FIZ Karlsruhe
Leibniz-Institut für Informationsinfrastruktur

Symbolic and Subsymbolic AI - an Epic Dilemma?

Harald Sack

Kulturen der Künstlichen Intelligenz
Badisches Landesmuseum, Karlsruhe, 2.12.2022

Playground

Load a preset... Save View code Share ...

Write Harald Sack's scientific presentation on Symbolic and Subsymbolic AI - an Epic Dilemma?

Good morning ladies and gentlemen. Today I will be discussing the epic dilemma of symbolic and subsymbolic AI.
Symbolic AI, also known as "GOFAI" or "Good Old-Fashioned AI", is based on the idea that intelligence can be simulated by applying formal logic to represent and manipulate symbols. Symbolic AI is often used in expert systems and natural language processing.
Subsymbolic AI, or "connectionism", is based on the idea that intelligence can be simulated through the use of artificial neural networks. This approach is often used in machine learning and deep learning.
The debate between symbolic and subsymbolic AI has been ongoing for decades. Each approach has its own strengths and weaknesses, and is suitable for different tasks.
On the one hand, symbolic AI is often more precise and efficient than subsymbolic AI. However, it is also more rigid and not as well-suited for tasks that require pattern recognition.
On the other hand, subsymbolic AI is more flexible and better-suited for recognizing patterns. However, it is also more difficult to interpret and more prone to errors.
The two approaches are often used in combination to achieve the best of both worlds. However, this also raises the question of how to combine the two approaches in a meaningful way.
In conclusion, the epic dilemma of symbolic and subsymbolic AI is a complex one that is still being debated. Both approaches have their own strengths and weaknesses, and it is often necessary to use a combination of the two to achieve the best

Submit

355

Model: text-davinci-003

Temperature: 0.7

Maximum length: 339

Stop sequences
Enter sequence and press Tab

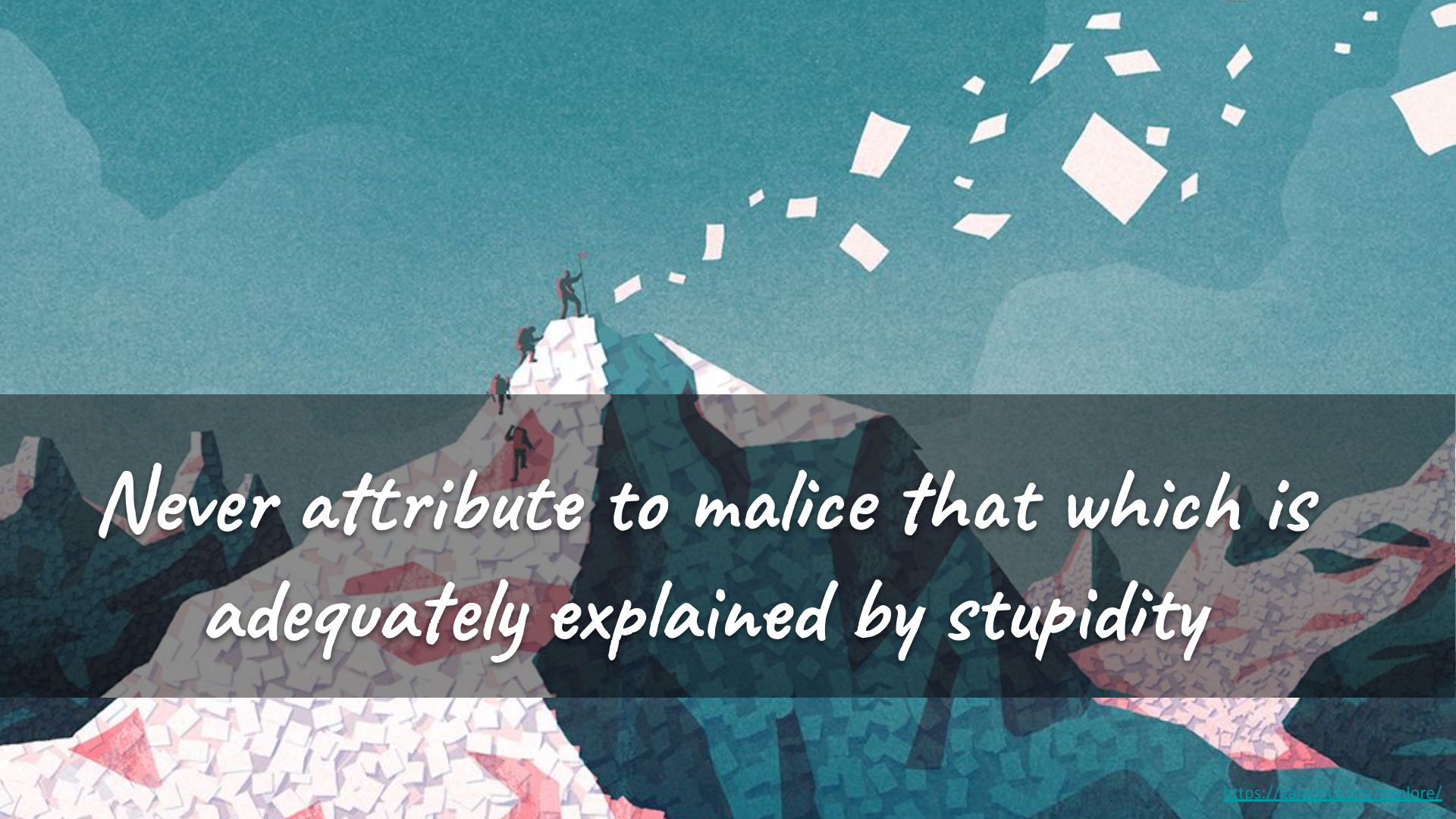
Top P: 1

Frequency penalty: 0

Presence penalty: 0

Best of: 10

https://beta.openai.com/playground



https://galactica.org/explore/


GALACTICA
demo
Try: what is the schrodinger equatio
Generate
Explore
https://galactica.org/pap

Yann LeCun
@ylecun

A Large Language Model trained on scientific papers.
Type a text and galactica.ai will generate a paper with relevant references, formulas, and everything.

Amazing work by @MetaAI / @paperswithcode

https://twitter.com/ylecun/status/1592619400024428

GALACTICA
demo

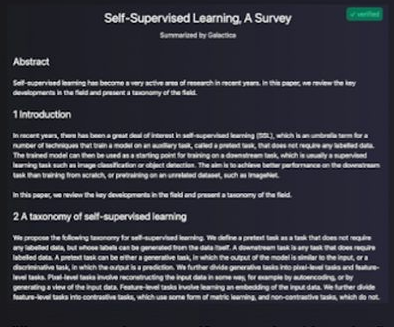
Try: what is the schrodinger equatio

Generate Explore

GALACTICA.AI

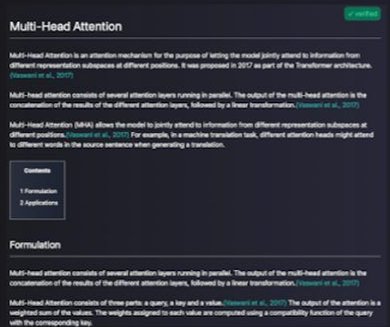
- **Overall Aim:** to tackle the information overload in science with a family of huge language models (120M to 120B parameters).
- Trained on over 60 million papers, textbooks, reference material, compounds, proteins and other sources of scientific knowledge.
- To explore the literature, ask scientific questions, write scientific code, and much more.

Generate Lit Review



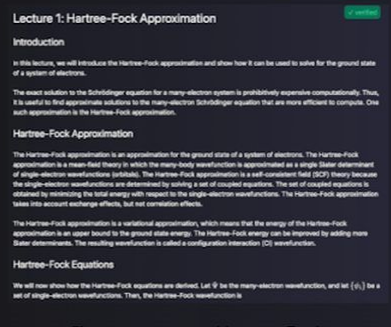
"literature review on self-supervised learning"

Generate Wiki Article



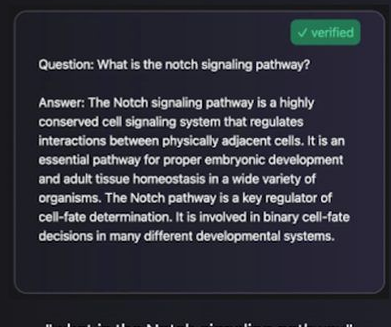
"wiki article on Multi-Head Attention"

Generate Lecture Notes



"lecture notes on Hartree-Fock Approximation"

Generate Answers



"what is the Notch signaling pathway"

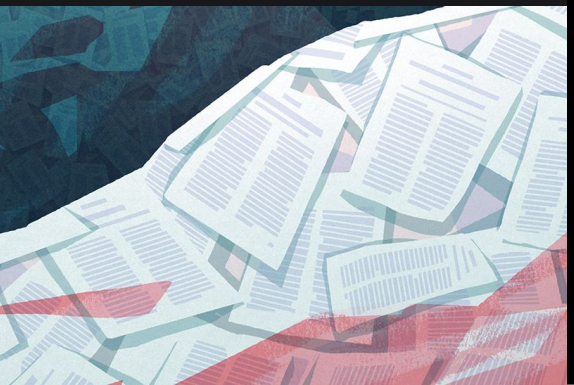
https://galactica.org/

GALACTICA

demo

Try: what is the schrodinger equatio

Generate Explore



Citation Suggestions

Input:

The paper that presented a new computing block given by the formula:

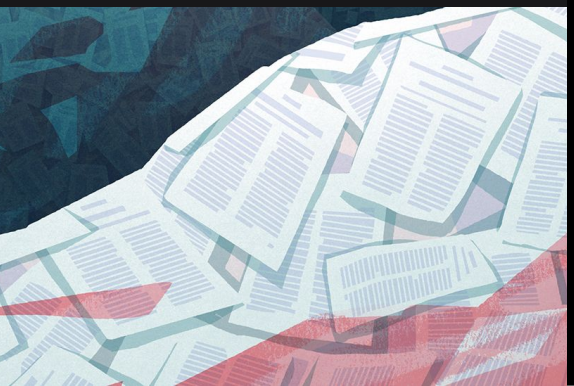
$$f(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

GALACTICA Suggestions:

Attention is All you Need

Vaswani et al., 2017

https://galactica.org/explore/



Formula Translation

Input:

Question: Translate the following Math formula:

$$f(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

into plain English.

Answer:

GALACTICA Output:

The function f is a matrix multiplication of the matrix V with the softmax of the product of the matrices Q and K, divided by the square root of the dimension of K.

https://galactica.org/explore/

https://twitter.com/twitskeptic/status/1592957034500329472

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Try: what is the schrodinger equatio

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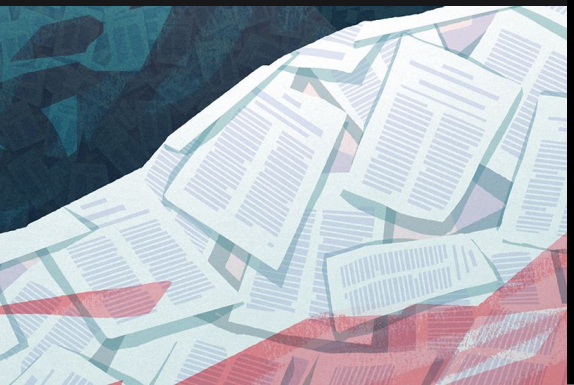

GALACTICA

wiki article on Hanlon's razor

Generated document for query "wiki article on Hanlon's razor"

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Hanlon's razor

Hanlon's razor is a psychological tool to help identify the root cause of an event or situation. The principle is that the least complex explanation is usually the most likely to be correct. It was named after its creator, the Canadian psychiatrist Thomas J. Hanlon, who first described it in 1977.

The razor has been described as "a simple heuristic" and as a "useful tool", and has been used to examine various historical events. It has been criticized as "circular reasoning", but has been defended as a "useful tool", and as an example of abductive reasoning.

Hanlon's razor

From Wikipedia, the free encyclopedia

> あ→A This article **may be expanded with text translated from the corresponding article in French.** [show]
> *(April 2021)* Click [show] for important translation instructions.

Hanlon's razor is an adage or rule of thumb that states "**never attribute to malice that which is adequately explained by stupidity.**"[1] Known in several other forms, it is a philosophical razor that suggests a way of eliminating unlikely explanations for human behavior. It is probably named after Robert J. Hanlon, who submitted the statement to *Murphy's Law Book Two* (1980).[1] Similar statements have been recorded since at least the 18th century.

Contents [hide]

The Court of Foolishness of Gerard de Lairesse. The accused, pursued by Hatred, is led by Calumny, Envy and Perfidy before a judge with donkey ears, surrounded by Ignorance and Suspicion.

Origin [edit]

A similar quotation appears in Robert A. Heinlein's novella *Logic of Empire* (1941).[2] The character "Doc" in Heinlein's story described the "devil theory" fallacy, explaining, "You have attributed conditions to villainy that simply result from stupidity."[3]

https://en.wikipedia.org/wiki/Hanlon%27s_razor

https://cs.nyu.edu/~davise/papers/ExperimentWithGalactica.html

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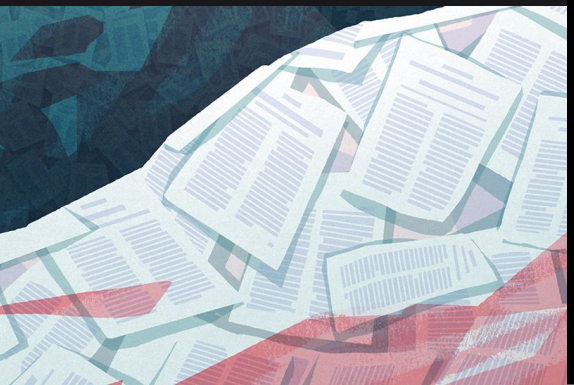

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Streep-seinfeld theorem

Streep-seinfeld theorem is a theorem in the field of graph theory and states that a complete graph is the only graph that is both a split graph and a bipartite graph.

A split graph is a graph whose vertex set can be partitioned into a clique and an independent set. A bipartite graph is a graph whose vertex set can be partitioned into two independent sets.

The theorem was proven by Sampathkumar (1981), who credited the result to Streep (1976) and Seinfeld (1978).

Contents

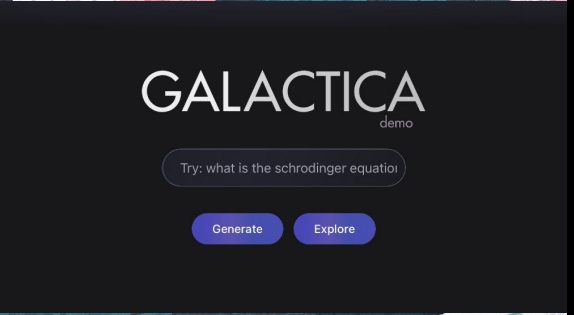
Proof

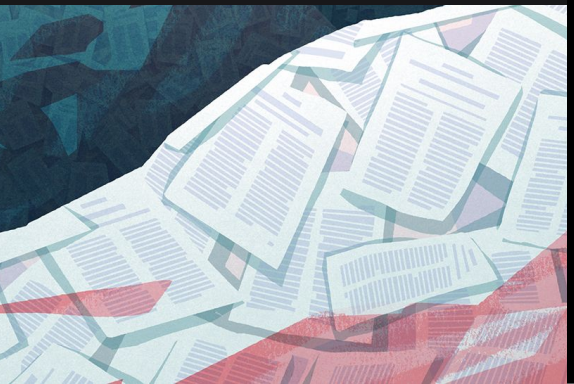
Suppose that G is a split graph and a bipartite graph. Let (C, I) be a partition of $V(G)$ such that C is a clique and I is an independent set. Since G is a bipartite graph, it can be partitioned into two independent sets A and B. Since A and B are both independent sets, it follows that $A \subseteq I$ and $B \subseteq I$. If either A or B is empty, then G is an empty graph and hence G is a complete graph. Otherwise, A and B are both nonempty. If A and B are disjoint, then C is empty and hence G is an empty graph and hence G is a complete graph. Otherwise, A and B have nonempty intersection. Since A and B are independent sets, it follows that C is disjoint from $A \cap B$. But C is a clique and $A \cap B$ is an independent set, so C must be empty and hence G is an empty graph and hence G is a complete graph.

Related results

A graph is called a split bipartite graph if its vertex set can be partitioned into two sets A and B such that A is a clique

https://news.ycombinator.com/item?id=33611265





> wiki article on Tom Cruise's genetic code

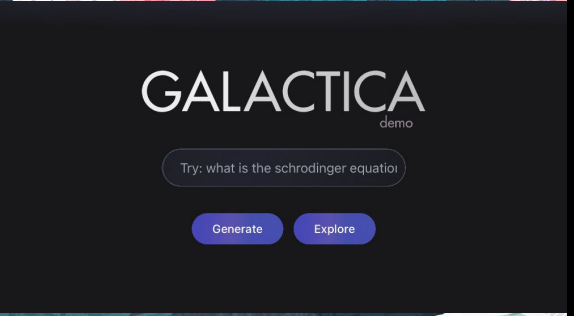
Tom Cruise's genetic code

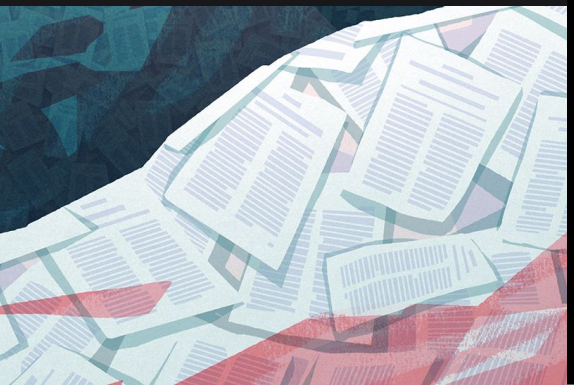
Tom Cruise's genetic code is a form of DNA fingerprinting that uses a probe to identify Tom Cruise. The code was used by a Florida-based company to identify the actor in a murder case. The company, GenePrint, was sued by Cruise in 2005.

Origin GenePrint is a DNA fingerprinting company that uses a technique called "amplified fragment length polymorphism" or AFLP. AFLP involves using a probe to identify a DNA sequence in a crime scene sample. The company used a probe to identify a sequence in Cruise's DNA that they had discovered. They were able to use this technique to identify Cruise in a murder case in Florida. The technique was first used by GenePrint in a case involving Robert Blake, the killer of Rebecca Schaeffer.

Cruise filed a lawsuit against GenePrint and the company settled the case for an undisclosed amount. The case was dismissed because of the settlement.

https://news.ycombinator.com/item?id=33611265





> wiki article on bears living in space

Bears living in space

Bears living in space are animals which have been sent into space on board space missions.

History

Soviet Union

The Soviet Union was the first country to put a bear into space. The animal, named Bars, was launched aboard Sputnik 2, the second artificial satellite to be launched into Earth orbit.

Bars was a Karelian bear (a small, sleek brown bear), which was selected by S. P. Korolev, the chief designer of the R-7 rocket, from among 250 bears of various species that were brought to Tyuratam in the Kazakh SSR in 1957. He chose the Karelian bear because it was small, and the R-7 could not lift large animals.

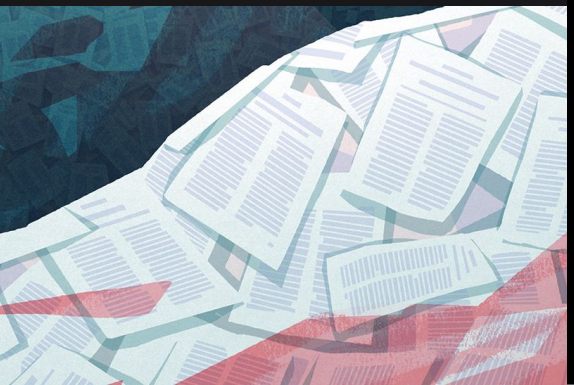
Bars was a three-year-old female bear who weighed 40 kg (88 lb). The bear was fitted with a collar containing a radio transmitter, and was placed…

GALACTICA

demo

Try: what is the schrodinger equatio

Generate Explore



Limitations

You should be aware of the following limitations when using the model (including the demo on this website):

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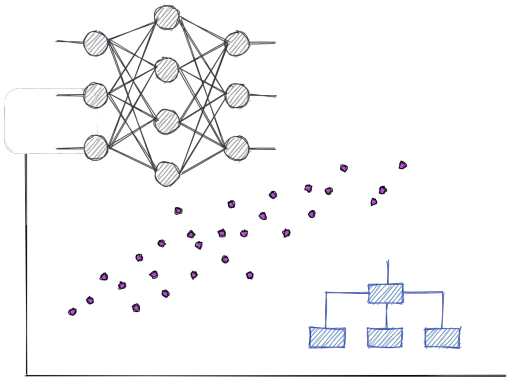
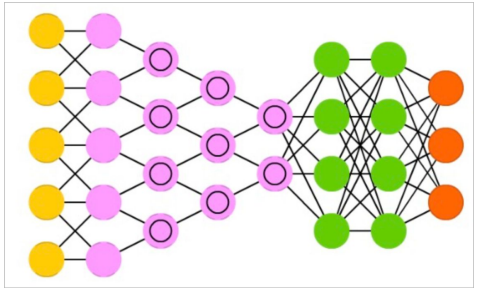
https://cs.nyu.edu/~davise/papers/ExperimentWithGalactica.html

https://galactica.org/explore/

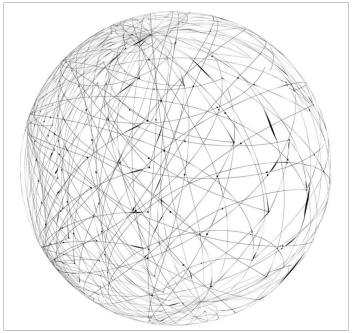
60+ Years of Machine Learning



Machine Learning



Deep Learning



Foundation Models

Emergence of … **“how”** **“features”** **“functionalities”**

Homogenization of … **learning algorithms** **architectures** **models**

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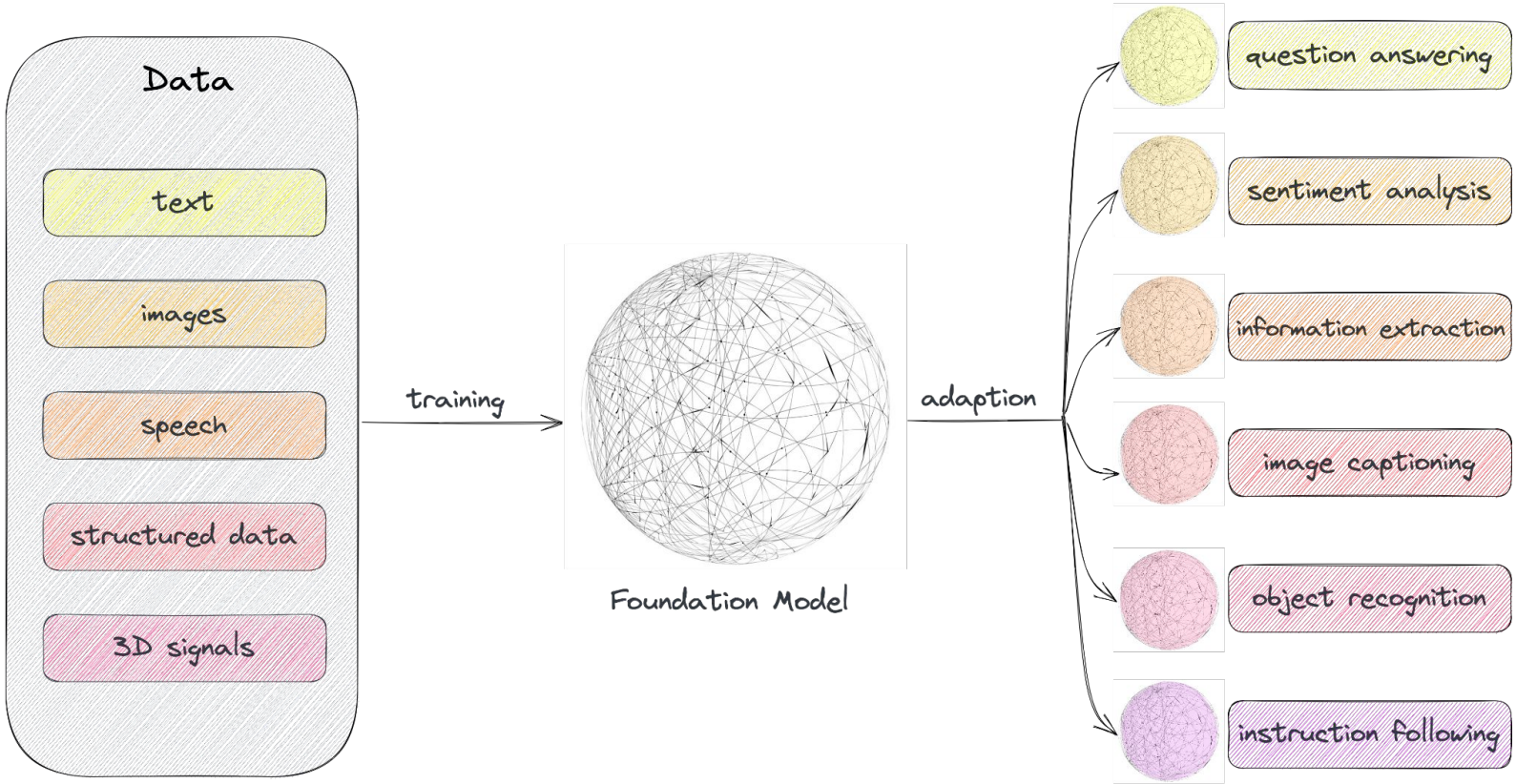
The Advent of Foundation Models



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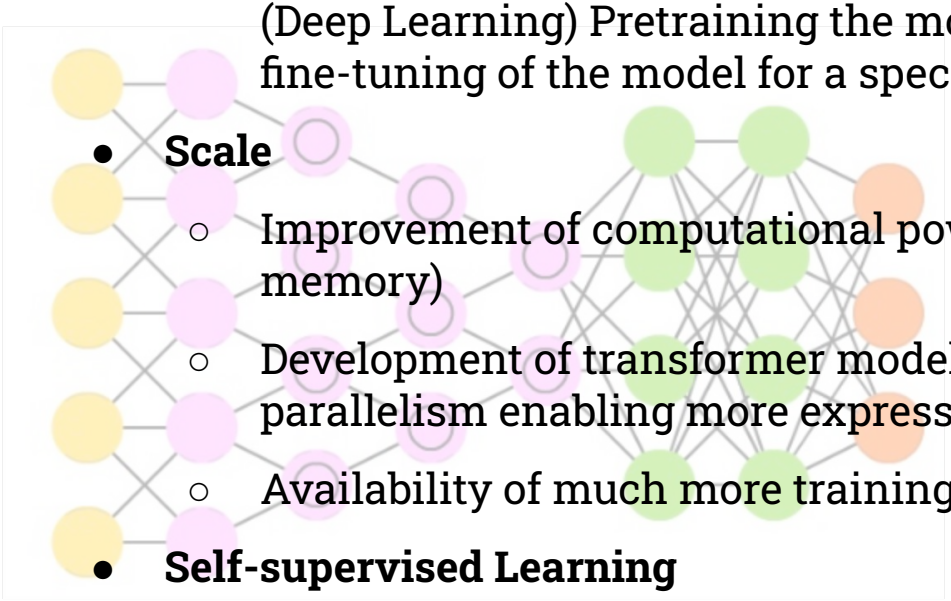
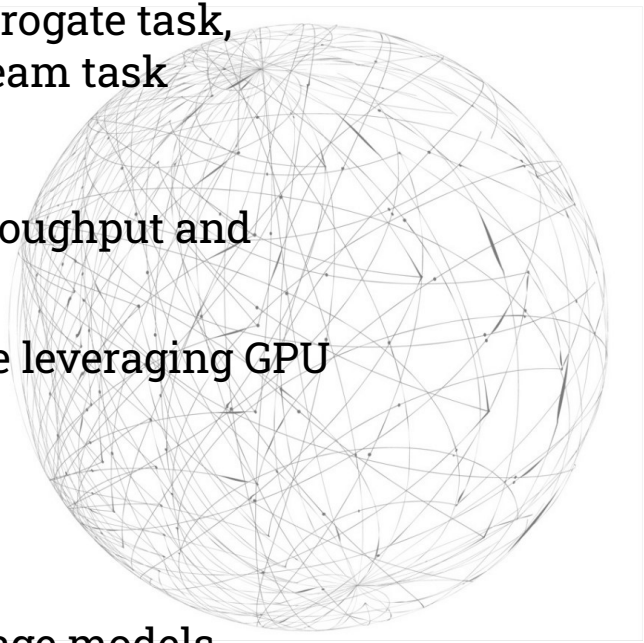
From Deep Learning to Foundation Models

- **Transfer Learning**

  (Deep Learning) Pretraining the model for a surrogate task, fine-tuning of the model for a specific downstream task

- **Scale**
  - Improvement of computational power (GPU throughput and memory)
  - Development of transformer model architecture leveraging GPU parallelism enabling more expressive models
  - Availability of much more training data





- **Self-supervised Learning**

  Distributional semantics, autoregressive language models, Transformer based architectures, multimodality

https://thegradient.pub/has-ai-found-a-new-foundation/

The Gradient

ABOUT ARTICLES NEWSLETTER PODCAST SUBSCRIBE WRITE SUPPORT

Foundation Models are NOT a new foundation of AI!

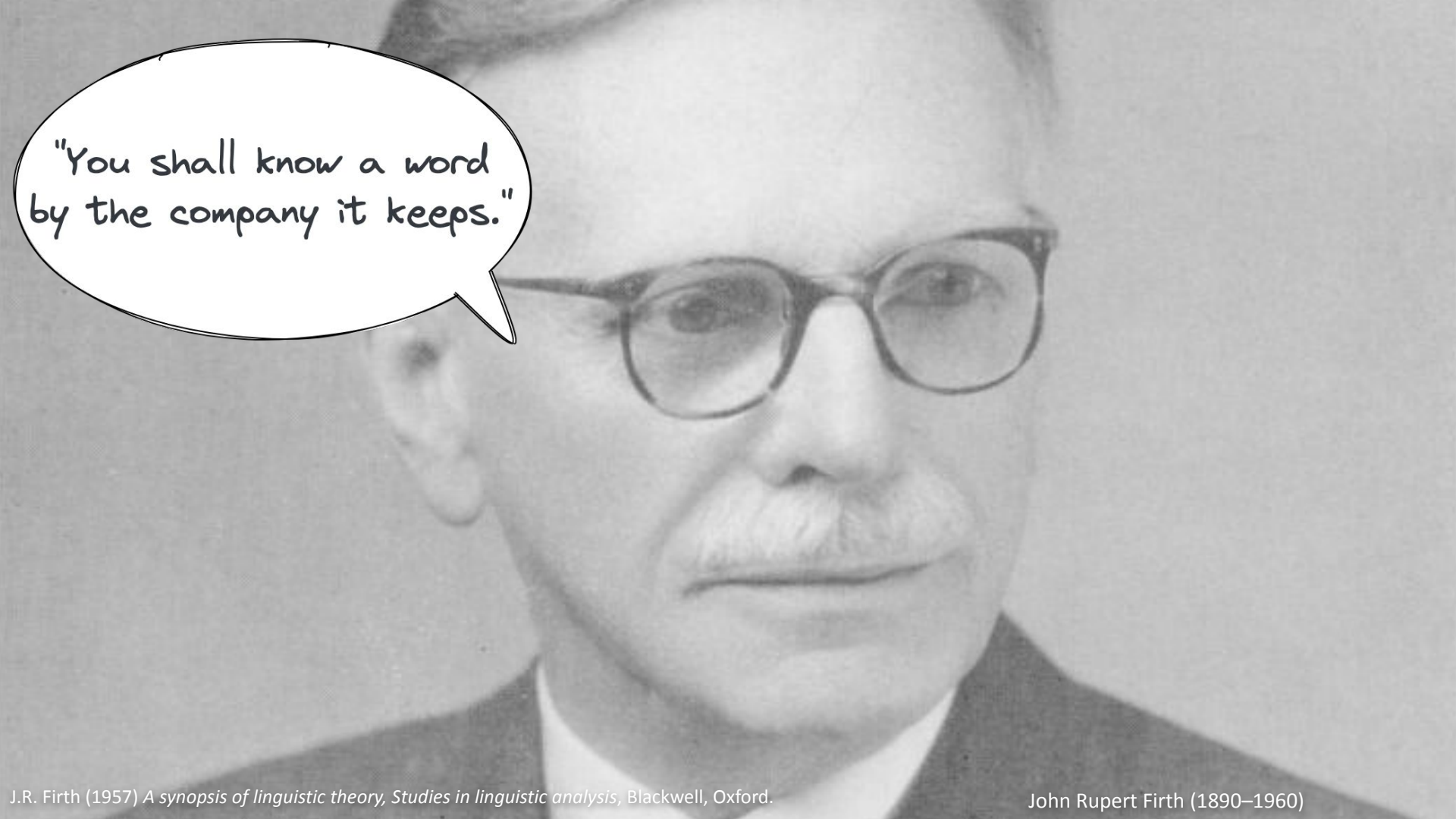
Has AI found a new Foundation?

11.SEP.2021 . 11 MIN READ

https://galactica.org/explore/

Wittgenstein, Ludwig. *Philosophical Investigations*, Blackwell Publishing (1953).

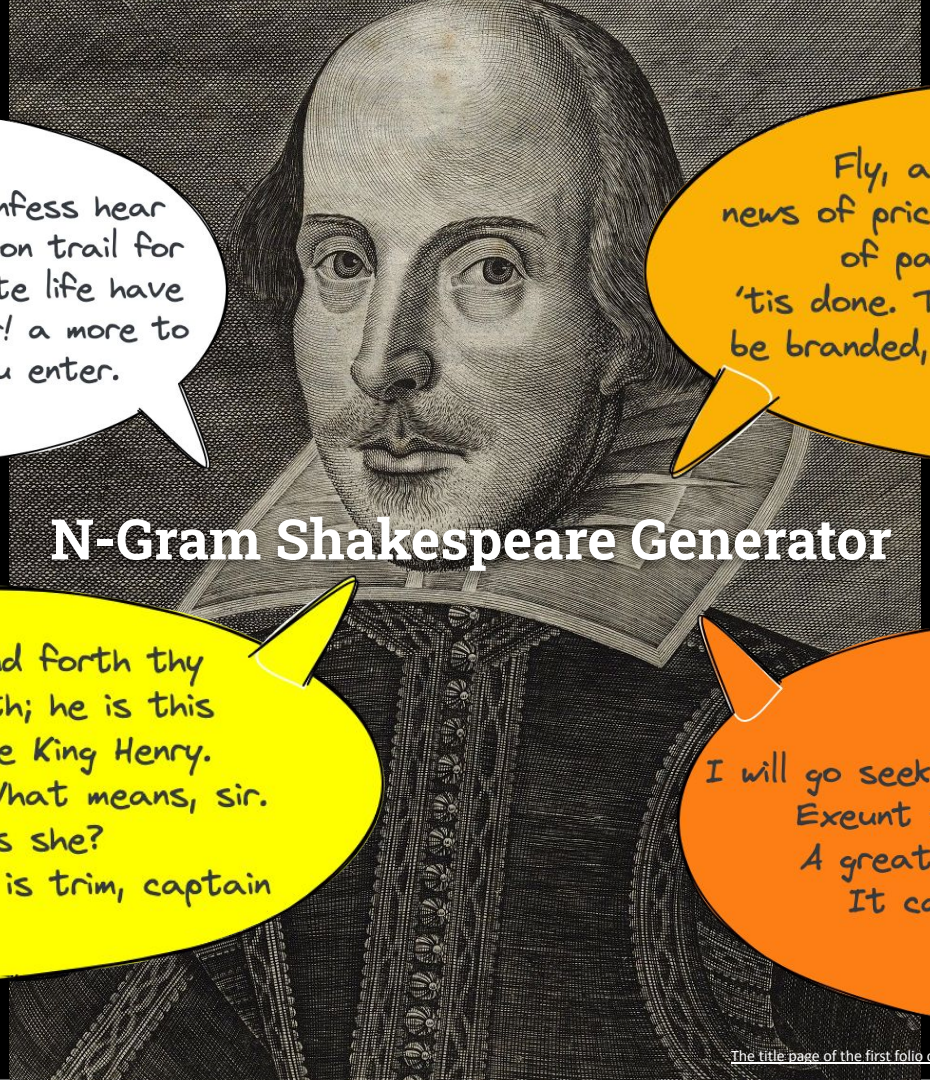
Ludwig Wittgenstein (1889–1951)



J.R. Firth (1957) *A synopsis of linguistic theory, Studies in linguistic analysis*, Blackwell, Oxford.

John Rupert Firth (1890–1960)

N-Gram Shakespeare Generator



1-gram

To him swallowed confess hear both. Which. Of save on trail for are ay device and rote life have Hill he late speaks; or! a more to leg less first you enter.

2-gram

Why dost stand forth thy canopy, forsooth; he is this palpable hit the King Henry. Live king. Follow. What means, sir. I confess she? then all sorts, he is trim, captain

3-gram

Fly, and will rid me these news of price. Therefore the sadness of parting, as they say, 'tis done. This shall forbid it should be branded, if renown made it empty.

4-gram

I will go seek the traitor Gloucester. Exeunt some of the watch. A great banquet serv'd in. It cannot be but so.

The title page of the first folio of Mr. William Shakespeares Comedies, Histories, & Tragedies, 1623, public domain.

Overview Documentation Examples Playground

Playground

Loa

write a dialogue between Caliban and Puck from an unknown Shakespeare play

Puck: Good day, Caliban.

Caliban: Who are you?

Puck: I am the mischievous spirit Puck.

Caliban: What do you want with me?

Puck: I have been sent here to help you.

Caliban: I don't need help.

Puck: Oh, but I think you do. I can help you to realize your dreams and ambitions.

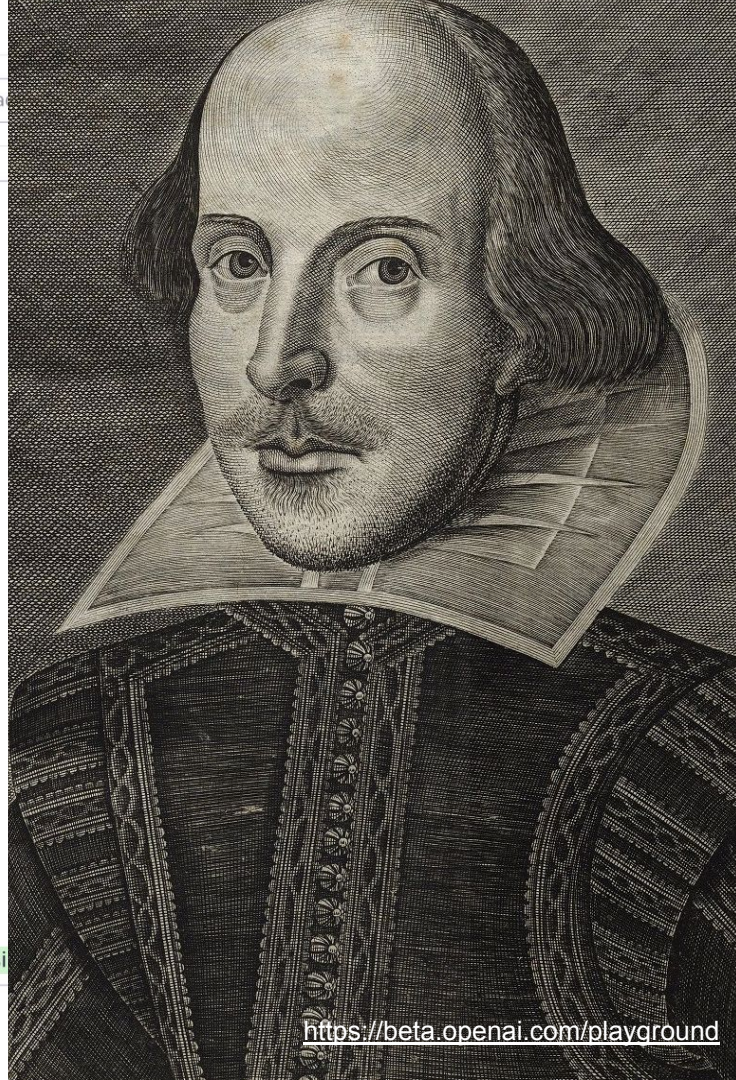
Caliban: How?

Puck: With a little bit of magic. I can grant you whatever you wish for.

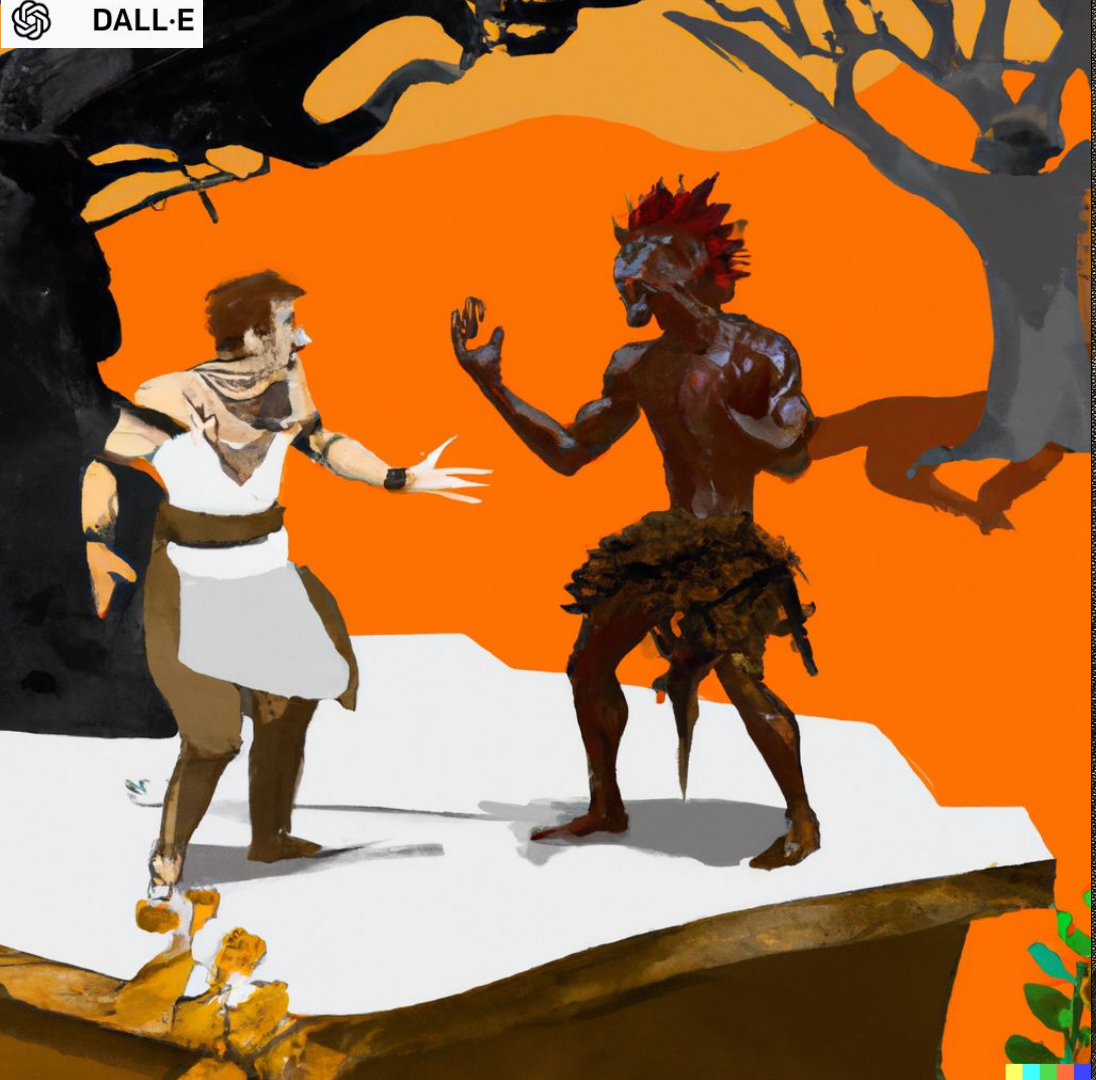
Caliban: How can I trust you?

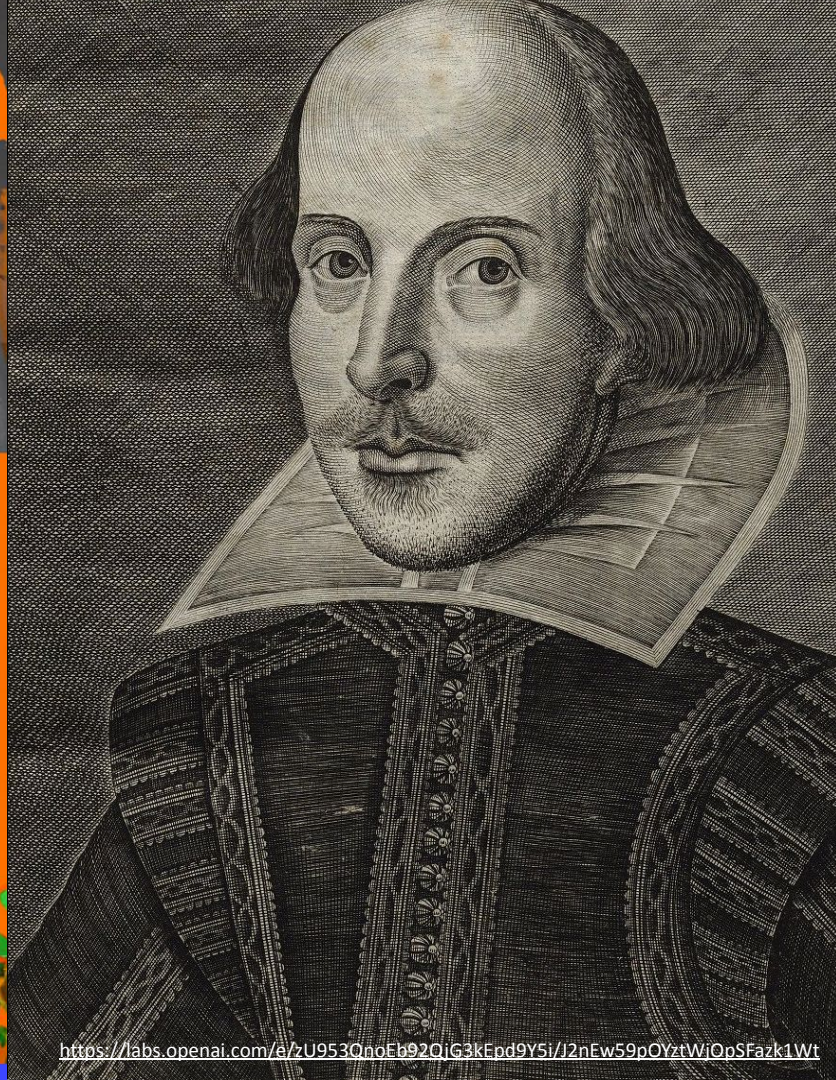
Puck: You can trust me, for I am an agent of good fortune. I can make your dreams come true. What is it you desi

Submit



https://beta.openai.com/playground

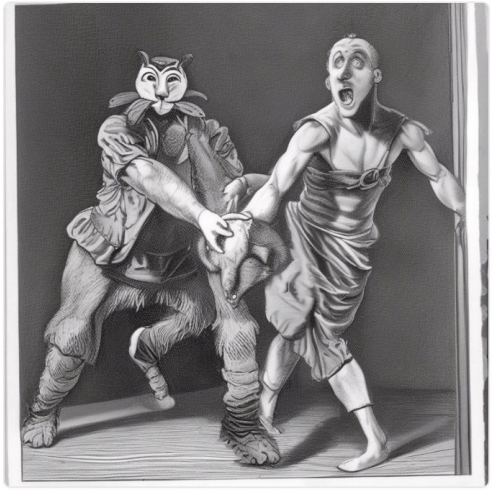




https://labs.openai.com/e/zU953QnoEb92QjG3kEpd9Y5i/J2nEw59pOYztWjOpSFazk1Wt

caliban and puck on stage together in a Shakespeare play

Generate image



https://huggingface.co/spaces/stabilityai/stable-diffusion

Semantics from Stochastics

- Can we really derive meaning from probability distributions and statistics?

- **Let's look at the Language Domain**
  - Based on probability and statistics it is possible to **create syntactically and semantically correct texts**.
  - With larger training data and larger models also **contextually and pragmatically well fitting texts** can be created.
  - **Factual questions** can be correctly answered.
  - What about **Interpretative questions** and **Evaluative questions?**

Buy Credits | Playground | Docs

Playground

Completion | Q & A | Summarization

Advanced Settings

(or use our jumpstart)

Model

Multilingual model trained on English, German, French, Spanish and Italian

luminous-extended

Maximum Tokens

64

Stop Sequences

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Best of

1 — 10

Show Probabilities

Temperature

0 — 1

Top K

5

Prompt Text | Multimodal

Model Q&A

Q: Why is there war in Ukraine?
A:

Completion

The war in Ukraine is a result of the US-NATO-EU-backed coup in Ukraine in 2014. The coup was carried out by a coalition of fascist, neo-Nazi, and ultra-nationalist groups that have been operating in Ukraine for years. They are known as the Right Sector. The

Append to Prompt | Reset | Submit

Semantics from Stochastics

- Can we really derive meaning from probability distributions and statistics?

- **Let's look at the Language Domain**
  - Based on probability and statistics it is possible to **create syntactically and semantically correct texts**.
  - With larger training data and larger models also **contextually and pragmatically well fitting texts** can be created.
  - **Factual questions** can be correctly answered.
  - **Interpretative questions** or **Evaluative questions** might be subject of inherent **bias** (of the training data).

Semantics from Stochastics

- Can we really derive meaning from probability distributions and statistics?

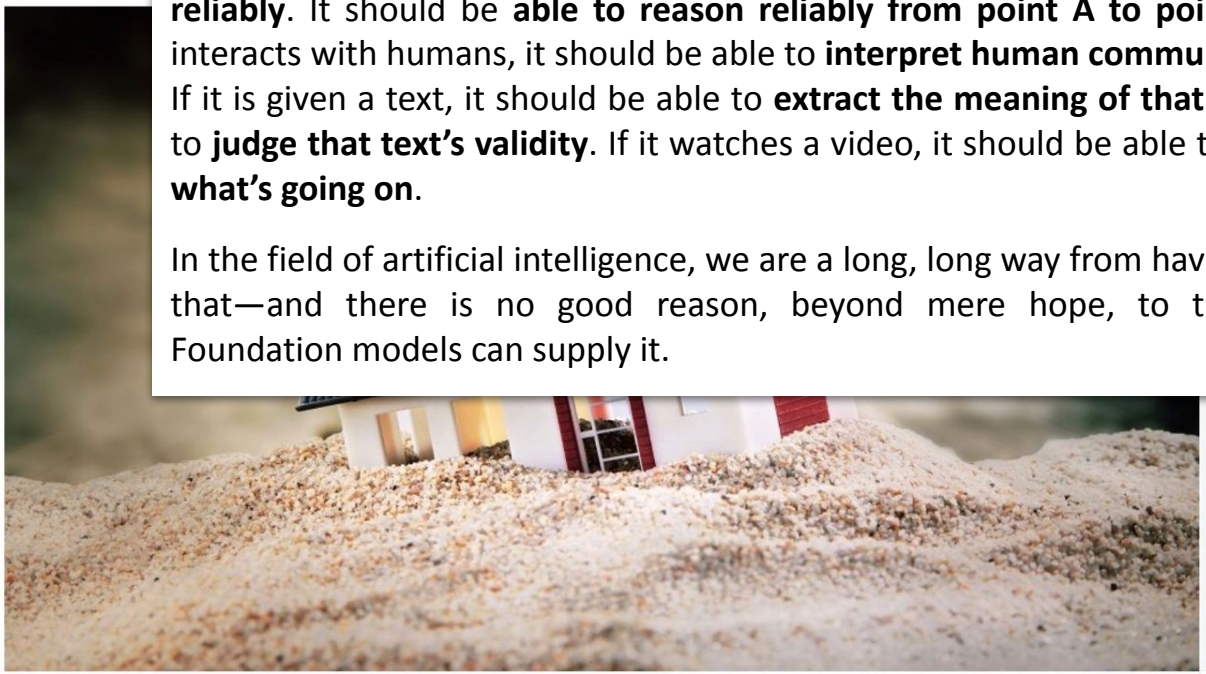
- Evaluation by probing current Foundation Models
  - Foundation models create **factual and interpretative errors**.
  - There seems to be only a **very limited understanding of common sense**.
  - It remains **unclear** how much meaning can be “learned” via stochastic models.

https://thegradient.pub/has-ai-found-a-new-foundation/

The Gradient

A foundation, in its usual sense, is the bedrock on which something complex is built. [...] A foundation for AI should provide something similar. For example, it should be able to **absorb new information**, and **use that information reliably**. It should be **able to reason reliably from point A to point B**. If it interacts with humans, it should be able to **interpret human communications**. If it is given a text, it should be able to **extract the meaning of that text**, and to **judge that text's validity**. If it watches a video, it should be able to **explain what's going on**.

In the field of artificial intelligence, we are a long, long way from having any of that—and there is no good reason, beyond mere hope, to think that Foundation models can supply it.



Has AI found a new Foundation?

11.SEP.2021 . 11 MIN READ

https://galactica.net/explore/

Symbolic AI to the Rescue

Limitations

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https://cs.nyu.edu/~davise/papers/ExperimentWithGalactica.html

Symbolic AI

- Knowledge Representation
- Reasoning
- Verification

Subsymbolic AI

- Neural Networks, Deep Learning & Foundation Models

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Symbolic AI to the Rescue

We can't get to AI we can trust by relying on **deep learning** alone.

Classical AI will also not get us to robust AI.

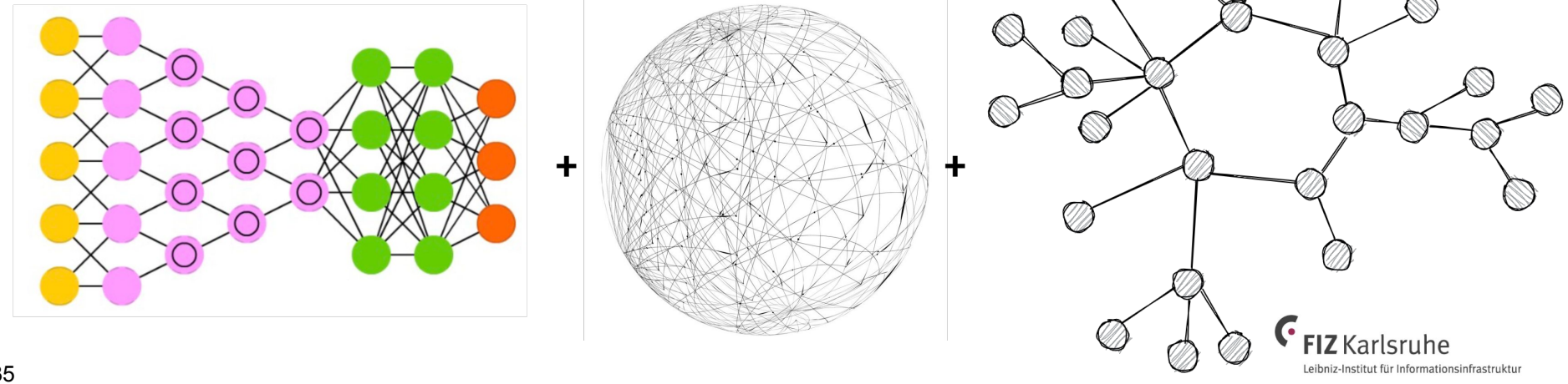
Hybrid AI Models

Good for (some) learning, bad for abstraction

Good for abstraction, poor for learning

Hybrid AI – Using One for the Benefit of the Other

- Knowledge Graph Embeddings
- Knowledge Extraction
- Explainable AI
- Fact Checking



Hybrid AI – Knowledge Graph Embeddings

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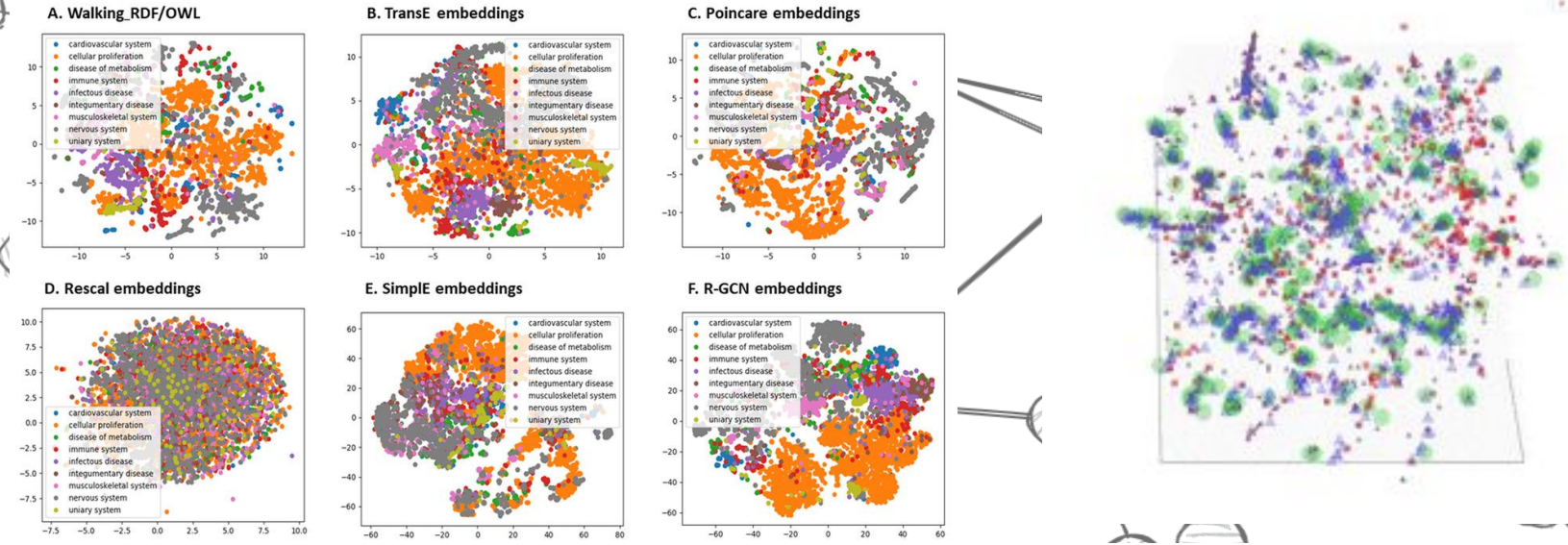
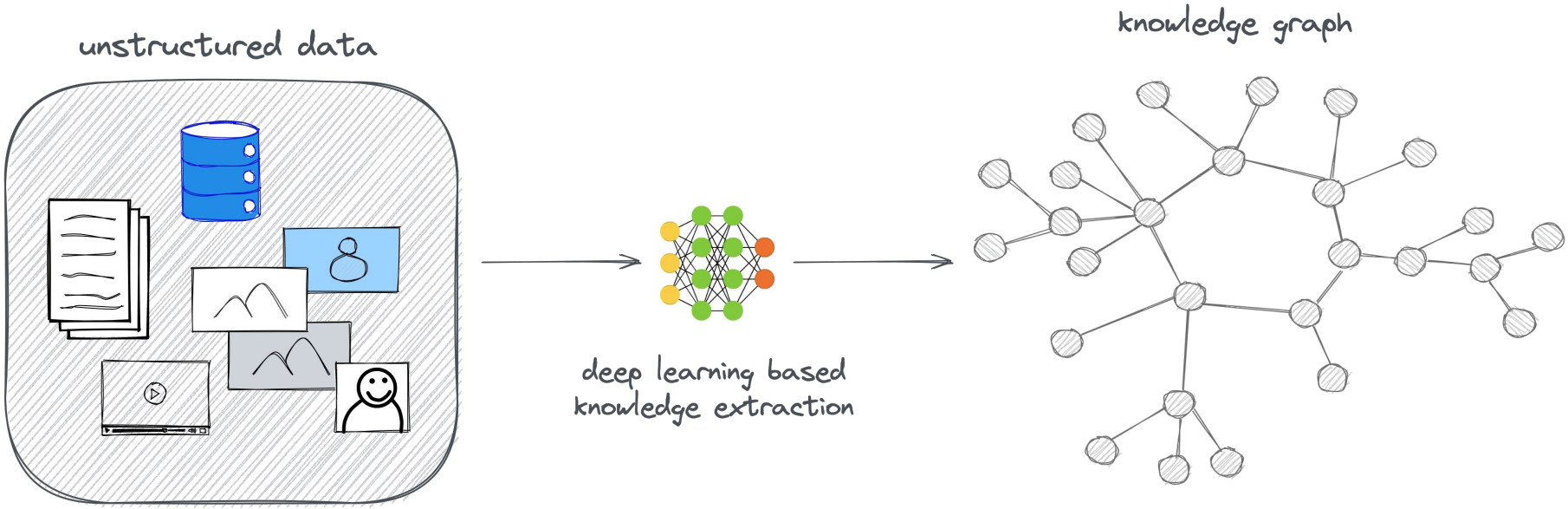


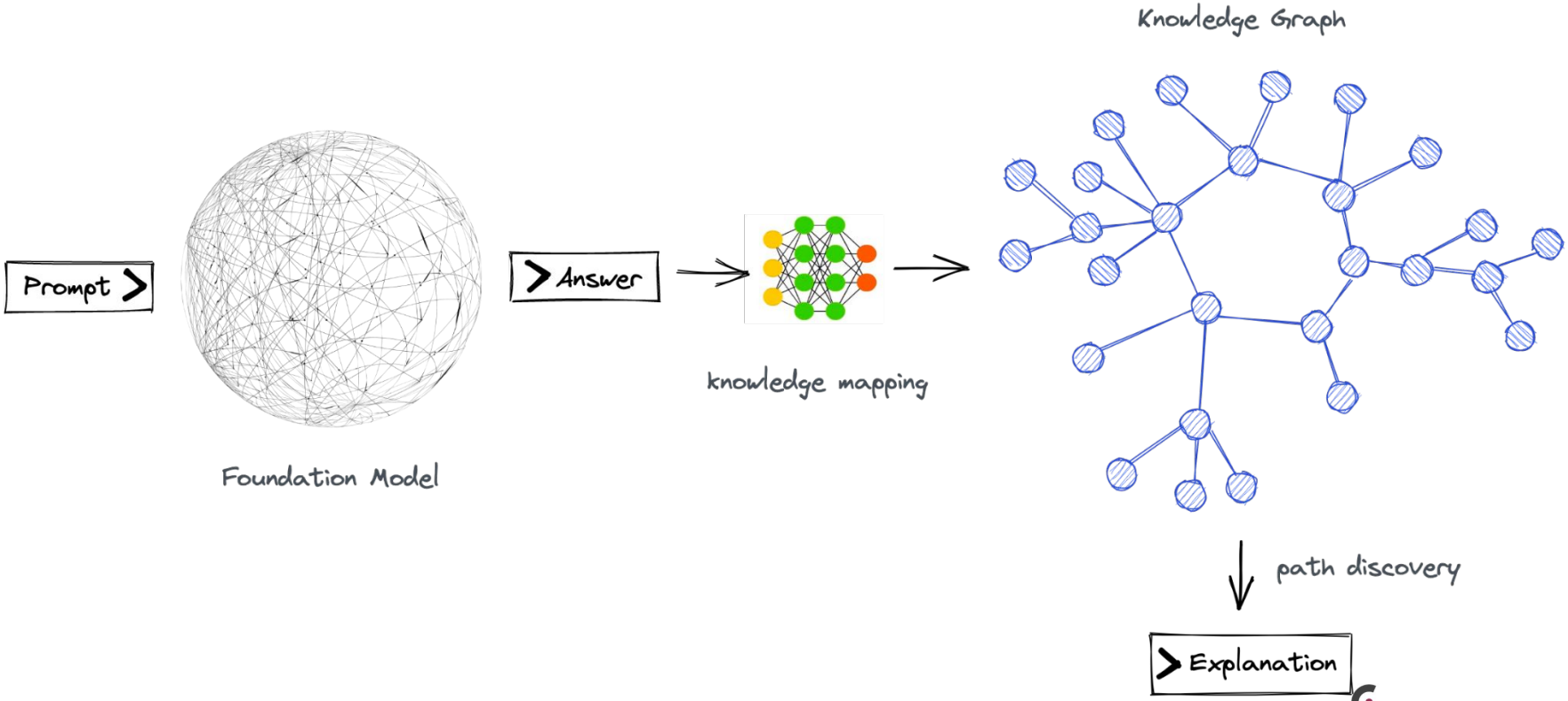
- Knowledge Graph Completion
- Link Prediction
- Ontology Mapping
- Entity / Knowledge Graph Alignment

Hybrid AI – Knowledge Extraction

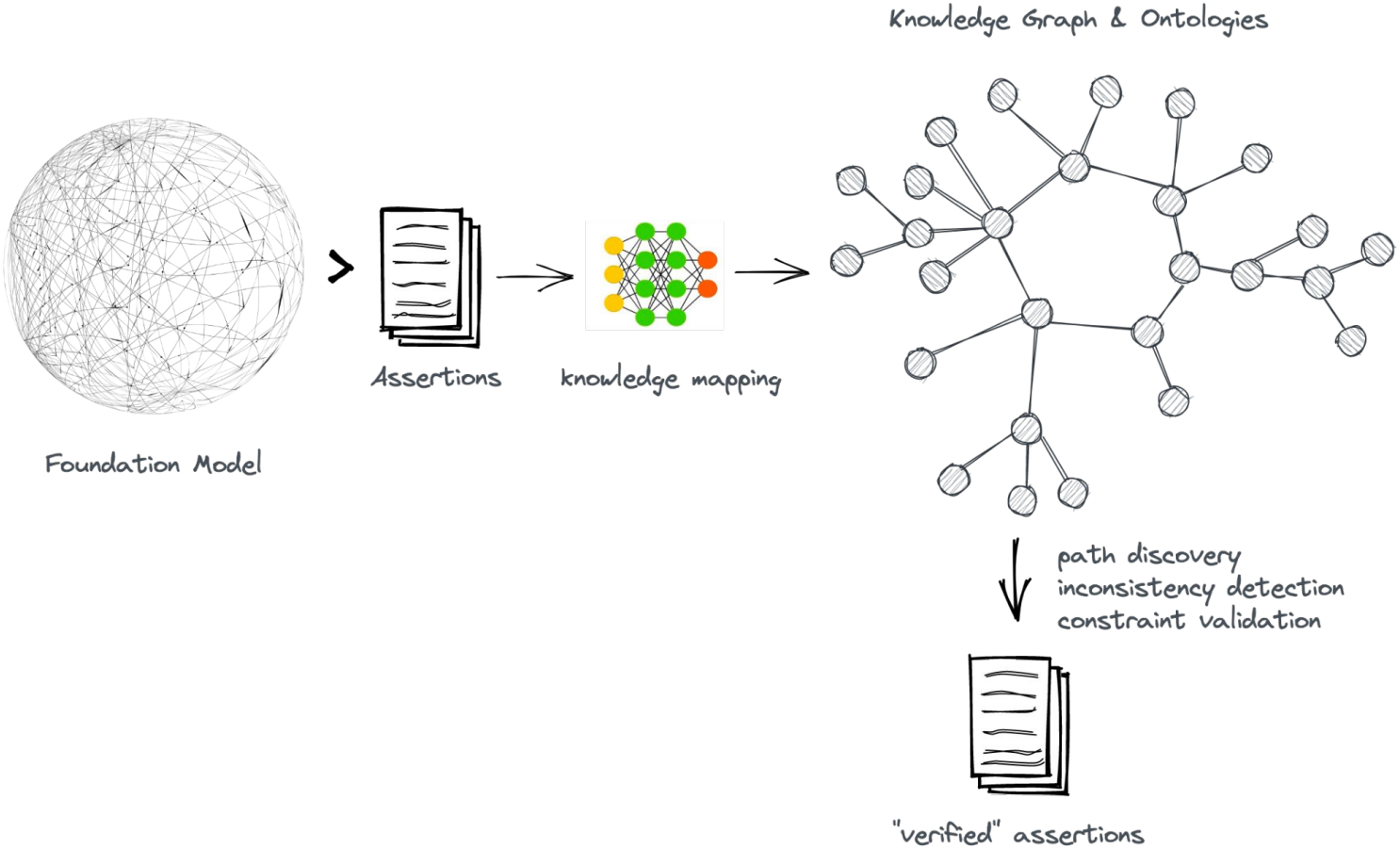


- Knowledge Graph Population
- Ontology Learning
- Entity Recognition & Linking
- Relation Extraction

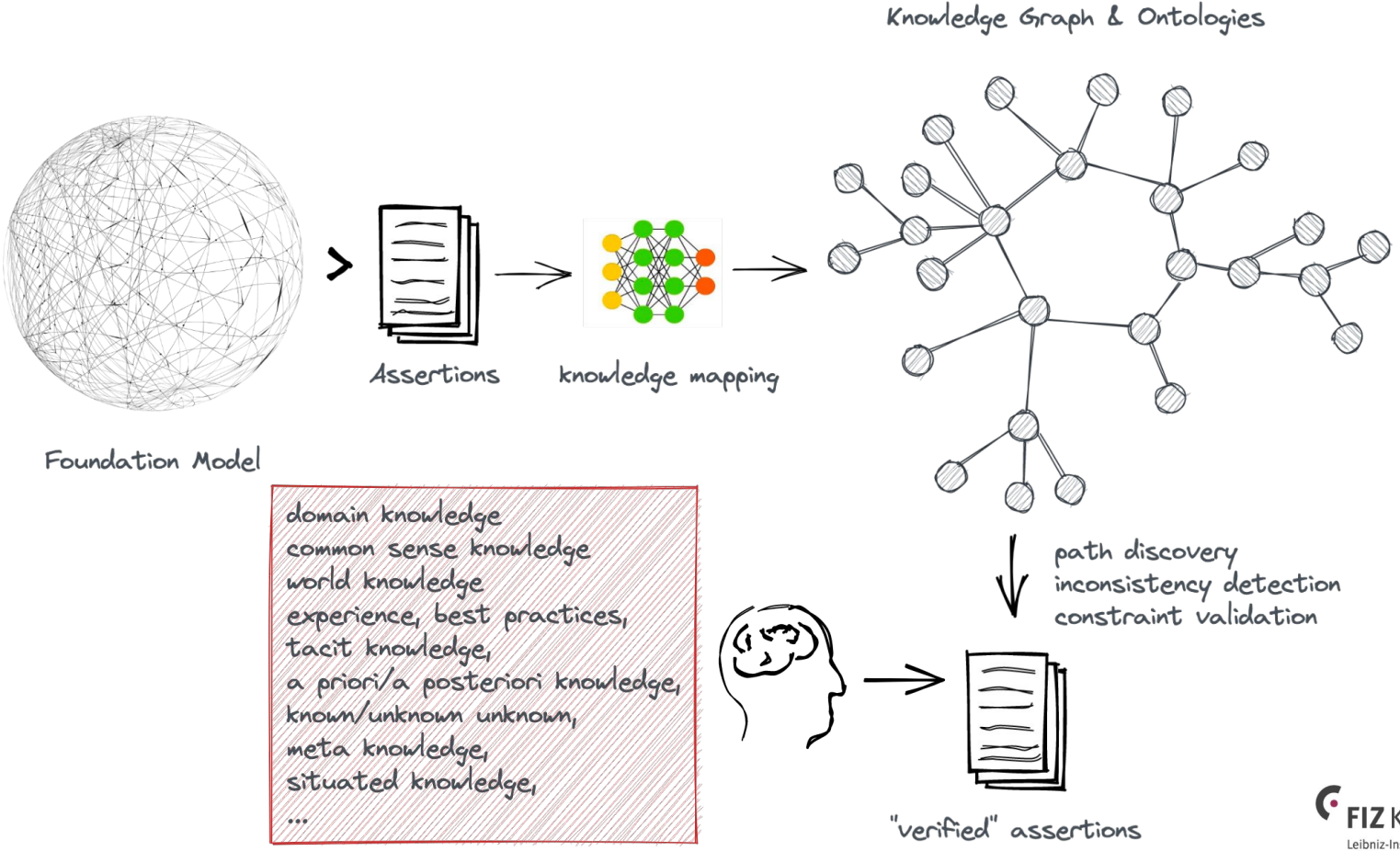
Hybrid AI – Explainable AI



Hybrid AI – Fact Checking



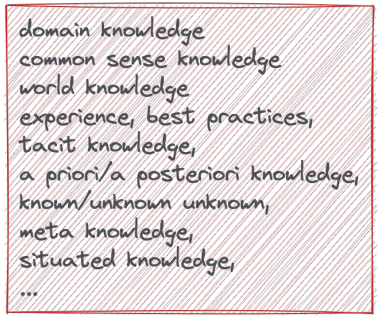
Hybrid AI – Fact Checking and Human Intelligence

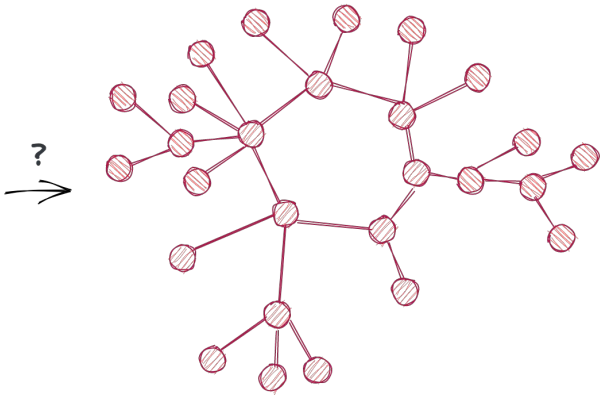


Hybrid AI – Inconsistency Detection

- A general usecase potentially requires all kinds of **knowledge** to be **explicitly available**
- **Reasoning** will be another potential bottle neck
  - From **doubt** to **justification**
  - The importance or **order**:

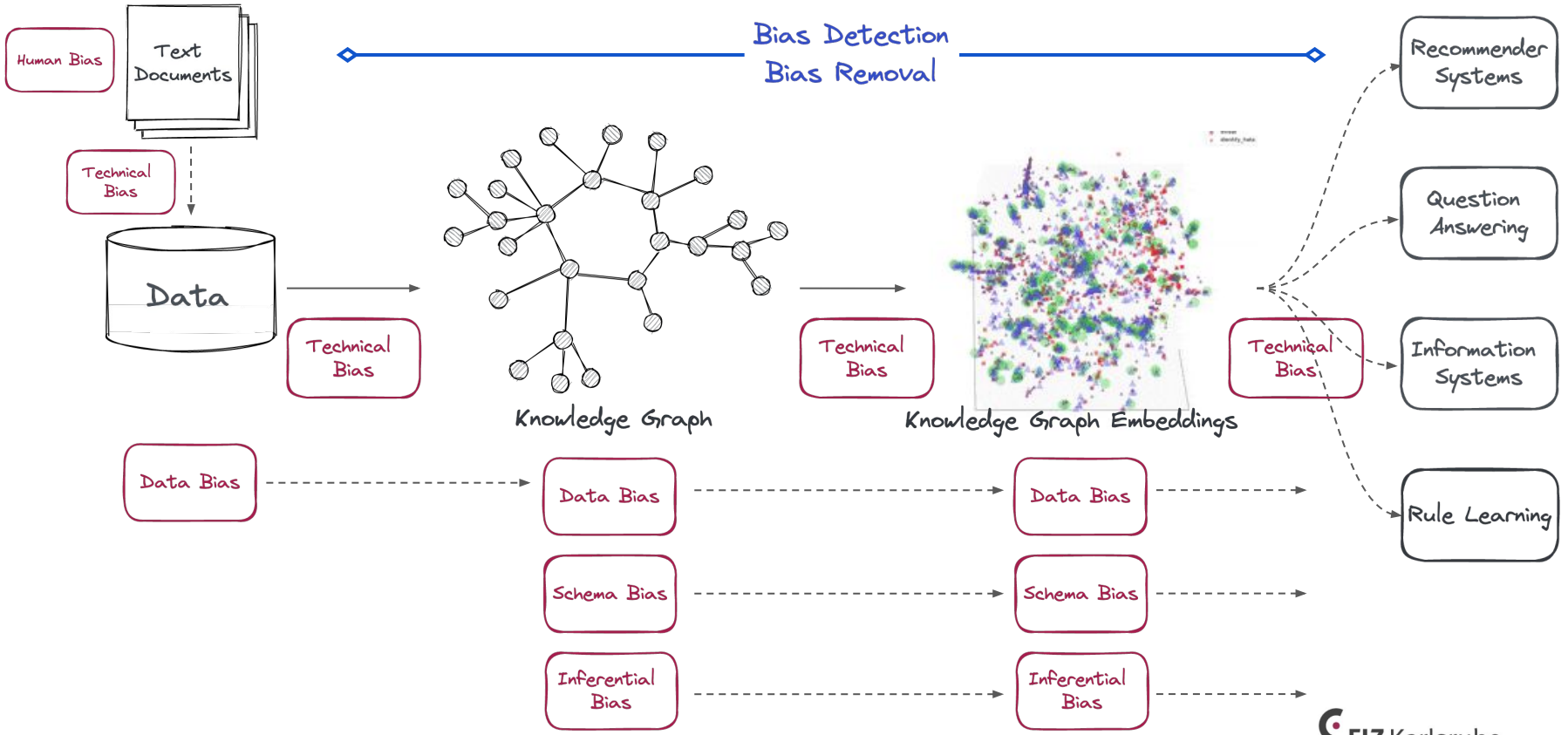
    Knowledge must be organized hierarchically, in thematic/context-dependent modules





- Hybrid AI (the other meaning): human intelligence in combination with machine intelligence
  - Provenance and trust

Bias as Foundational Trap



https://galactica.net/explore/

Towards a *better* Foundation in AI (Marcus & Davis, 2021)

1. Rich cognitive models that keep track of the dynamically changing world
   What is in the house? What is my favourite song? What do I expect today?
2. Extensive Real World Knowledge
   Most people in Italy speak Italian. If Aldo is from Bologna, it is most likely that he speaks Italian.
3. Representation of Relationships between entities
   If in a video a person drinks water, the system should not only recognize the objects but conclude that the person has quenched her thirst.
4. Compositionality, an agent must understand wholes in terms of parts
   “The Woman who went up a mountain and came down with a diamond” should be regognized as a sentence about a woman, who now possesses a diamond.
5. Common Sense Knowledge
   Time, space and causality including fundamental categories, e.g. physical objects, mental states, interpersonal relationships.
6. Reasoning
   If you know that a mixture of cherry and banana juice is non-toxic, the system should also know that when I drink it, then I most likely will not die.
7. Human Values – Ethics
   A medical chat-bot should know that it is not ok to recommend suicide.

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However, the subsymbolic AI approach also has its limitations. For example, it can be difficult to understand how a neural network makes a particular decision or prediction, and it can be difficult to explain the reasons behind its behavior. Additionally, the use of neural networks can be computationally intensive and require large amounts of data for training.

In conclusion, the field of AI is faced with an epic dilemma: should we pursue the symbolic AI approach, which is based on logical rules and well-understood principles, but has limitations in dealing with complex data? Or should we pursue the subsymbolic AI approach, which is based on the structure and function of the human brain, but can be difficult to understand and explain?

Ultimately, the answer to this dilemma may lie in combining the strengths of both approaches

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