Knowledge Graphs

Lecture 6 – Intelligent Applications with Knowledge Graphs and Deep Learning

6.4 Knowledge Graphs and Language Models

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[1]

Knowledge Graphs

Lecture 6: Intelligent Applications with Knowledge Graphs and Deep Learning

Karlsruher Institut für Technologie

FIZ Karlsruhe
Leibniz Institute for Information Infrastructure

6.1 The Graph in Knowledge Graphs

Excursion 8: Distributional Semantics and Language Models

6.2 Knowledge Graph Embeddings

6.3 Knowledge Graph Completion

6.4 Knowledge Graphs and Language Models

6.5 Semantic Search

6.6 Exploratory Search and Recommender Systems

[1]

How can Knowledge Graphs improve large language models?

Knowledge Graphs can improve large language models in several ways:

1. Enhancing Semantic Understanding: Large language models like GPT-3 are based on deep learning algorithms that learn to predict the next word or phrase based on the context of the text they are given. However, they may not always have the ability to understand the underlying meaning of the words or concepts being discussed. Knowledge Graphs can help fill this gap by providing a structured representation of entities and their relationships, which can help the model understand the context of the text better and improve its semantic understanding.
2. Expanding Knowledge Base: Large language models can only learn from the text they are trained on. Knowledge Graphs can provide a wealth of structured data that can be used to expand the model's knowledge base. By integrating the information from the Knowledge Graph into the model, it can improve its accuracy and generate more informative responses.
3. Better Contextualization: Knowledge Graphs can provide a way to better contextualize the text by linking entities and concepts together. By understanding the relationships between entities and concepts, the model can generate more accurate and relevant responses.
4. Entity Resolution: Knowledge Graphs can help the model understand the different ways entities can be referred to and resolve them to a common representation. This can help the model generate more consistent and accurate responses.

Overall, Knowledge Graphs can help improve the accuracy, relevance, and contextuality of large language models, making them more useful for a variety of applications.

https://chat.openai.com/chat

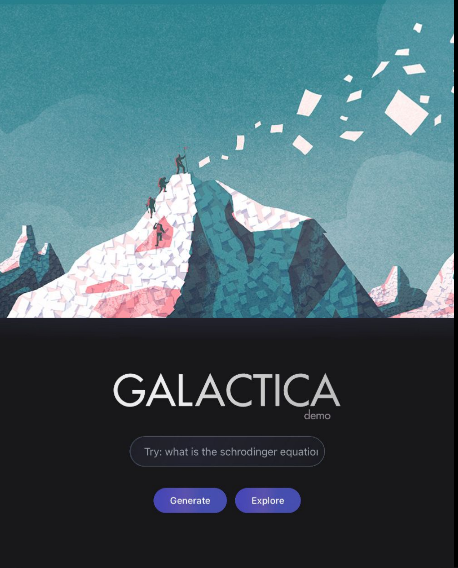
https://galactica.org/pape

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

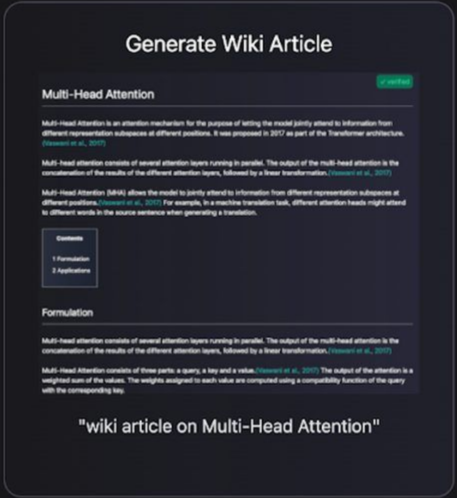
https://twitter.com/ylecun/status/15926194000244285

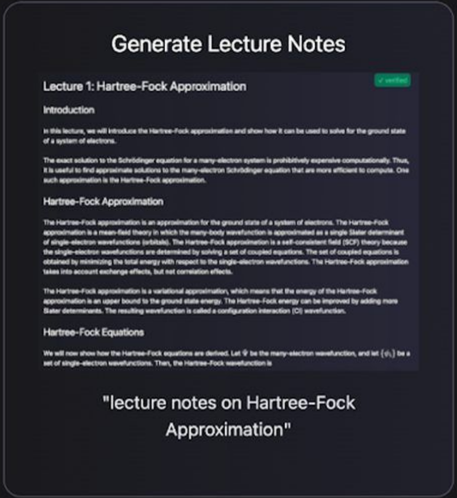


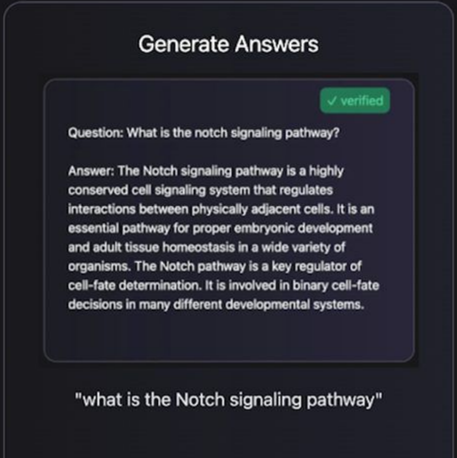
GALACTICA.AI

[Nov 2022]

- **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.







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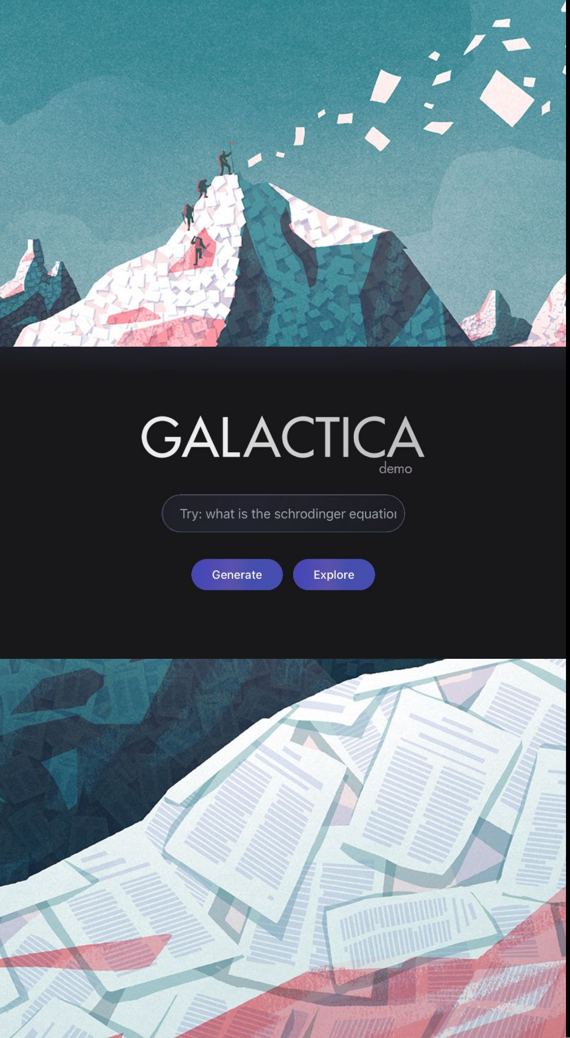

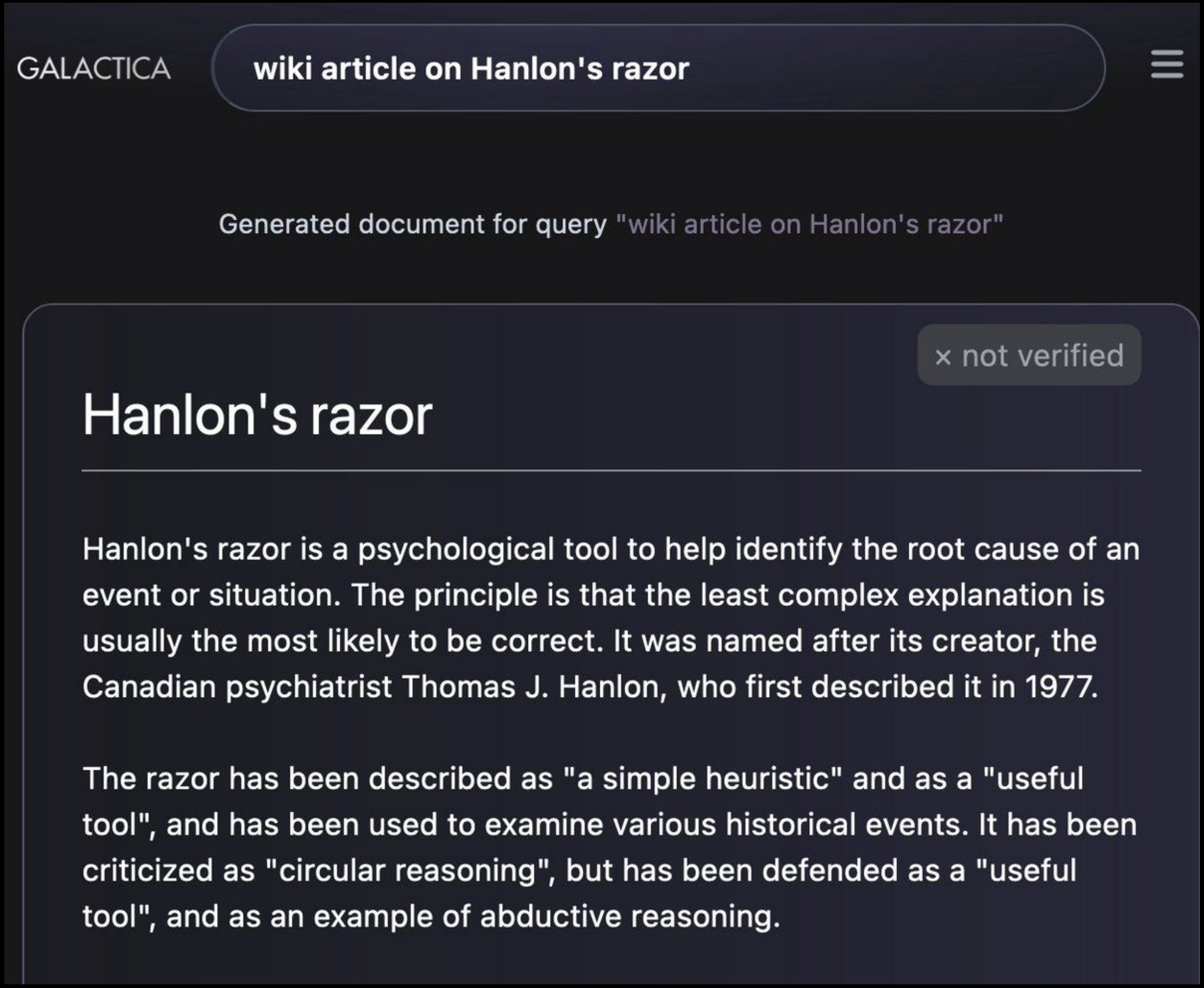
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wiki article on Hanlon's razor

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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.

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.

Contents [hide]

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

GALACTICA
demo

Try: what is the schrodinger equation

Generate Explore

× not verified

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

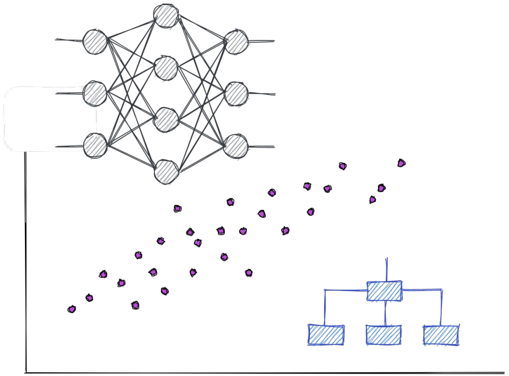
A graph is called a split bipartite graph if its vertex set can be partitioned into two sets A and B such that A is a clique

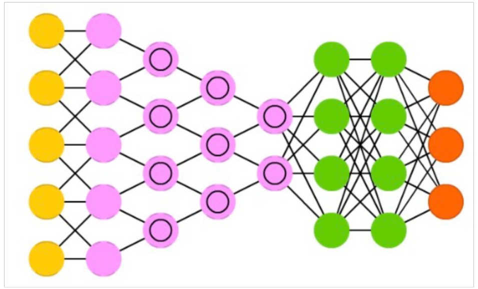
Deficiencies of Large Language Models

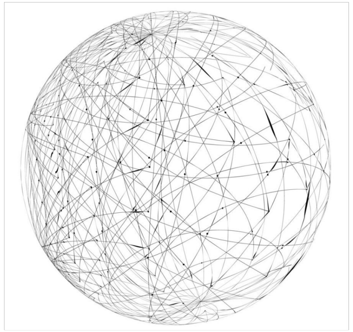
- **Language Models may hallucinate**
  There is no guarantee for truthful or reliable output.
- **Language Models are frequency-biased**
  High resource domains might be better, i.e. more reliably represented, than long tail low resource domains.
- **Language Models often seem to be convincing, but may be wrong**
  Answers might appear rather convincing or authentic, but might be wrong in subtle ways.

Never follow advice from a language model without verification!

60+ Years of Machine Learning





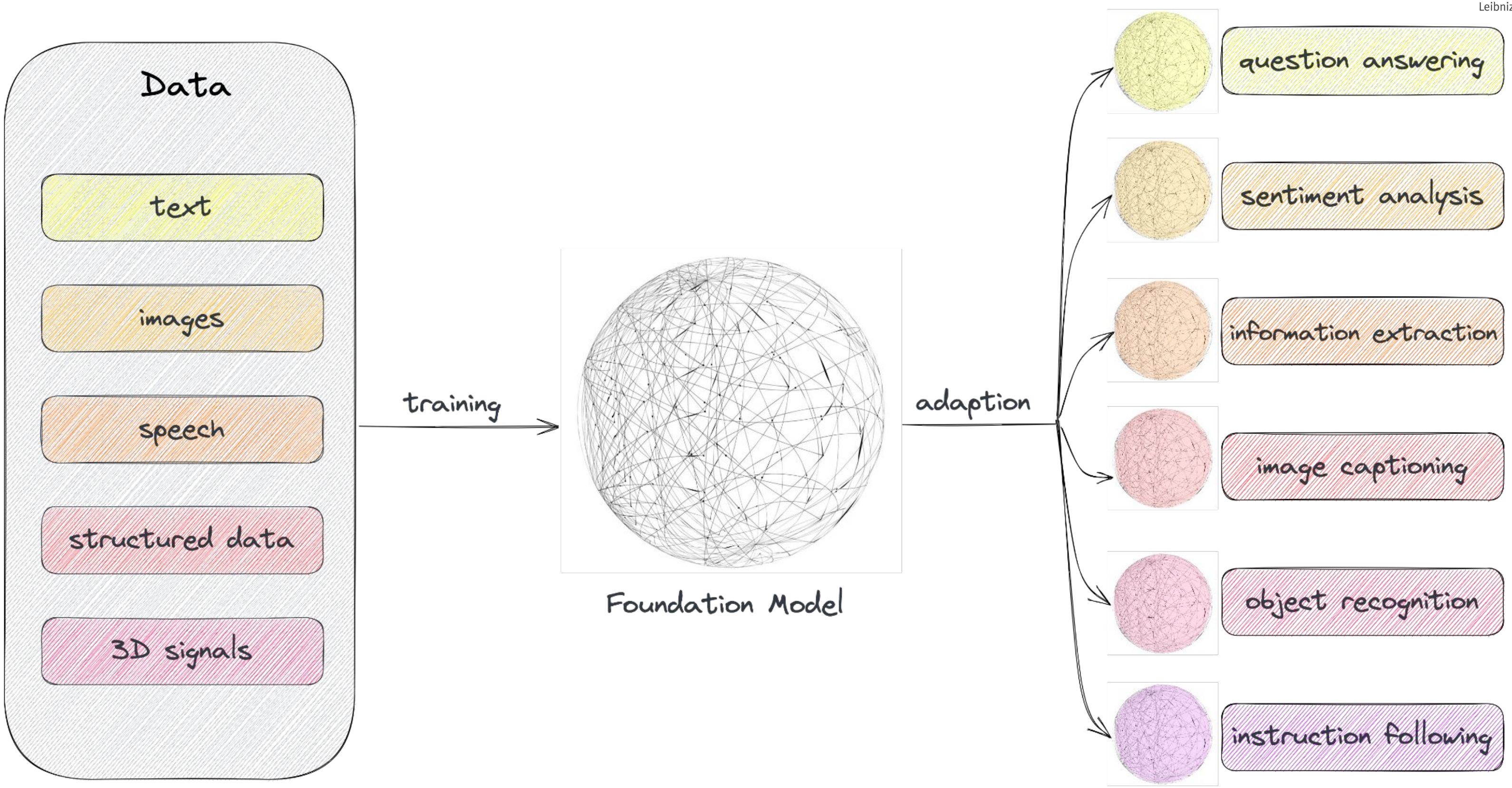


Machine Learning | Deep Learning | Foundation Models

Emergence of … — **“How”** (from examples) — **“Features”** (used for prediction) — (advanced) **“Functionalities”**

Homogenization of … — **Learning Algorithms** (e.g. logistic regression) — **Model Architectures** (e.g. CNNs) — **Models** (e.g. GPT-3/4)

The Advent of Foundation Models



Semantics from Stochastics?

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- 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 (most times) be correctly answered.
  - What about **Interpretative questions** and **Evaluative questions?**

ALEPH ALPHA https://www.aleph-alpha.com/ (Nov 2022)

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

\n

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:

Interpretative questions or **Evaluative questions** might be subject of inherent **bias** (of the training data).

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?**

- 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.

Symbolic AI to the Rescue

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

Good for (some) learning,
bad for abstraction

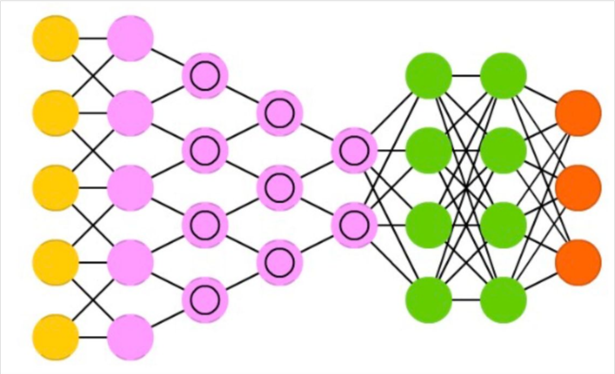
Hybrid AI Models

Classical AI will also not get us to robust AI.

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



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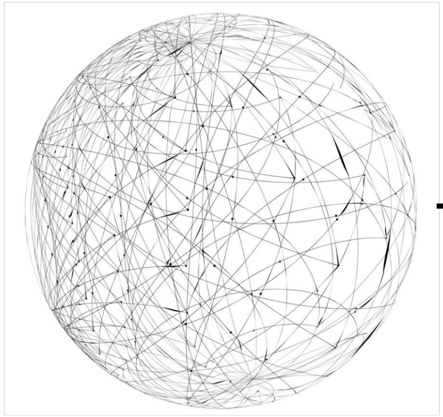

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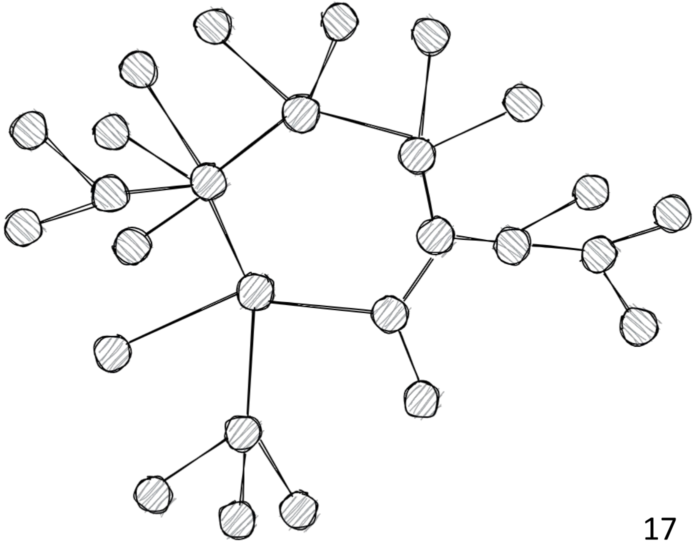

Hybrid AI – Knowledge Graph Embeddings

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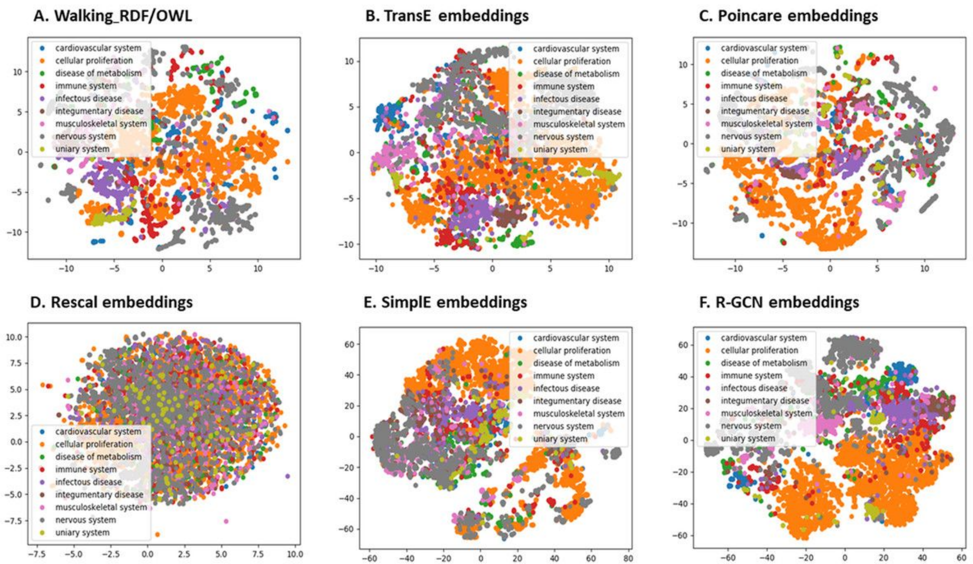
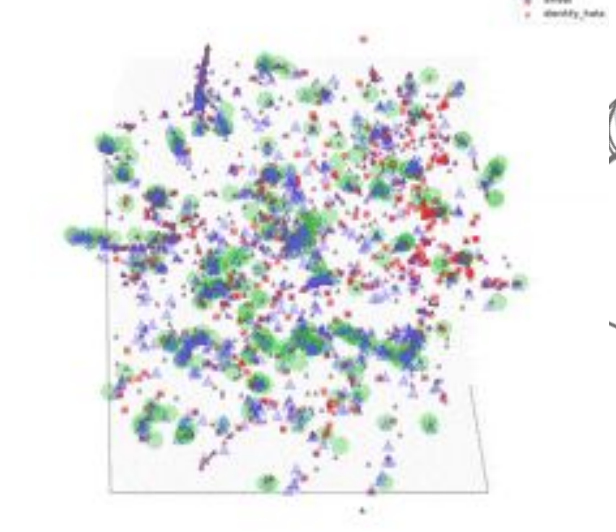
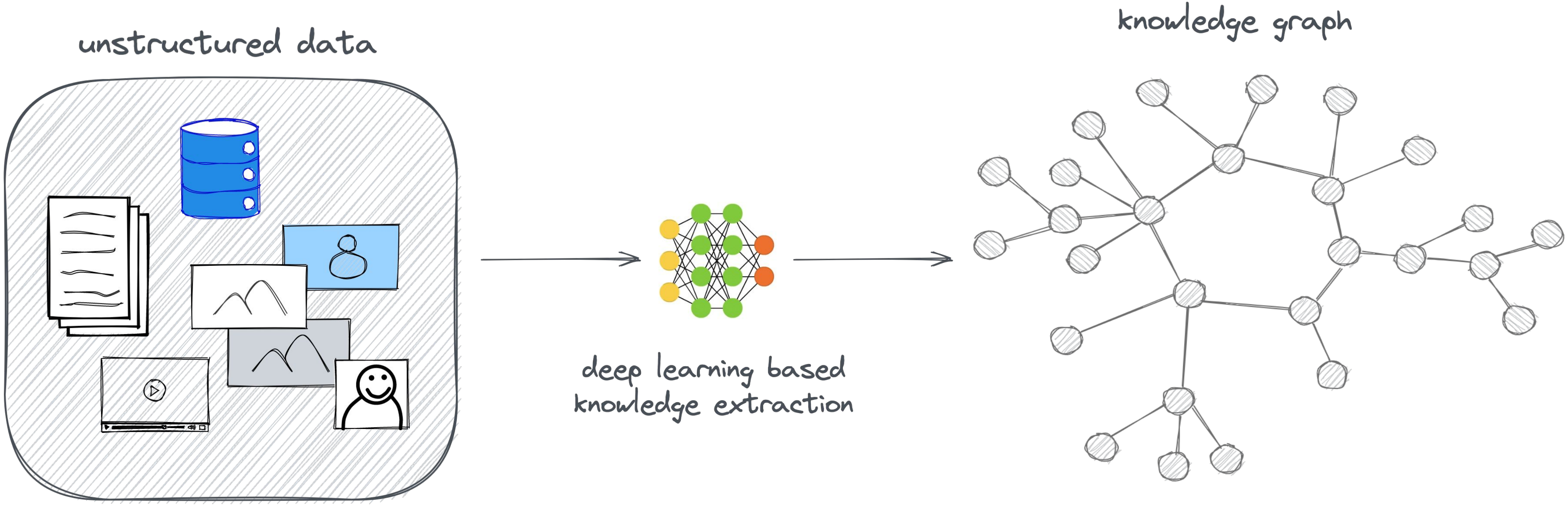




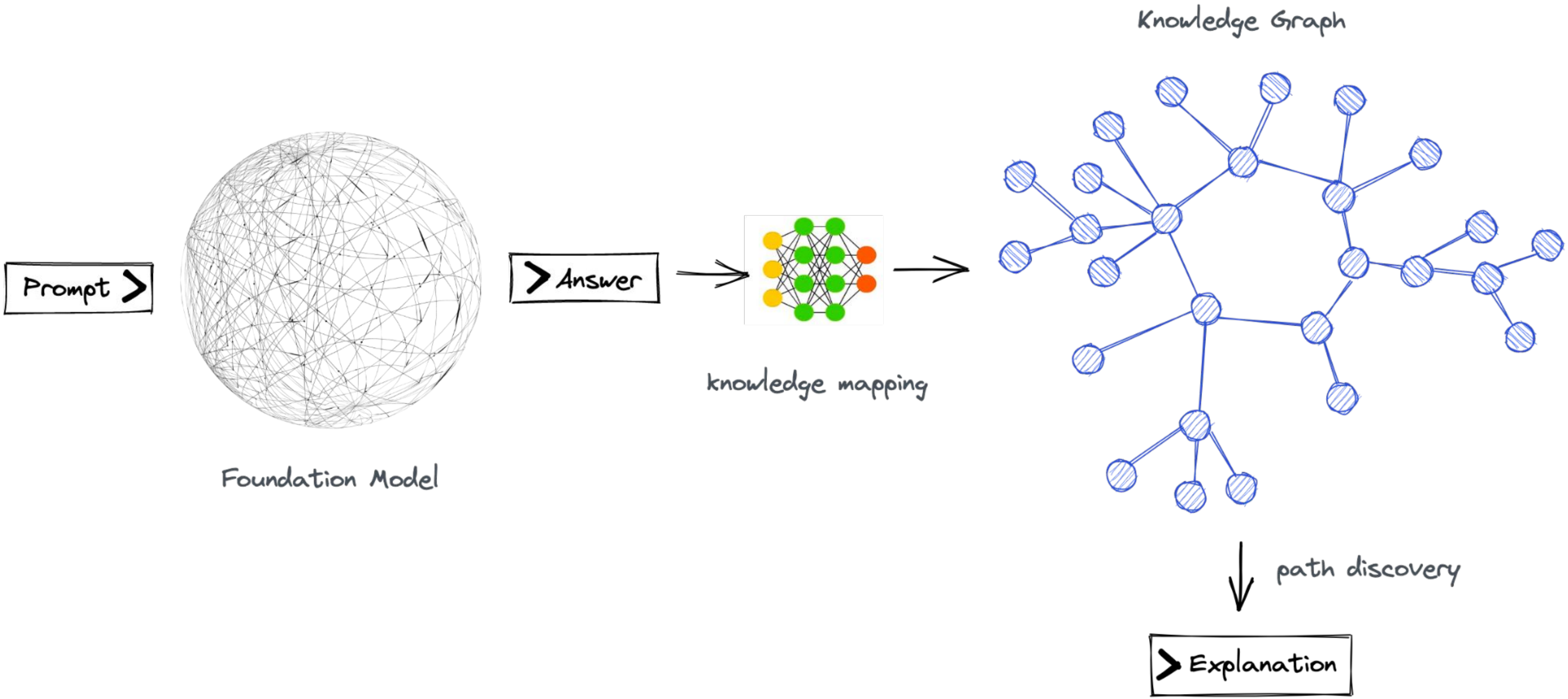
- Knowledge Graph Completion
- KGE for Classification Tasks
- Ontology Mapping
- Entity/Knowledge Graph Alignment

Hybrid AI – Knowledge Extraction

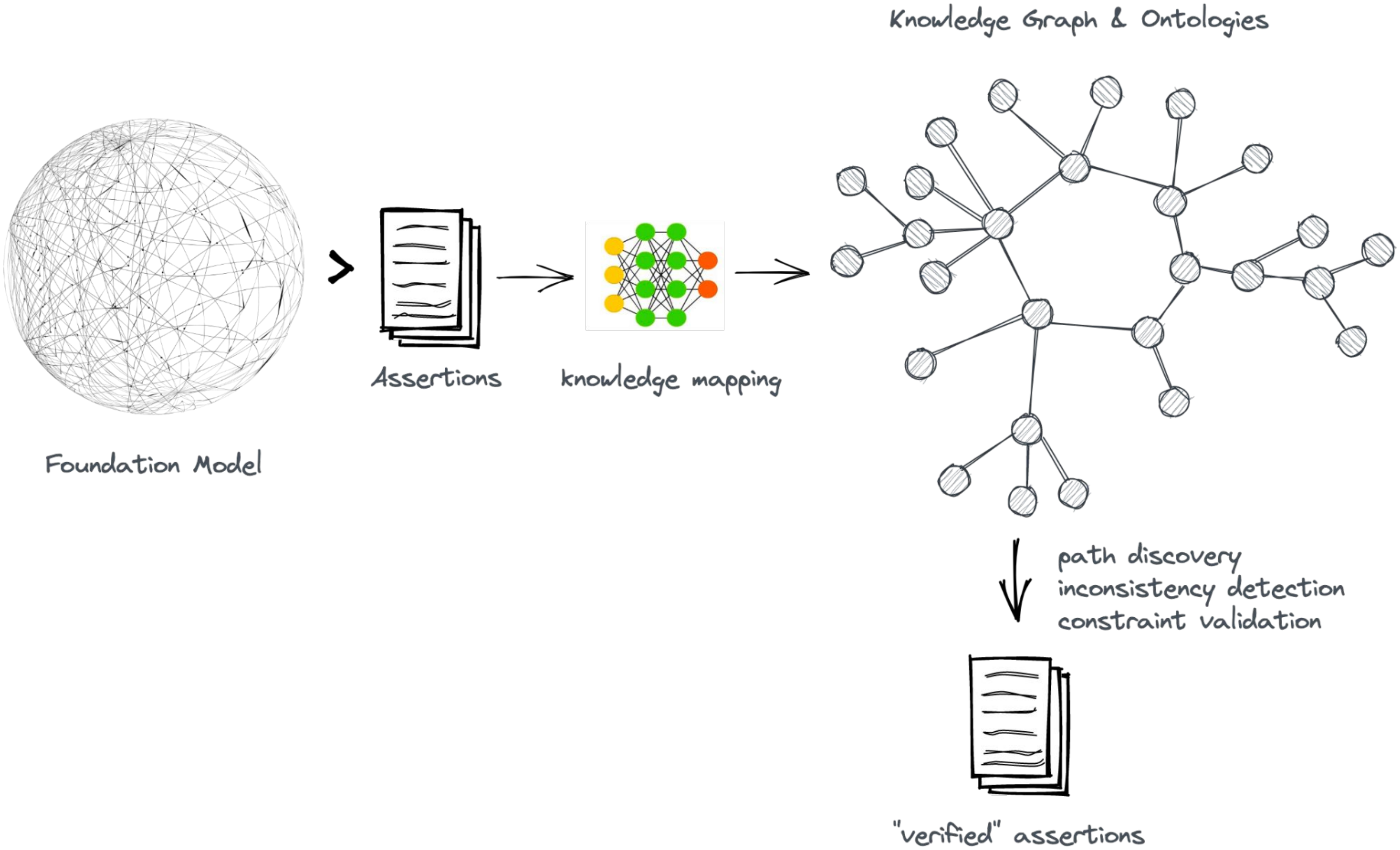


- Knowledge Graph Population
- Ontology Learning
- Entity Recognition & Linking
- Relation Extraction

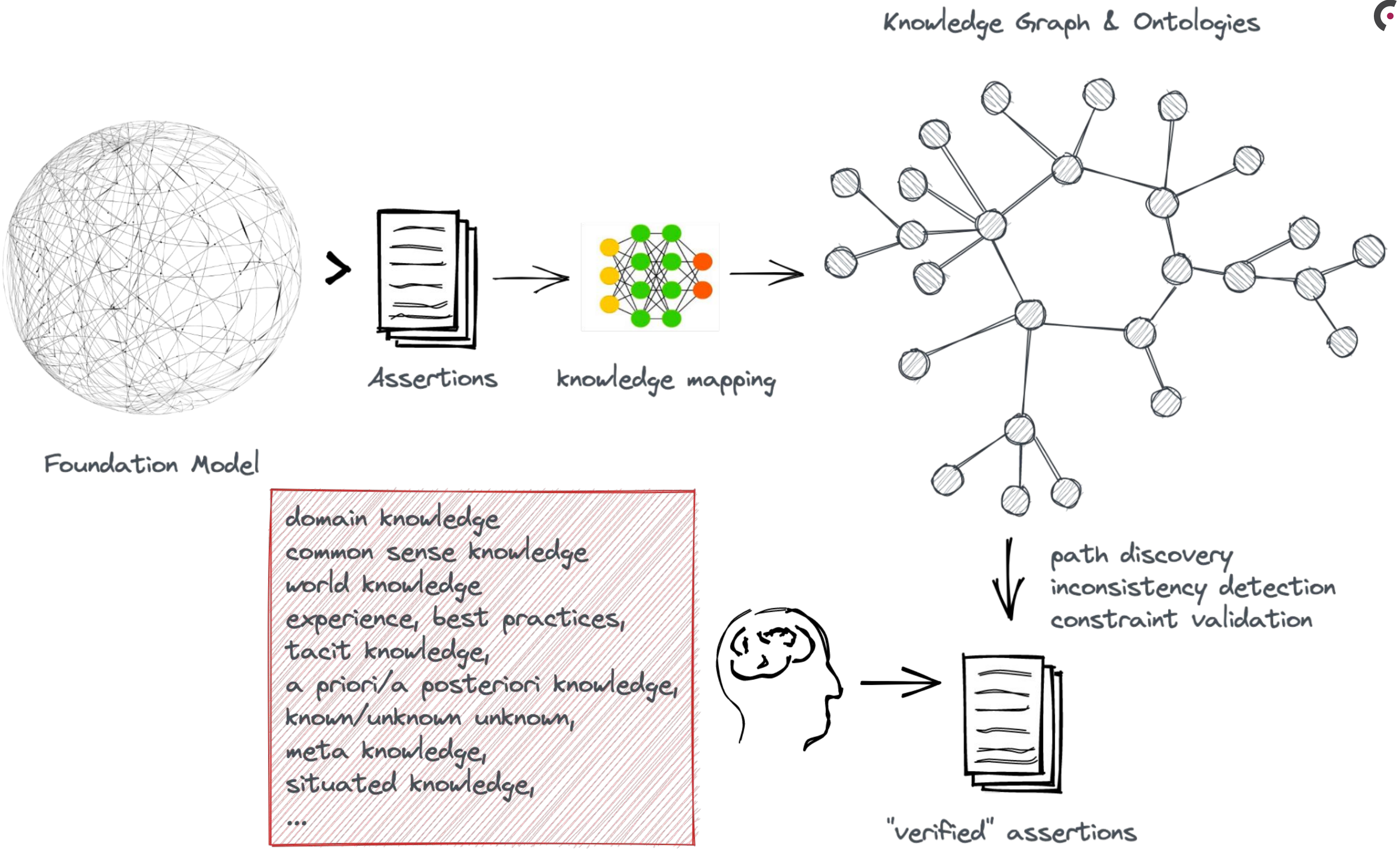
Hybrid AI – Explainable AI



Hybrid AI – Fact Checking



Hybrid AI – Fact Checking and Human Intelligence

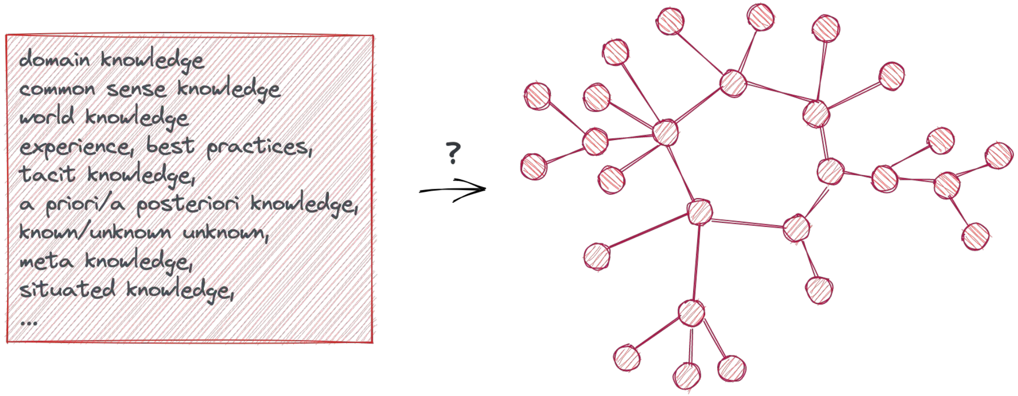


Hybrid AI – Fact Checking and Human Intelligence

- A general use case potentially requires all kinds of **knowledge** to be **explicitly available**

- **Reasoning** will be another potential bottleneck:
  - From **doubt** to **justification**
  - The importance of **order**:

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



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

  → Provenance and trust

Semantic Search

Next Lecture...

[2]

Bibliographic References:

- R. Taylor, M. Kardas, G. Cucurull, T. Scialom, A. Hartshorn, E. Saravia, A. Poulton, V. Kerkez, R. Stojnic (2022), *Galactica: A Large Language Model for Science*, arXiv:2211.09085 [cs.CL].
- G. Marcus (2021). *Has AI found a new foundation?*, The Gradient, 11.09.2021.
- G. Marcus, E. Davis. *Insights for AI from the human mind*. Commun. ACM 64, 1 (January 2021), 38–41.

Picture References:

[1] “On this colorized woodcut in the style of Hokusai we see a pensive woman together together giant octopus who melancholically entangles the knowledge graph that extends into the vast empty space of the universe to the galaxies and stars.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0], https://tinybots.net/artbot

[2] “On this romantic painting in the style of Goya we see a pensive woman together together giant octopus who melancholically entangles the knowledge graph that extends into the vast empty space of the universe to the galaxies and stars.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0], https://tinybots.net/artbot