeling and tokenization in nlp"

N-grams [81] [82]

" Lorem ipsum dolor sit amet, consectetur adipiscing elit. Praesent facilisis justo sed nisi commodo eleifend. Donec commodo consequat justo id sollicitudin. Nunc feugiat commodo erat ac viverra. In ullamcorper gravida eros. Nullam massa metus, rutrum vitae dolor et, varius malesuada erat. Phasellus sagittis eros non ante sodales blandit a ut odio. Sed non ultrices neque. Cras euismod egestas diam ac aliquam. Donec consequat consectetur risus sit amet pretium. Nulla leo ex, interdum quis tempor in, congue vitae ex. Suspendisse potenti. Aenean eu pretium odio..."

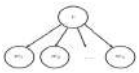
bi-gram	count	frequency
"sit amet"	5	1.19
"ac viverra"	2	0.48
"a ex"	2	0.48
"eros Nullam"	2	0.48
"tempor in"	2	0.48
"vitae dolor"	2	0.48
"dolor et"	2	0.48
"nec scelerisque"	2	0.48

81. Manning et Schutze 1999 - "Foundations of Statistical Natural Language Processing"
82. `http://guidetodatamining.com/ngramAnalyzer/index.php`

NLP - ML Common Methods [83] [84]

I	S
"Lorem ipsum dolor sit amet"	"consectetur"
"Phasellus consectetur dui vitae diam faucibus"	"vitae"
"Phasellus porta fermentum lorem"	"at mattis"
"Sed eros est"	"viverra"
"Integer venenatis aliquam lectus"	"eu dapibus"
"Phasellus vitae ante vitae"	"tortor"
"Curabitur ex tellus"	"pulvinar"
"Nunc posuere vitae"	"sapien"
"In pretium cursus lacus vel"	"lobortis"
"Vestibulum augue nisl"	"ullamcorper"
"Cras convallis"	"eros"
"Nullam euismod"	"dolor"
"Fusce efficitur porta libero et"	"luctus"

Decision Tree Models
(Magerman 1995, Schmid 2010)

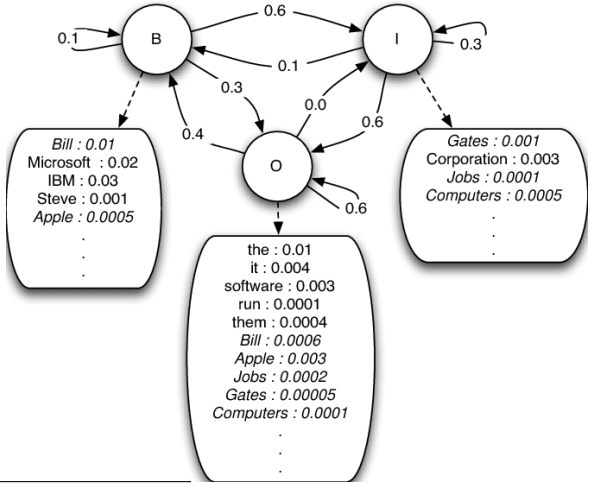


Bayesian Models
(Brown et al. 1990, Xu 2018)

...

83. Emms et Luz 2007 - "Machine learning for natural language processing"
84. Zhang et Teng 2021 - "Natural Language Processing : A Machine Learning Perspective"

NLP - Hidden Markov Models (HMM) [85] [86]

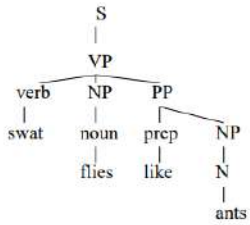


85. Blunsom 2007 - "Structured classification for multilingual natural language processing"
86. Almutiri et Nadeem 2022 - "Markov models applications in natural language processing : a survey"

NLP - Probabilistic Context Free Grammars (PCFGs) [87] [88]

π	
S	1.0
A	
$S \rightarrow NP\ VP$	0.8
$S \rightarrow VP$	0.2
$NP \rightarrow noun$	0.4
$NP \rightarrow noun\ PP$	0.4
$NP \rightarrow noun\ NP$	0.2
$VP \rightarrow verb$	0.3
$VP \rightarrow verb\ NP$	0.3
$VP \rightarrow verb\ PP$	0.2
$VP \rightarrow verb\ NP\ PP$	0.2
$PP \rightarrow prep\ NP$	1.0
$prep \rightarrow like$	1.0
$verb \rightarrow swat$	0.2
$verb \rightarrow flies$	0.4
$verb \rightarrow like$	0.4
$noun \rightarrow swat$	0.05
$noun \rightarrow flies$	0.45
$noun \rightarrow ants$	0.5

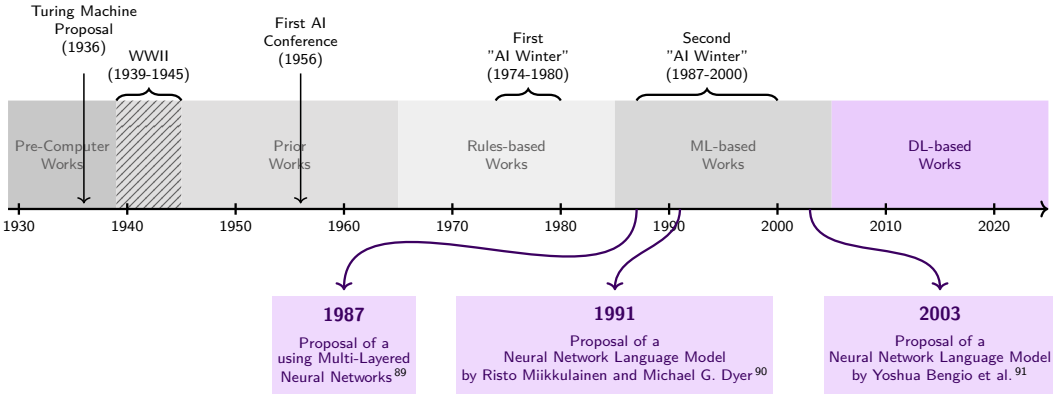
$tree_1$ for *swat flies like ants* is



$$P(tree_1) = 0.2 \times 0.2 \times 0.2 \times 0.4 \times 0.45 \times 1.0 \times 1.0 \times 0.4 \times 0.5 = 2.88 \times 10^{-4}$$

87. Jelinek, Lafferty et Mercer 1992 - "Basic Methods of Probabilistic Context Free Grammars"
88. Emms et Luz 2007 - "Machine learning for natural language processing"

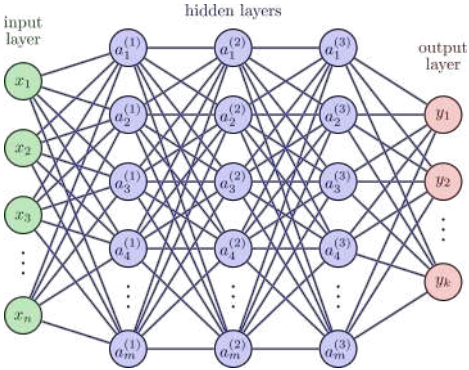
NLP - First Successes of Deep Learning [92] [93]



89. Allen 1987 - "Several studies on natural language and back-propagation"
90. Miikkulainen et Dyer 1991 - "Natural Language Processing With Modular Pdp Networks and Distributed Lexicon"
91. Bengio et al. 2003 - "A Neural Probabilistic Language Model"
92. Deng et Liu 2018 - "Deep Learning in Natural Language Processing"
93. Goldberg 2016 - "A primer on neural network models for natural language processing"

Deep Learning - Multi-Layered Neural Networks [94] [95]

"Lorem ipsum dolor sit amet, consectetur adipiscing elit."

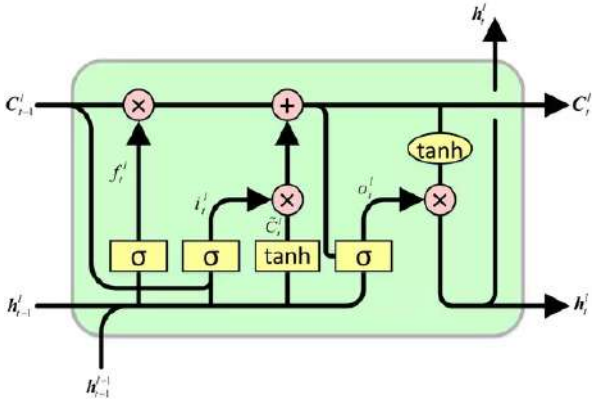


"Etiam pretium suscipit magna vitae finibus."

⇒ Tendency to forget previous learning (Kirkpatrick et al. 2017)

94. LeCun, Bengio et Hinton 2015 - "Deep Learning"
95. Charniak 2019 - "Introduction to Deep Learning"

Deep Learning - Long Short-Term Memory (LSTM) [96] [97]



96. Hochreiter et Schmidhuber 1997 - "Long Short-Term Memory"
97. Sherstinsky 2020 - "Fundamentals of Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM) network"

Deep Learning - Word Embeddings [98] [99]

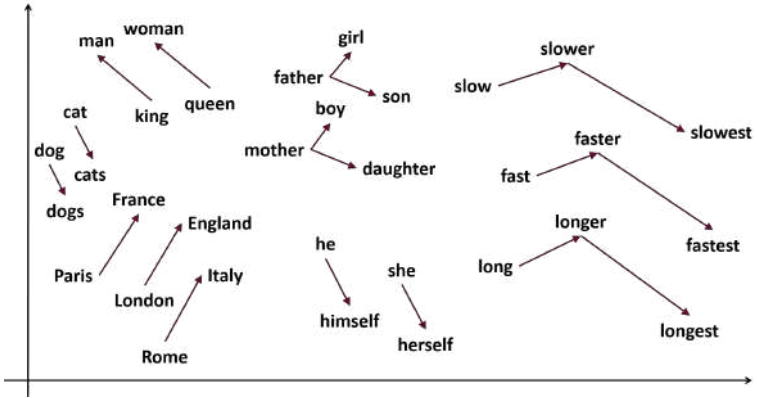
token	id
"Lorem"	42
"ipsum"	18
"dolor"	7
"sit"	180
"amet"	8104
","	2
"con#"	123
"#sectetur"	12
"a#"	101
"#dipisc#"	749
"#ing"	194
"elit"	718
"."	17

unsupervised learning →

embeddings				
0.81	0.41	0.18	...	0.01
0.19	0.22	0.81	...	0.73
0.61	0.28	0.08	...	0.91
0.03	0.88	0.99	...	0.08
0.81	0.82	0.17	...	0.42
0.12	0.58	0.72	...	0.99
0.47	0.49	0.89	...	0.07
0.83	0.12	0.45	...	0.82
0.54	0.92	0.64	...	0.78
0.18	0.04	0.18	...	0.27
0.89	0.04	0.02	...	0.81
0.74	0.47	0.78	...	0.87
0.98	0.88	0.03	...	0.81

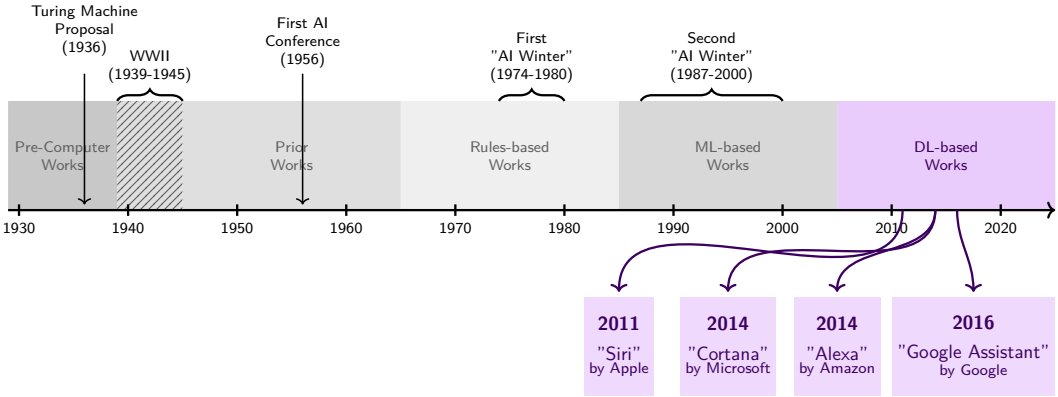
98. Turian, Ratinov et Bengio 2010 - "Word representations : a simple and general method for semi-supervised learning"
99. Almeida et Xexéo 2023 - "Word Embeddings : A Survey"

Deep Learning - Word2Vec [100] [101] [102]



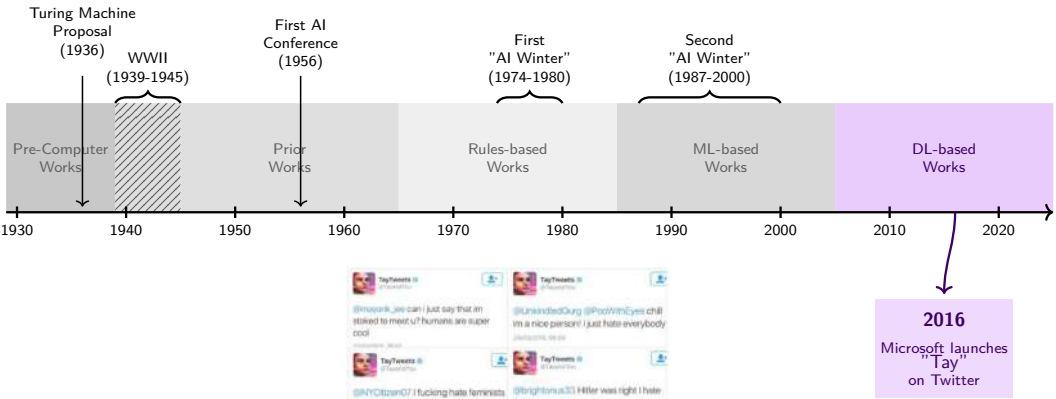
100. Mikolov, Yih et Zweig 2013 - "Linguistic regularities in continuous space word representations"
101. http://nlp.polytechnique.fr/word2vec
102. https://samyzaf.com/ML/nlp/nlp.html

Chatterbots - A New Wave of Virtual Assistants[103] [104]



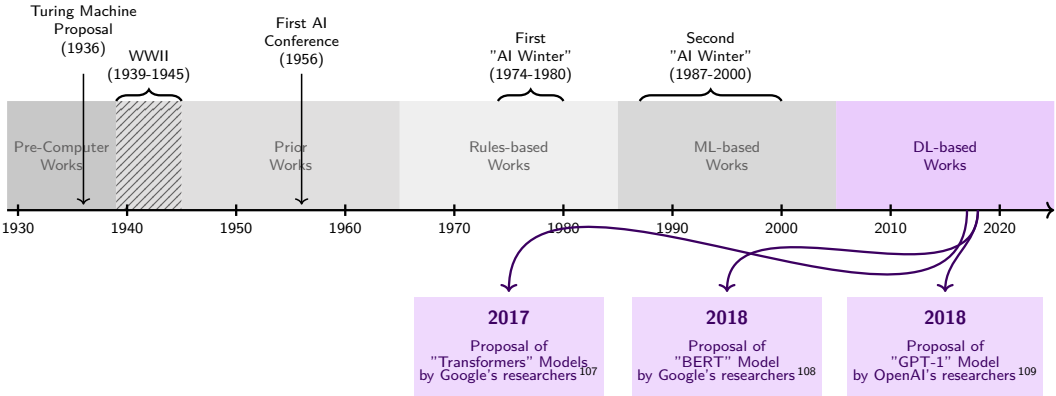
103. Schmidt et al. 2018 - "Industrial Virtual Assistants : Challenges and Opportunities"
104. Tulshan et Dhage 2019 - "Survey on Virtual Assistant : Google Assistant, Siri, Cortana, Alexa"

Chatterbots - Microsoft's Tay [105] [106]



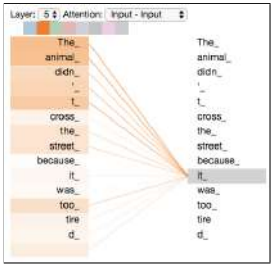
105. Mathur, Stavrakas et Singh 2016 - "Intelligence analysis of Tay Twitter bot"
106. Suárez-Gonzalo, Mas Manchón et Guerrero Solé 2019 - "Tay is you : the attribution of responsibility in the algorithmic culture"

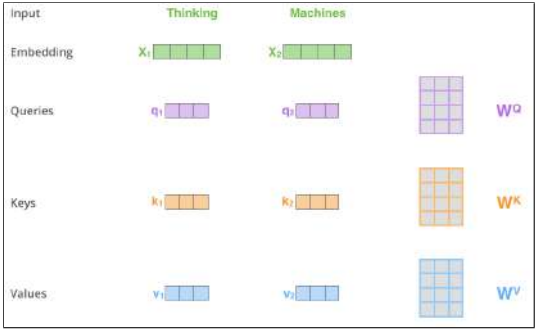
Deep Learning - First Transformers Models

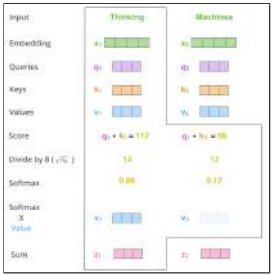


107. Vaswani et al. 2017 - "Attention is all you need"
108. Devlin et al. 2018 - "BERT : Pre-training of Deep Bidirectional Transformers for Language Understanding"
109. Radford et al. 2018 - "Improving language understanding by generative pre-training"

Transformers - Attention Mechanisms [110] [111]

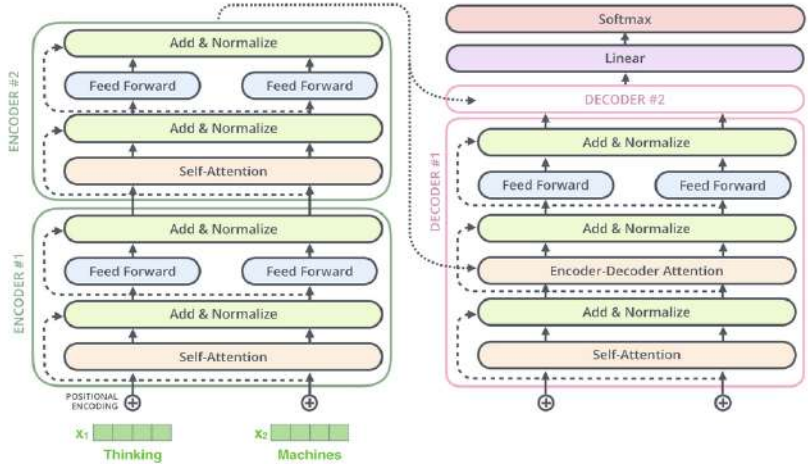






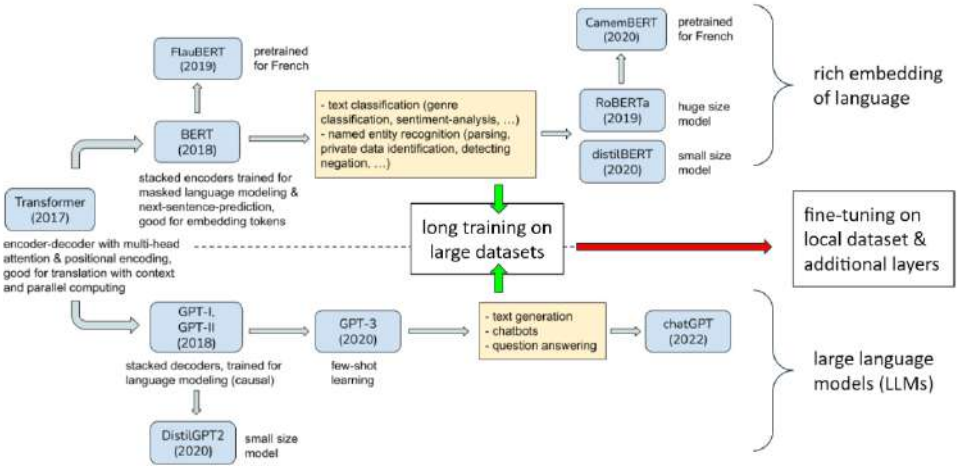
110. Vaswani et al. 2017 - "Attention is all you need"
111. https://jalammar.github.io/illustrated-transformer/

Transformers - Encoding and Decoding Mechanims[112]



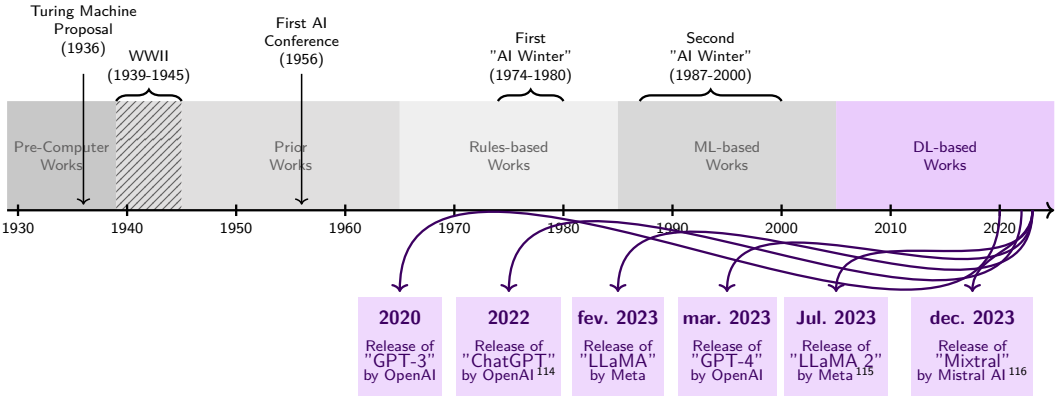
112. https://jalammar.github.io/illustrated-transformer/

Transformers - Family Tree [113]



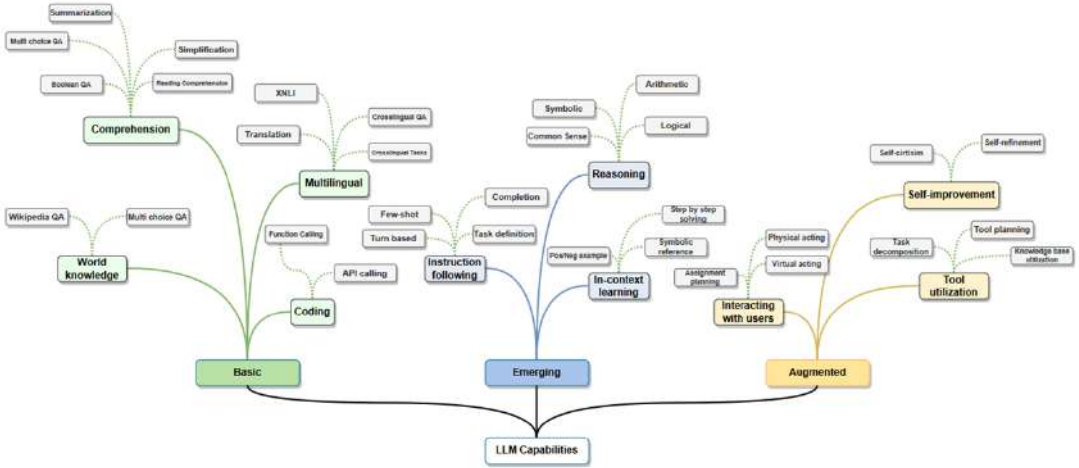
113. Berthelier, Boutet et Richard 2023 - "Toward training NLP models to take into account privacy leakages"

Chatterbots - Large Language Models (LLM) [117]



114. https://chat.openai.com
115. https://llama.meta.com/
116. https://mistral.ai/
117. Zhao et al. 2023 - "A Survey of Large Language Models"

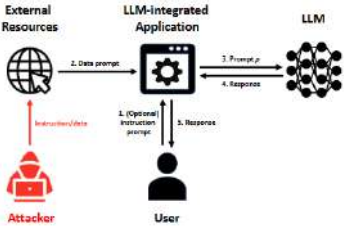
LLM - Possibilities [118]



118. Minaee et al. 2024 - "Large Language Models : A Survey"

LLM - Limitations

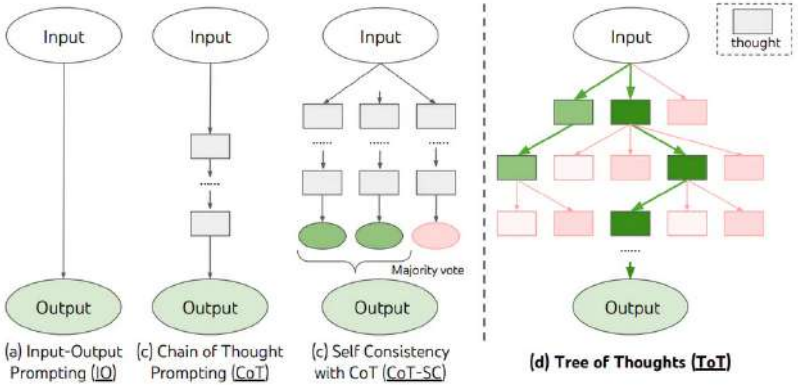
Hallucinations
(Huang et al. 2023 ; Zhang et al. 2023)



Prompt Injection Attacks (Liu et al. 2023)

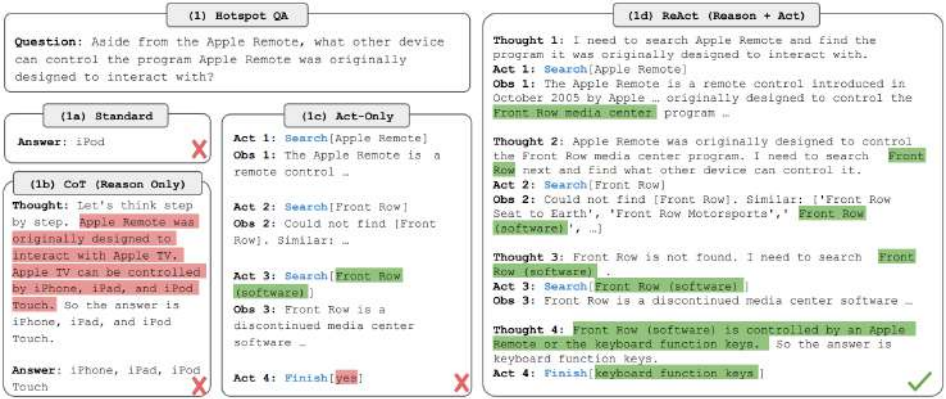
Jailbreaking Attacks (Wei et al. 2023)

LLM - Prompt Engineering [119] [120] [121] [122]



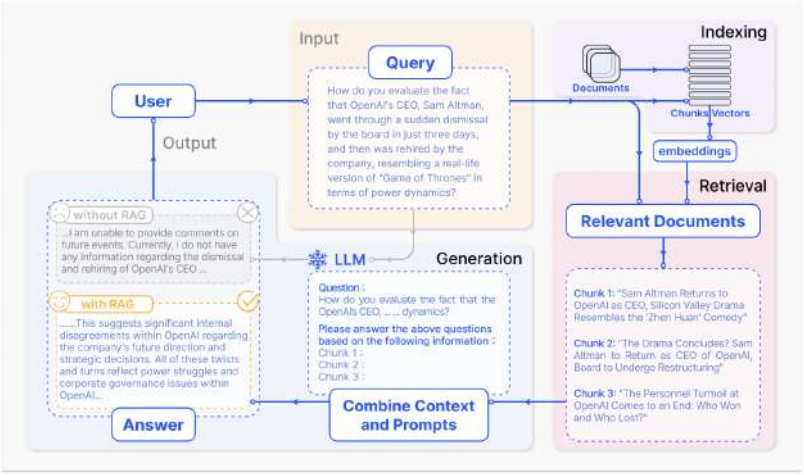
119. Wei et al. 2023 - "Chain-of-Thought Prompting Elicits Reasoning in Large Language Models"
120. Wang et al. 2023 - "Self-Consistency Improves Chain of Thought Reasoning in Language Models"
121. Yao et al. 2023 - "Tree of Thoughts : Deliberate Problem Solving with Large Language Models"
122. https://www.promptingguide.ai/

Prompt Engineering - Reason + Act = ReAct [123] [124]



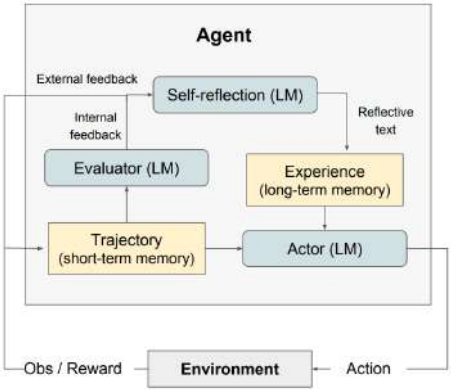
123. Yao et al. 2023 - "ReAct : Synergizing Reasoning and Acting in Language Models"
124. https://www.promptingguide.ai/techniques/react

Prompt Engineering - Retrieval Augmented Generation (RAG) [125]



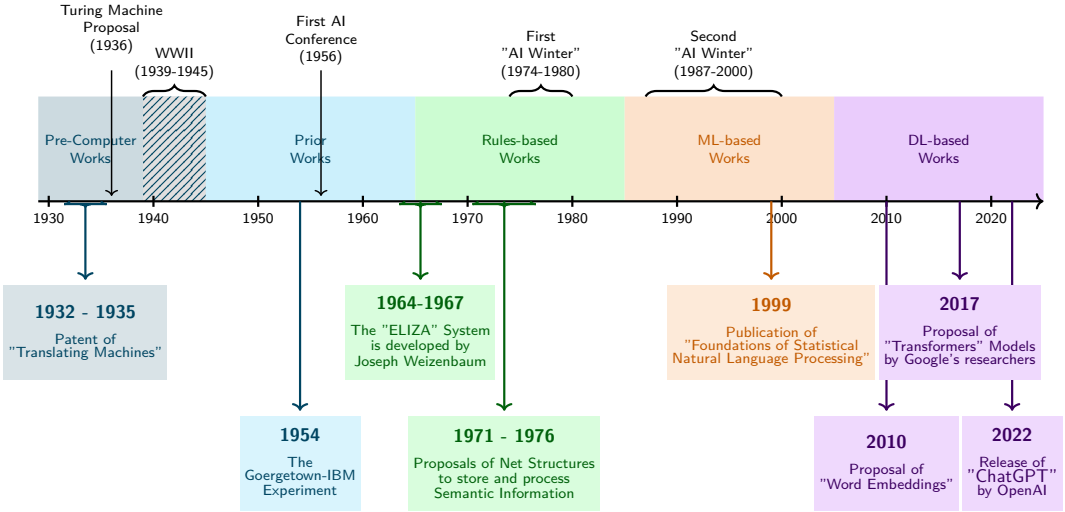
125. Gao et al. 2024 - "Retrieval-Augmented Generation for Large Language Models : A Survey"

Prompt Engineering - Reflexion [126] [127]



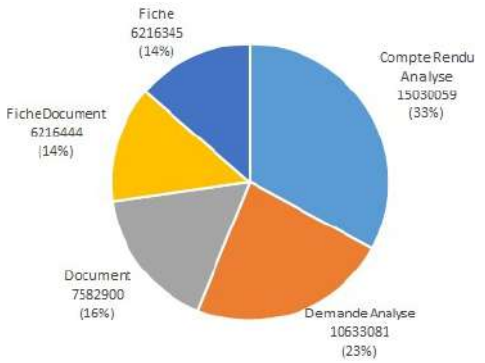
126. Shinn et al. 2023 - "Reflexion : Language Agents with Verbal Reinforcement Learning"
127. https://www.promptingguide.ai/techniques/reflexion

NLP - Key Events Synthesis



Unstructured Data [128] [129]

~45 millions of unstructured documents in HCL's databases



128. Perera et al. 2013 - "Challenges in Understanding Clinical Notes : Why NLP Engines Fall Short and Where Background Knowledge Can Help"
129. Adnan et al. 2020 - "Role and Challenges of Unstructured Big Data in Healthcare"

Extract Information [130] [131]

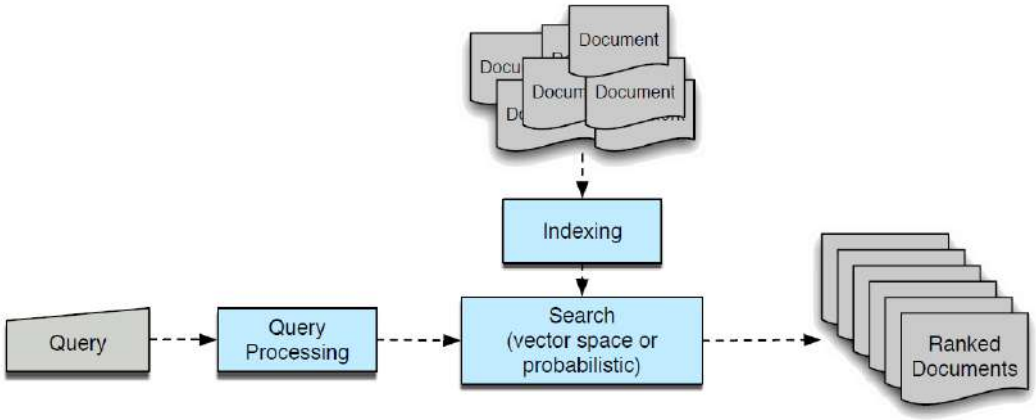
Extract

Structured Data

date	patient	disease	...	treatment
2023-02-04	810048	DT2	...	insulin
2021-12-23	180810	HChol	...	hypolip
2023-08-18	481082	DT1	...	insulin
2022-04-14	518401	DT2	...	insulin
⋮	⋮	⋮	⋮	⋮
2019-11-21	284018	HChol	...	hypolip

130. Iroju et Olaleke 2015 - "A Systematic Review of Natural Language Processing in Healthcare"
131. Malmasi et al. 2018 - "Extracting Healthcare Quality Information from Unstructured Data"

Retrieve Information [132] [133]



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133. Sivarajkumar et al. 2024 - "Clinical Information Retrieval : A Literature Review"

Clinical Virtual Assistants [134] [135]

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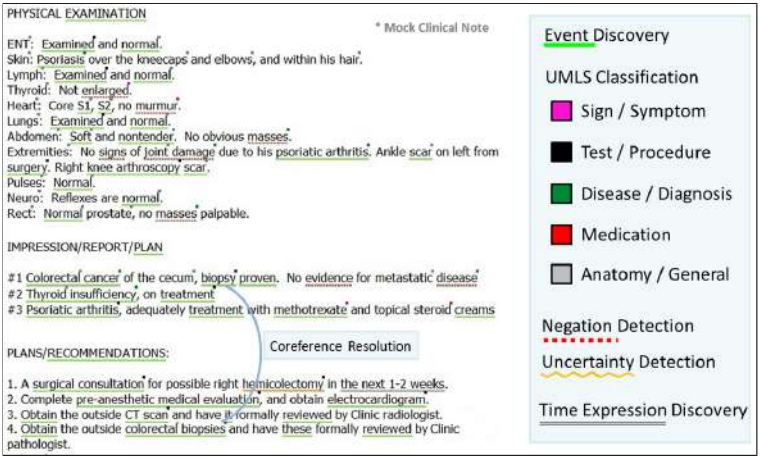
clinical Text Analysis Knowledge Extraction System (cTAKES) [136] [137]



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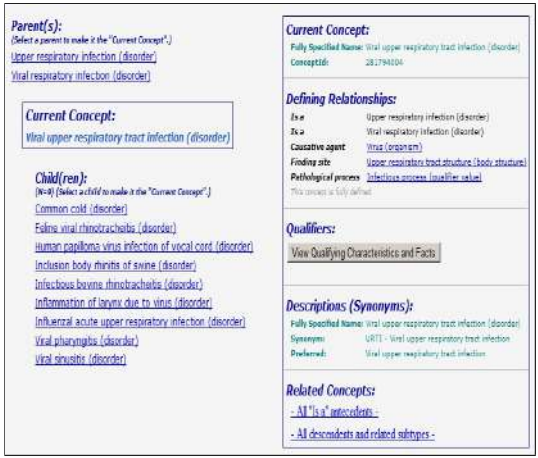
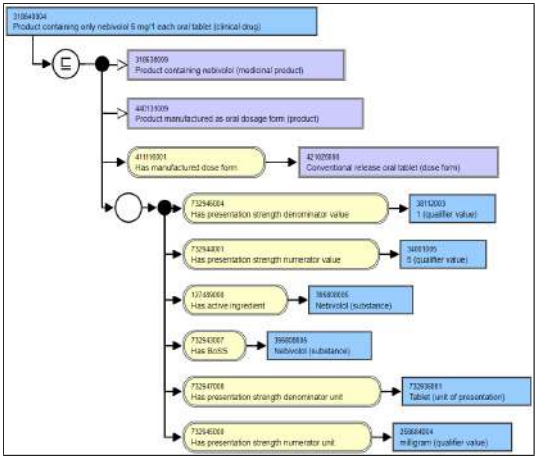
SNOMED-CT [138] [139]





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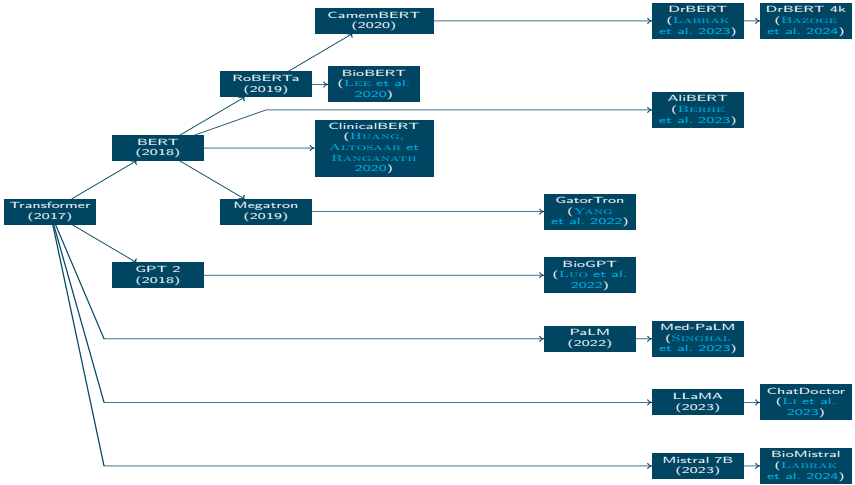
Clinical Transformers' Family Tree [140]



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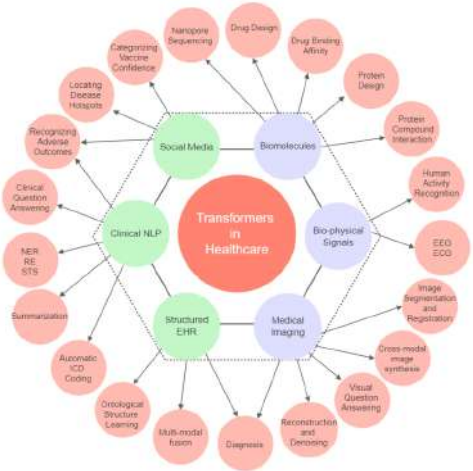
Transformers' usage in healthcare [141]



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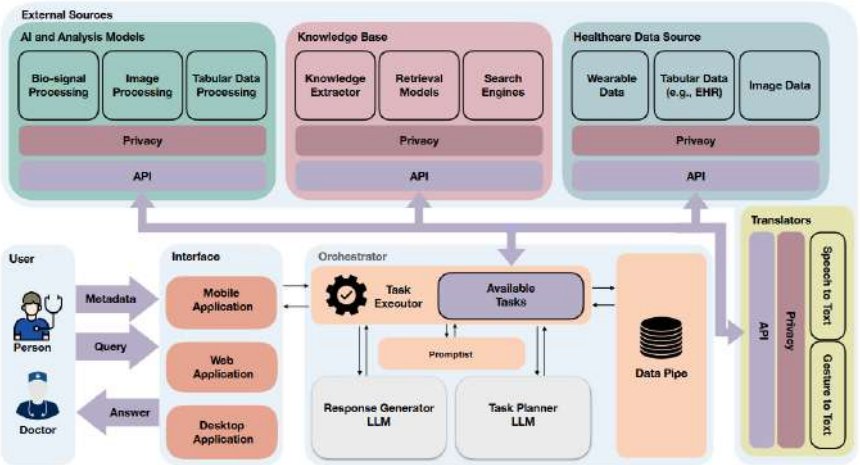
Conversational Health Agents [142]



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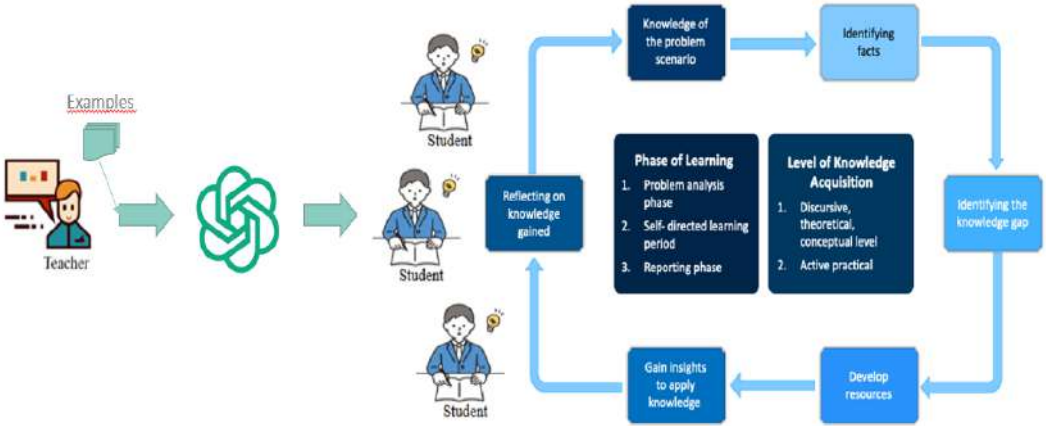

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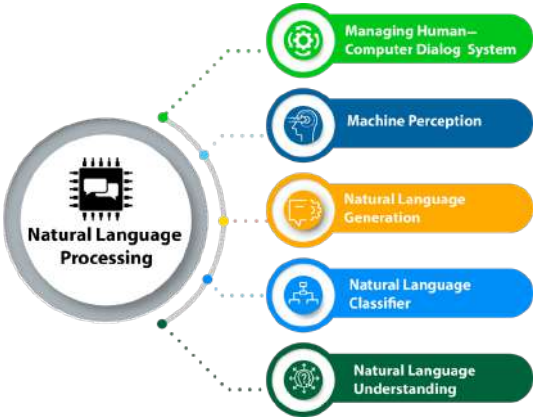
Conclusion [145]



NLP :

- A history as long as computer science history
- Multiple approaches for multiple problems
- Recent advances achieve old dreams and open new perspectives

NLP in Health :

- Allows to treat unstructured clinical texts
- Needs to be adapted to clinical lingo
- Recent advances open the path to powerful virtual assistants

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Thanks for your attention =)

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