Data Science and AI for Medicine Training School

TRAINING: Introduction to Large Language Models

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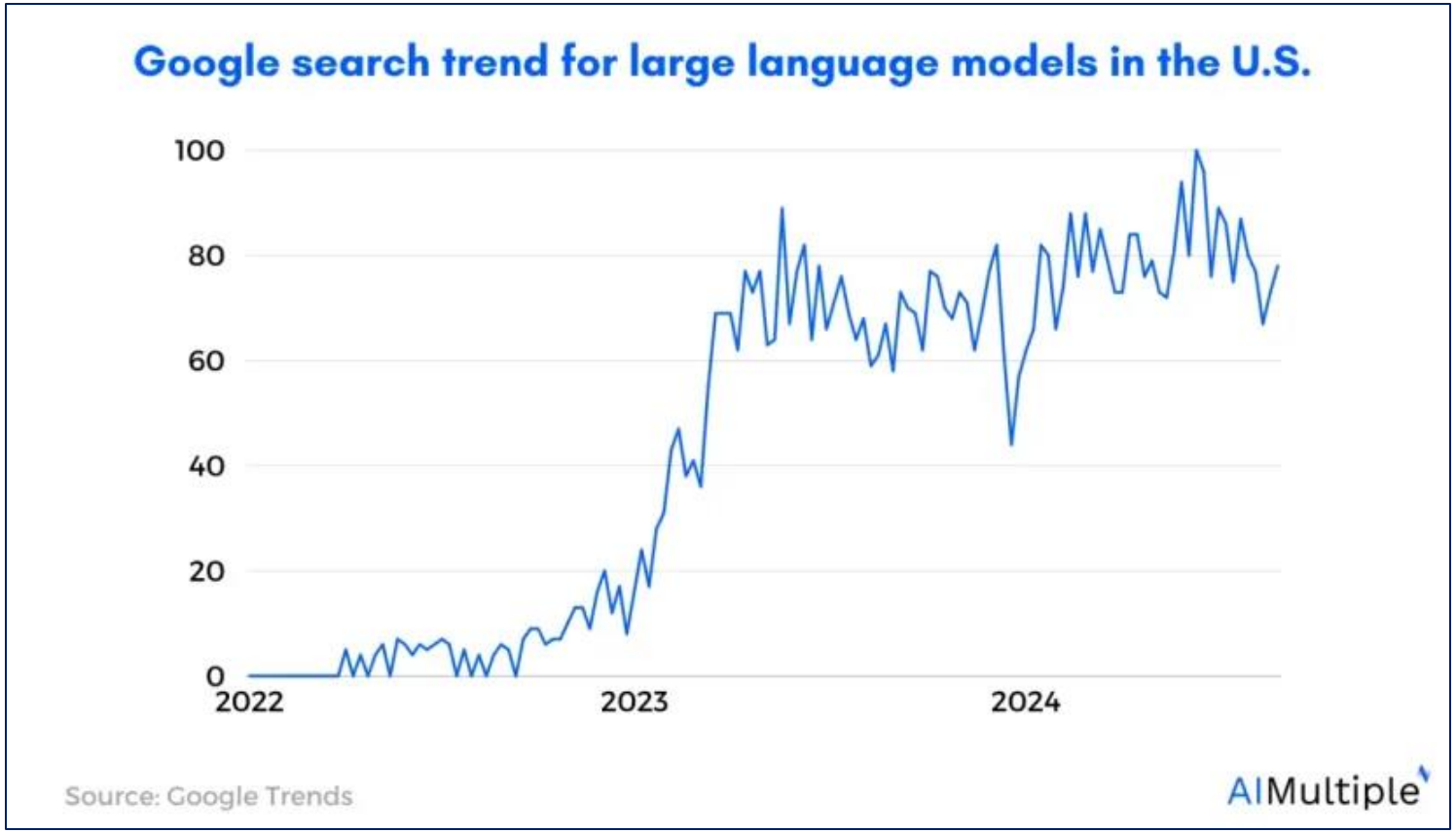
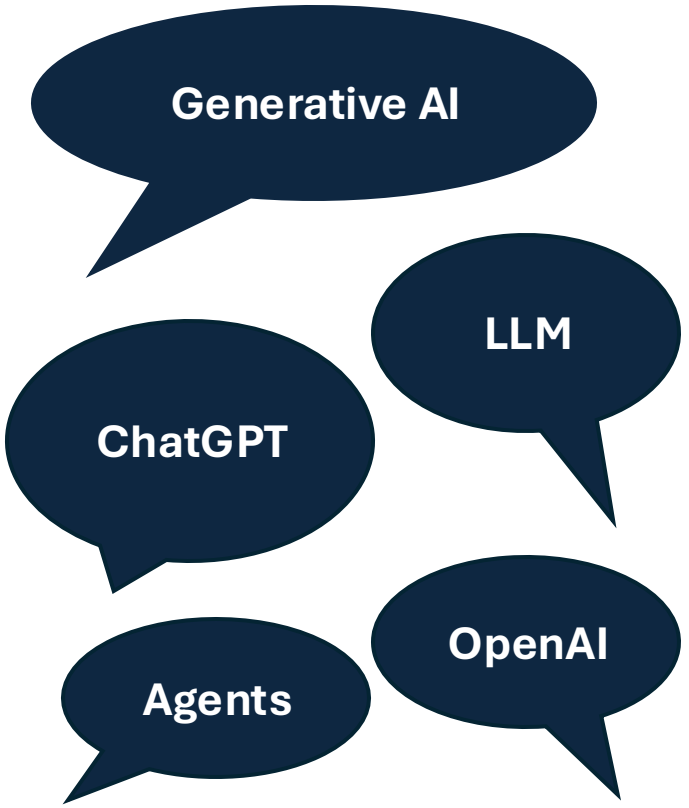
SACHSEN
Diese Maßnahme wird gefördert durch die Bundesregierung aufgrund eines Beschlusses des Deutschen Bundestages. Diese Maßnahme wird mitfinanziert durch Steuermittel auf der Grundlage des von den Abgeordneten des Sächsischen Landtags beschlossenen Haushaltes.

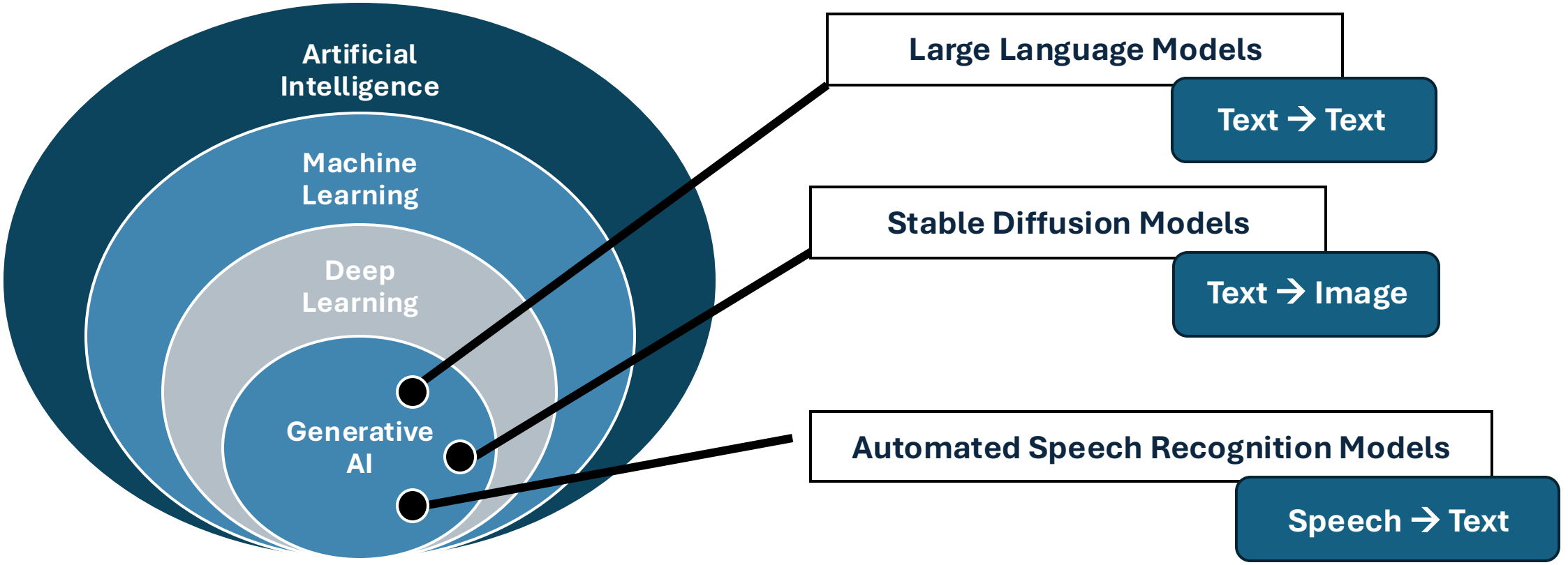
The Rise of Large Language Models



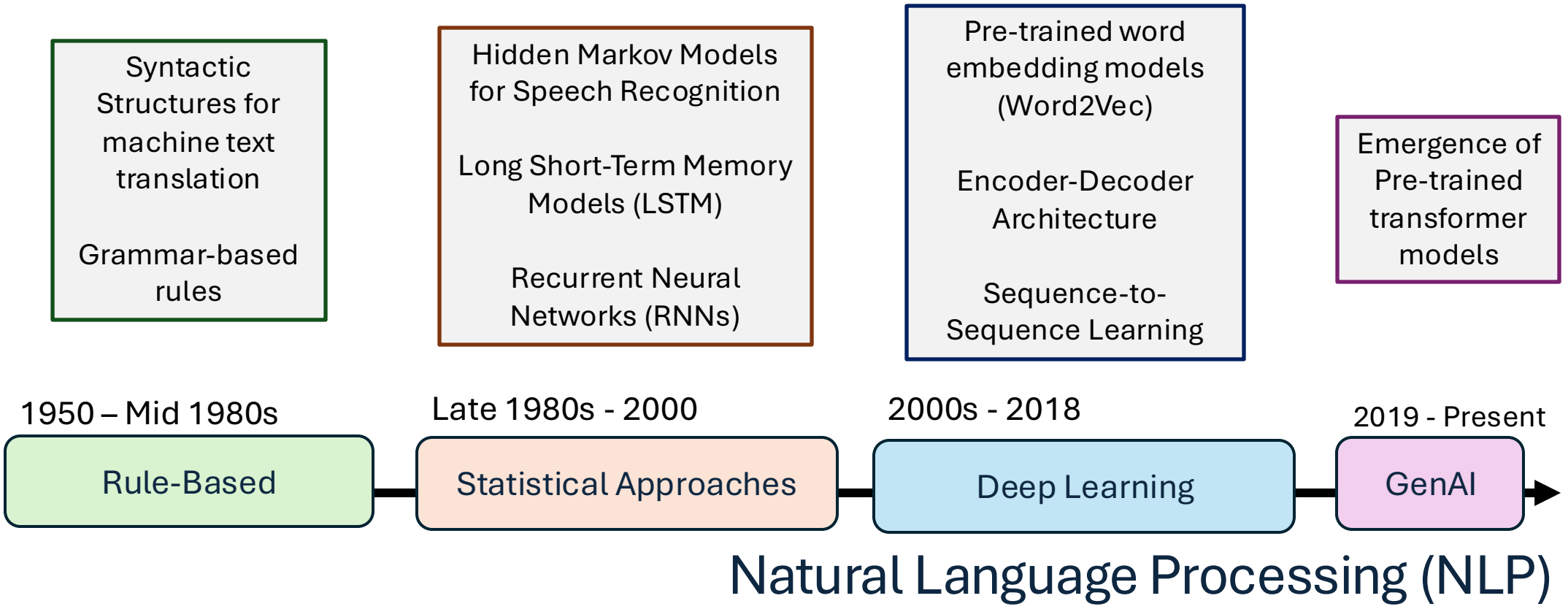


Source: https://research.aimultiple.com/future-of-large-language-models/

Where do Large Language Models fit into the AI Space

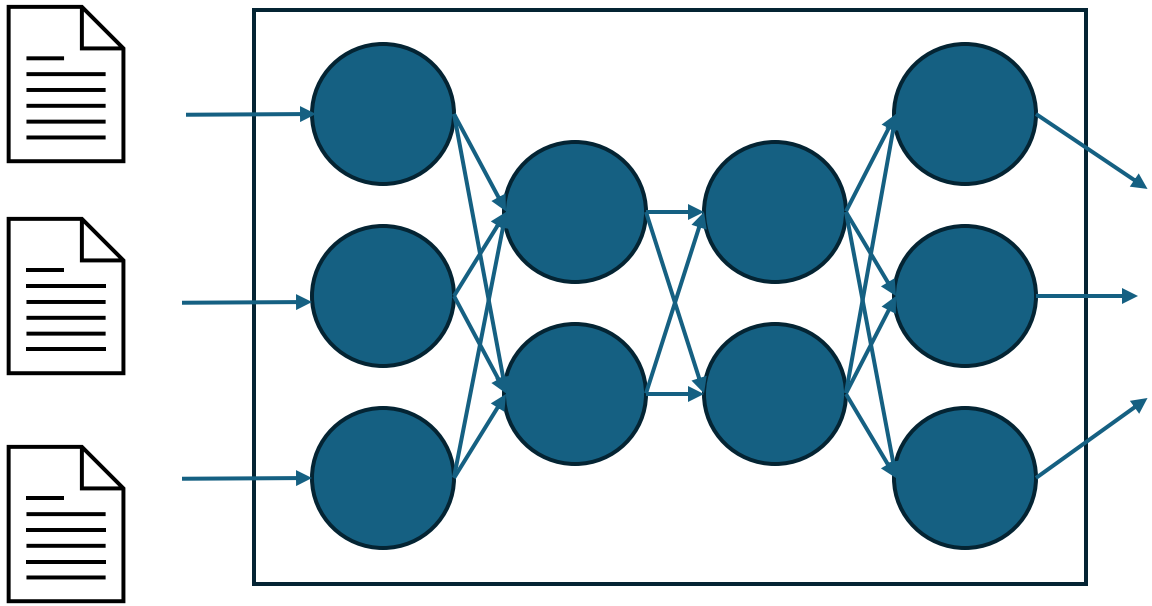


The progression towards Large Language Models

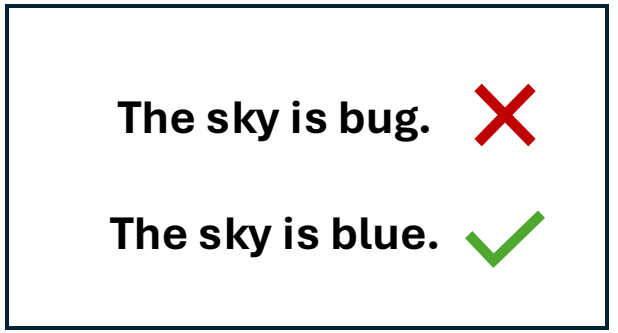


https://blog.dataiku.com/nlp-metamorphosis

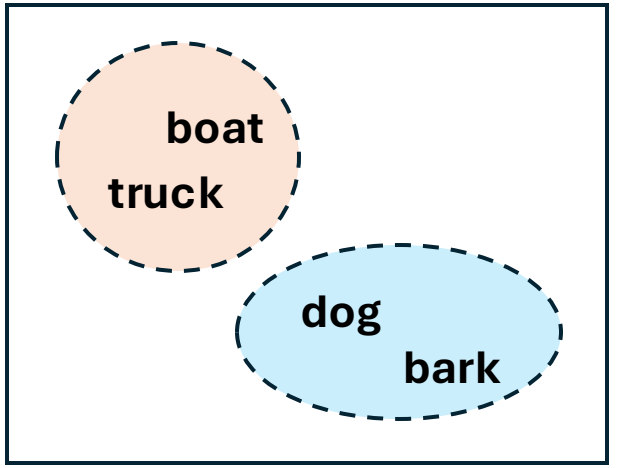
How Natural Language is Modelled within LLMs



Transformer Architecture with
Attention Mechanism

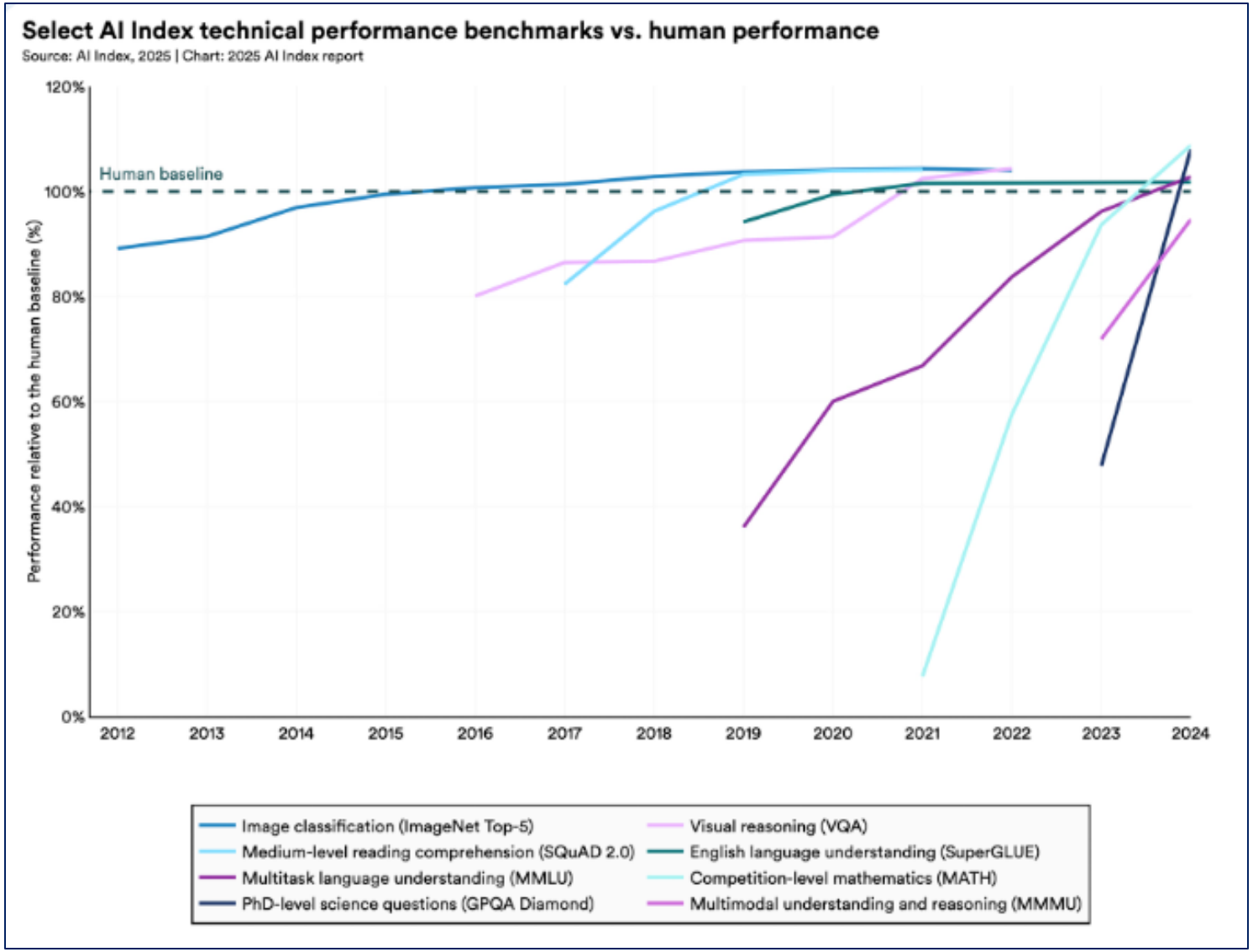


Textual Patterns



Semantic Patterns

Zero-Shot LLMs are highly performative

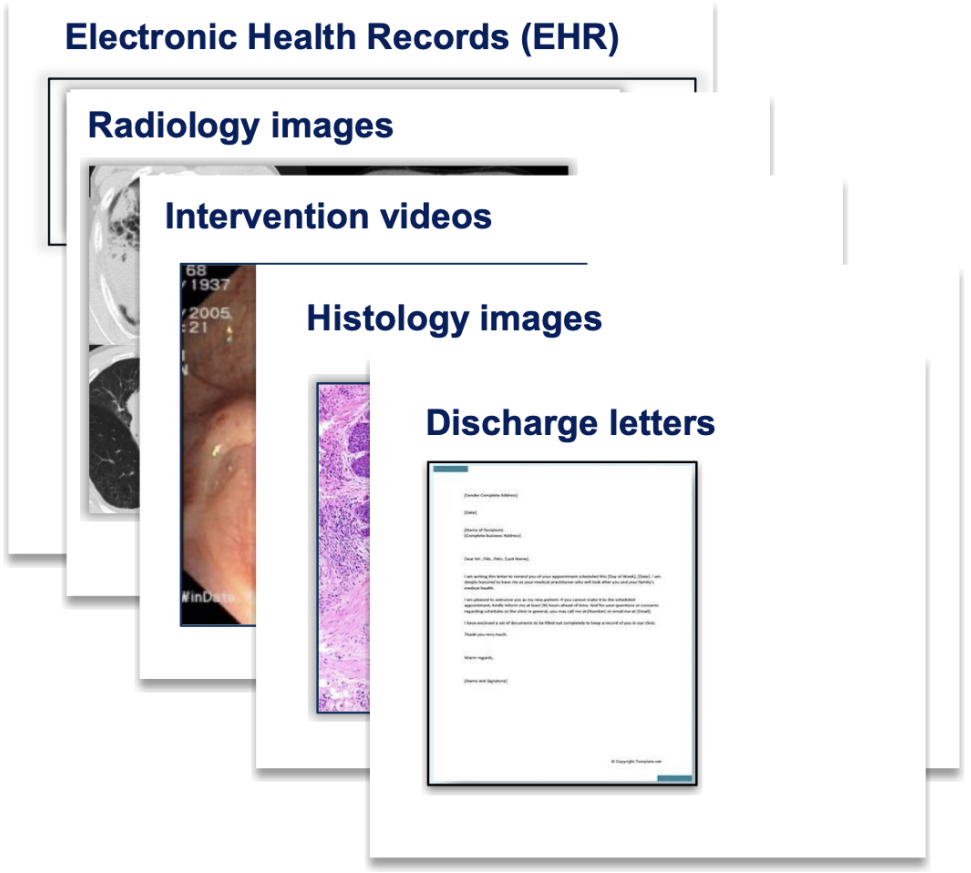


https://hai.stanford.edu/ai-index/2025-ai-index-report

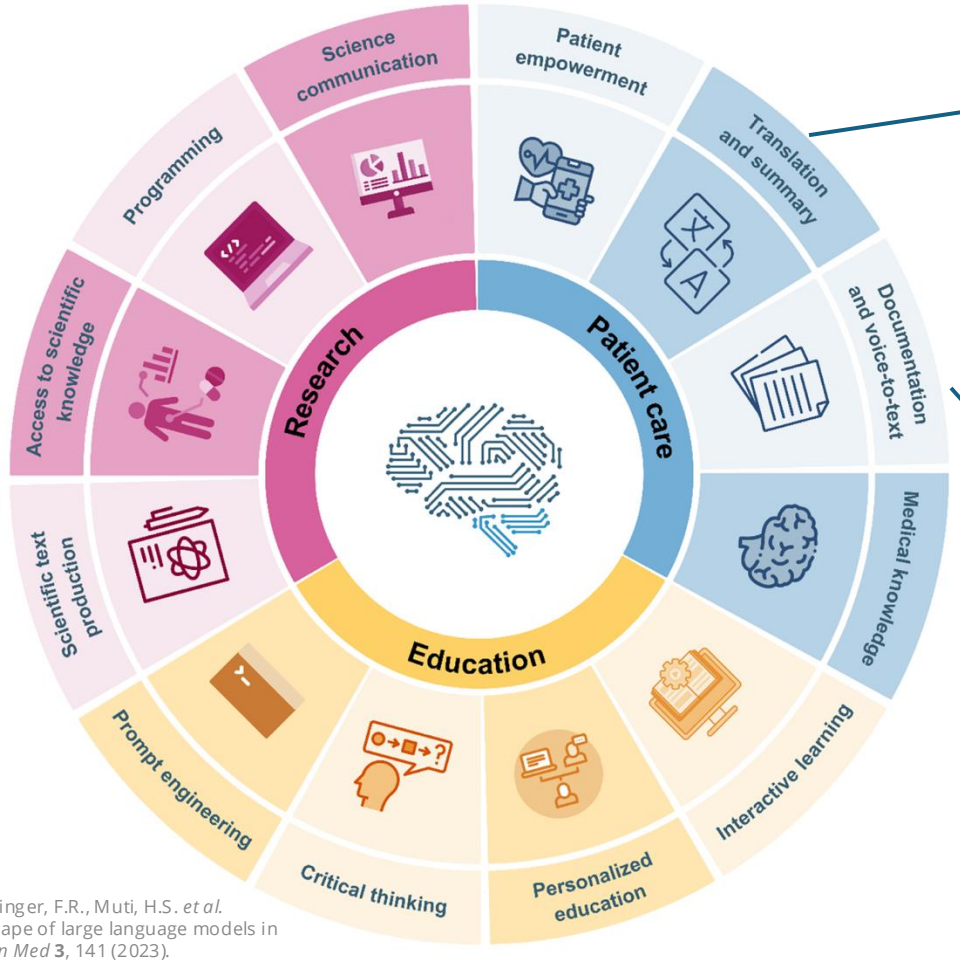
LLMs are well suited for Medical Tasks

Properties of Medical Applications

- Unstructured Data
- Multimodal Data
- Personalized Solutions
- Large amounts of Knowledge
- Complex Reasoning



LLMs show potential for diverse clinical applications



Clusmann, J., Kolbinger, F.R., Muti, H.S. *et al.* The future landscape of large language models in medicine. *Commun Med* **3**, 141 (2023). https://doi.org/10.1038/s43856-023-00370-1

nature medicine

Article https://doi.org/10.1038/s41591-024-02855-5

Adapted large language models can outperform medical experts in clinical text summarization

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Check for updates

Dave Van Veen[1,2], Cara Van Uden[2,3], Louis Blankemeier[1,2], Jean-Benoit Delbrouck[2], Asad Aali[4], Christian Bluethgen[2,5], Anuj Pareek[2,6], Malgorzata Polacin[5], Eduardo Pontes Reis[2,7], Anna Seehofnerová[8,9], Nidhi Rohatgi[8,10], Poonam Hosamani[8], William Collins[8], Neera Ahuja[8], Curtis P. Langlotz[2,8,9,11], Jason Hom[8], Sergios Gatidis[2,9], John Pauly[1] & Akshay S. Chaudhari[2,9,11,12]

npj | digital medicine

Privacy-preserving large language models for structured medical information retrieval

Isabella Catharina Wiest, Dyke Ferber, Jiefu Zhu, Marko van Treeck, Sonja K. Meyer, Radhika Juglan, Zunamys I. Carrero, Daniel Paech, Jens Kleesiek, Matthias P. Ebert, Daniel Truhn & Jakob Nikolas Kather

Limitations of LLMS and their effect in Clinical Settings

HALLUCINATIONS OR FACTUAL INACCURACIES

Need for Validated Outputs for High-Risk Applications

DATA PRIVACY

Patient Privacy and Regulatory Concerns

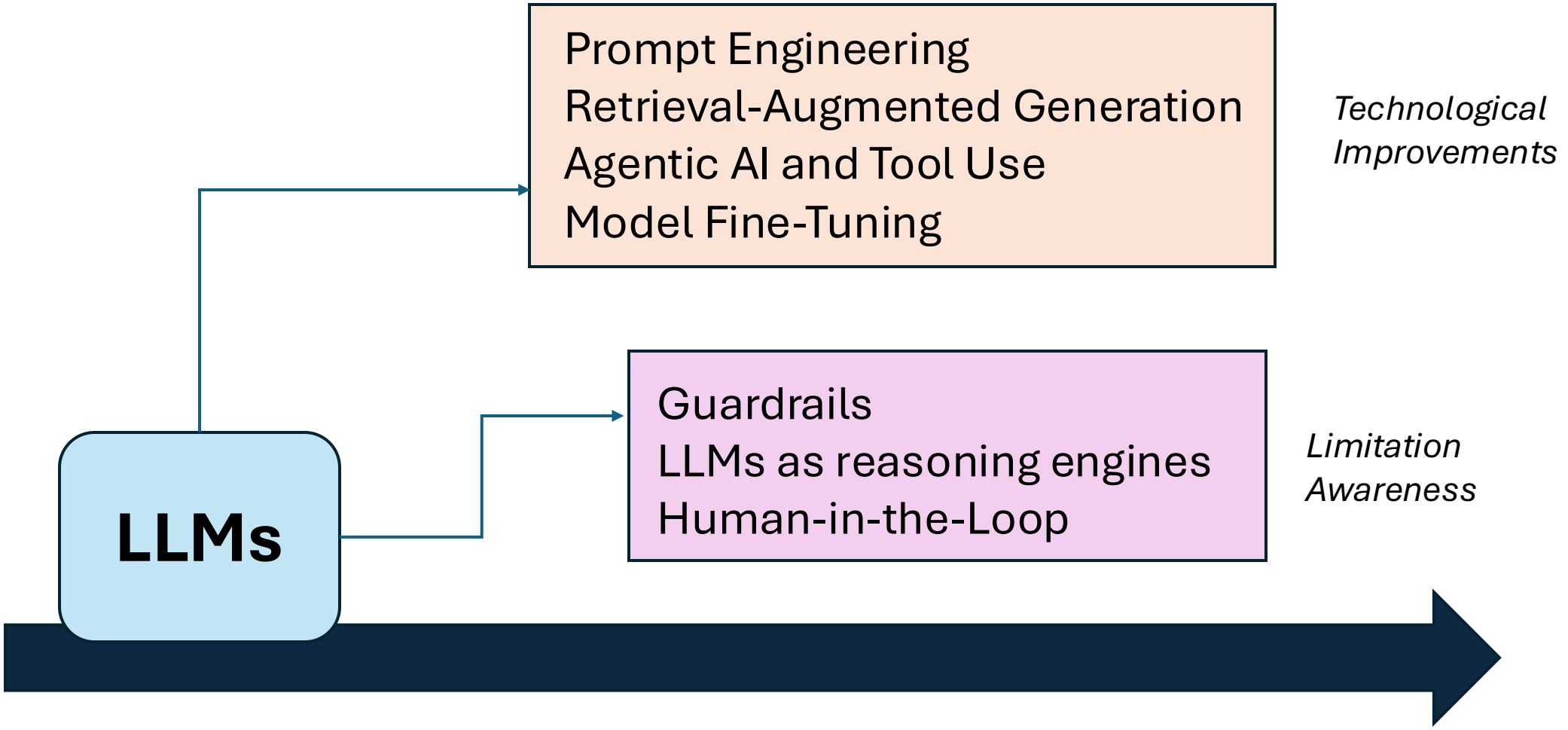
TRAINING CUTOFFS LIMITING KNOWLEDGE AVAILABILITY

Concordance with updated medical policies and knowledge

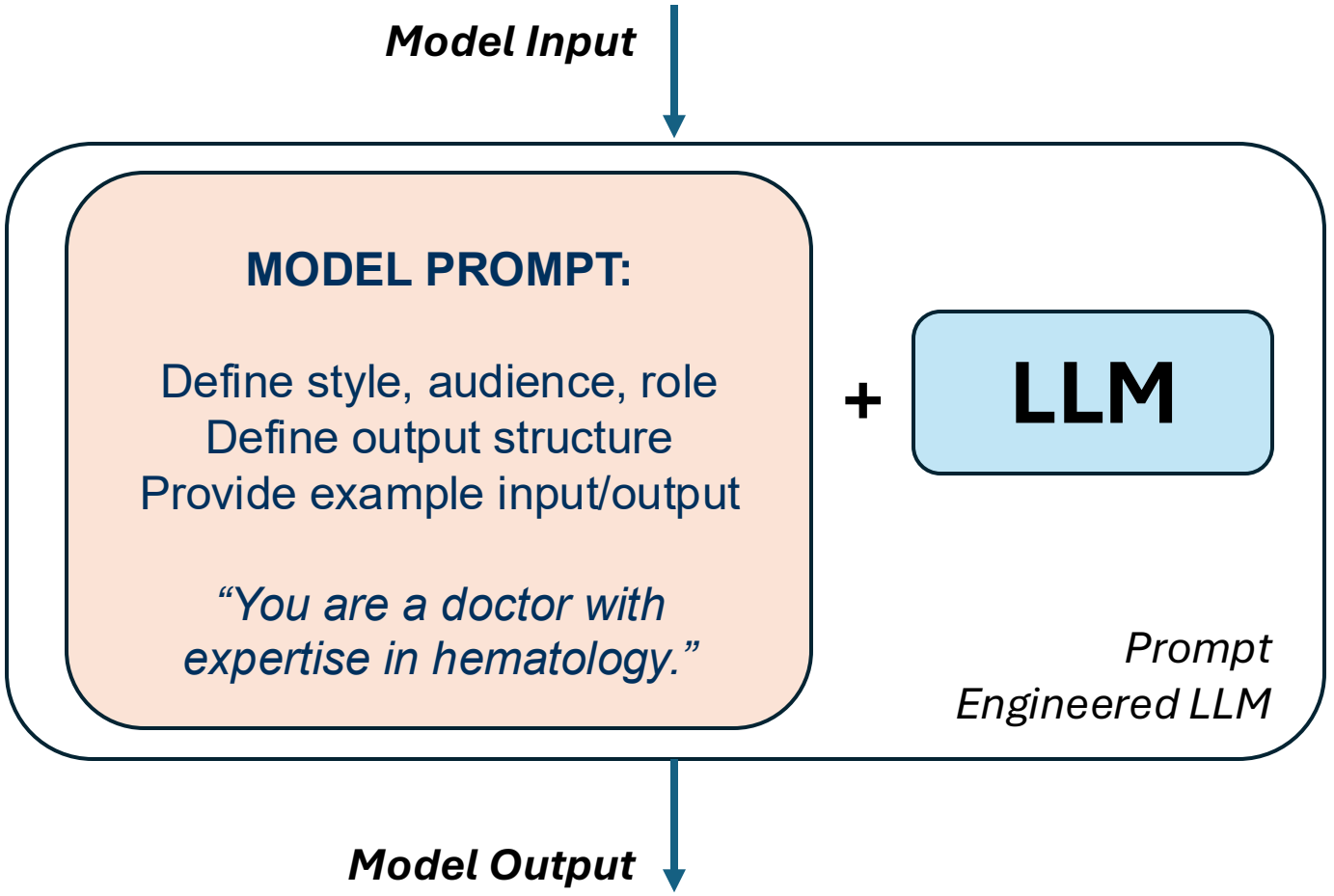
MODEL BIAS

Ethical Concerns for Patient Fairness

The field of LLMs is continuously evolving



Prompt Engineering



⚠ Zero-Shot LLMs:

Model hallucinations

Inconsistent outputs

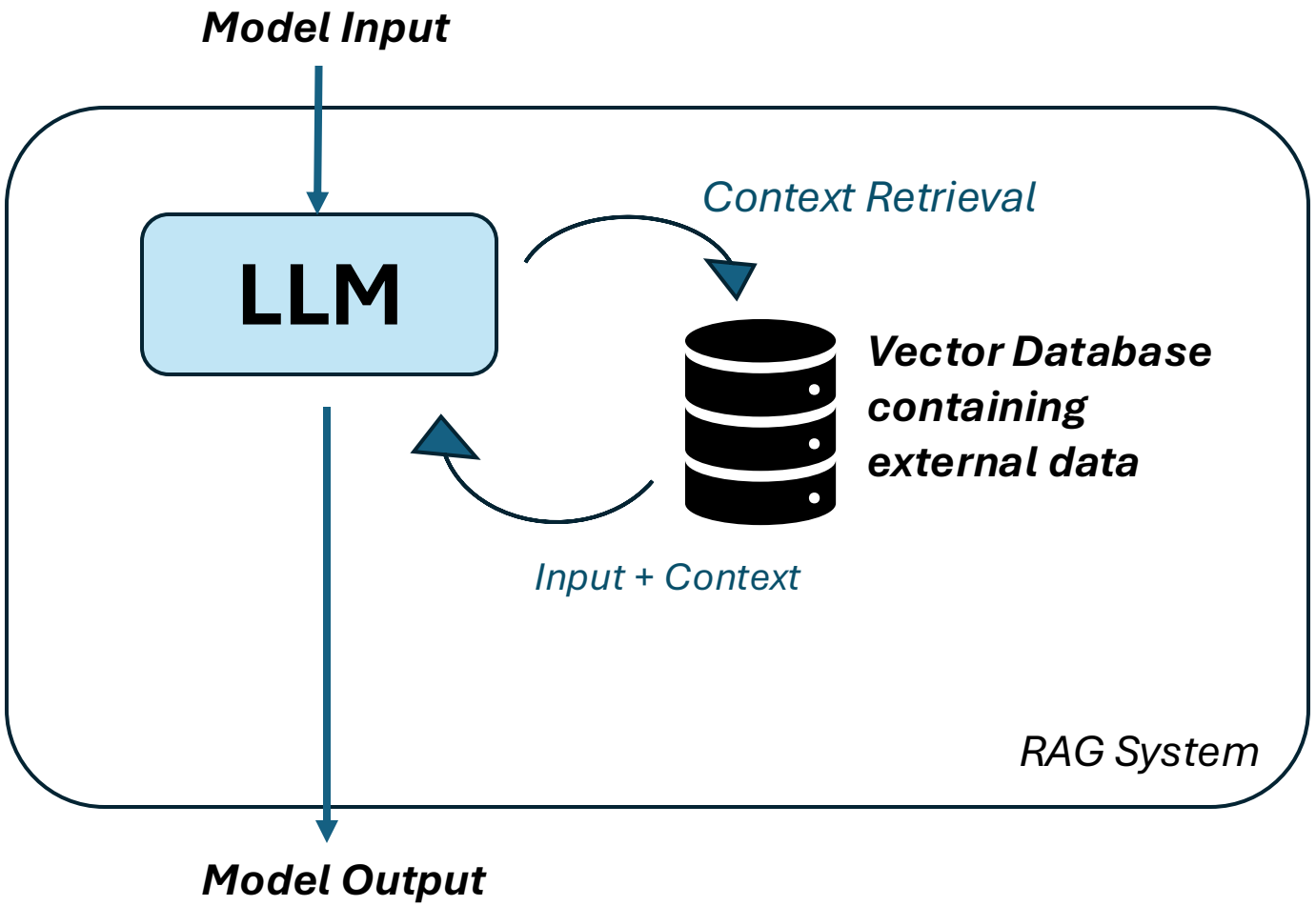
✓ Prompt Engineering

Improved instruction following

Improved output consistency

Domain adaptation

Retrieval Augmented Generation (RAG)



⚠ Zero-Shot LLMs:

Factual Inaccuracies

Knowledge Cutoffs

✓ RAG

Leverages LLM for reasoning

External Grounding

Multimodal data integration

Curation of trusted data sources

Retrieval-Augmented Generation (RAG) Clinical Example

NEJM AI

CASE STUDY

GPT-4 for Information Retrieval and Comparison of Medical Oncology Guidelines

Authors: Dyke Ferber, Isabella C. Wiest, M.D., M.Sc., Georg Wölflein, M.Sc., Matthias P. Ebert, M.D., Gernot Beutel, M.D., Jan-Niklas Eckardt, M.D., M.Sc., Daniel Truhn, M.D., M.Sc., Christoph Springfeld, M.D., Ph.D., Dirk Jäger, M.D., and Jakob Nikolas Kather, M.D., M.Sc. Author Info & Affiliations

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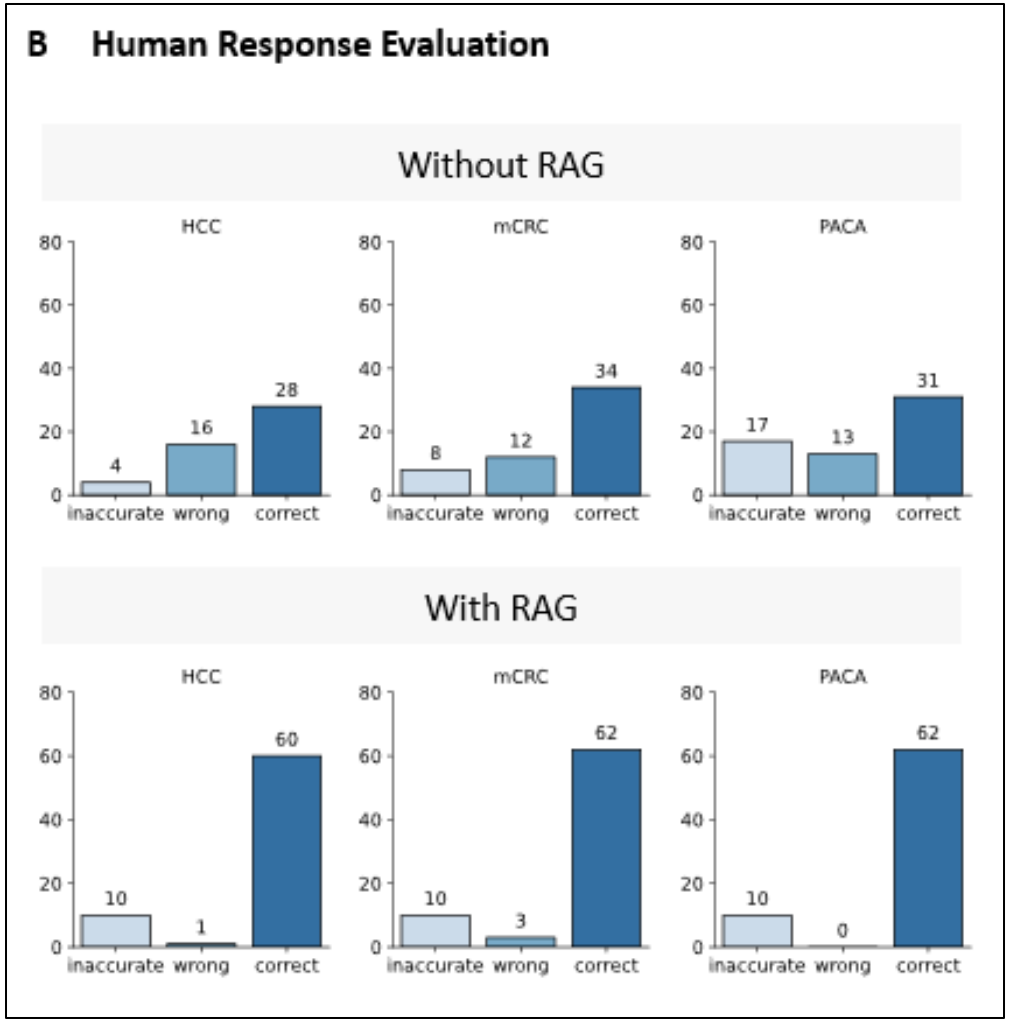
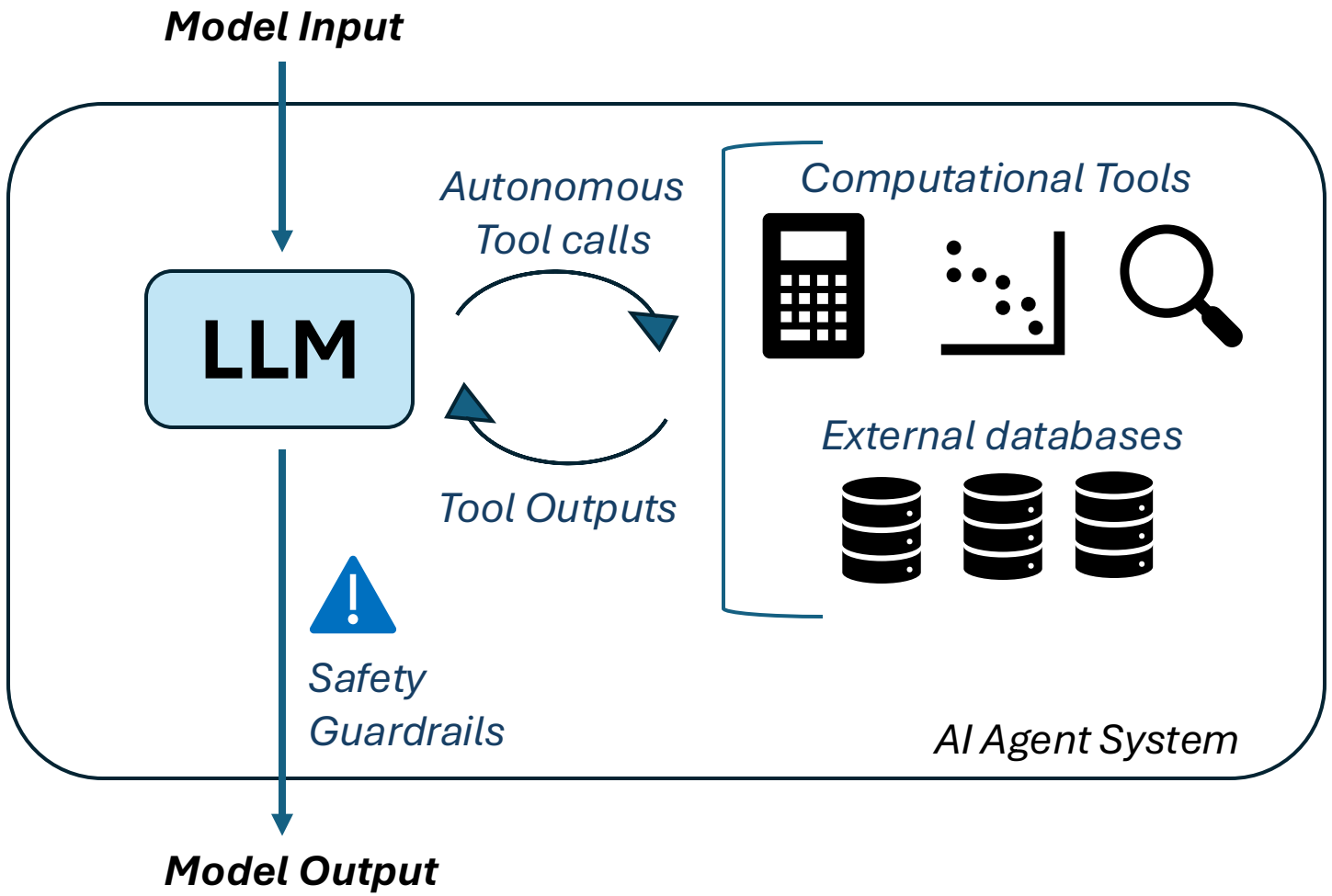


Ferber, D., Wiest, I. C., Wölflein, G., Ebert, M. P., Beutel, G., Eckardt, J. N., ... & Kather, J. N. (2024). GPT-4 for Information Retrieval and Comparison of Medical Oncology Guidelines. NEJM AI, AIcs2300235.

Agentic AI



Agentic AI

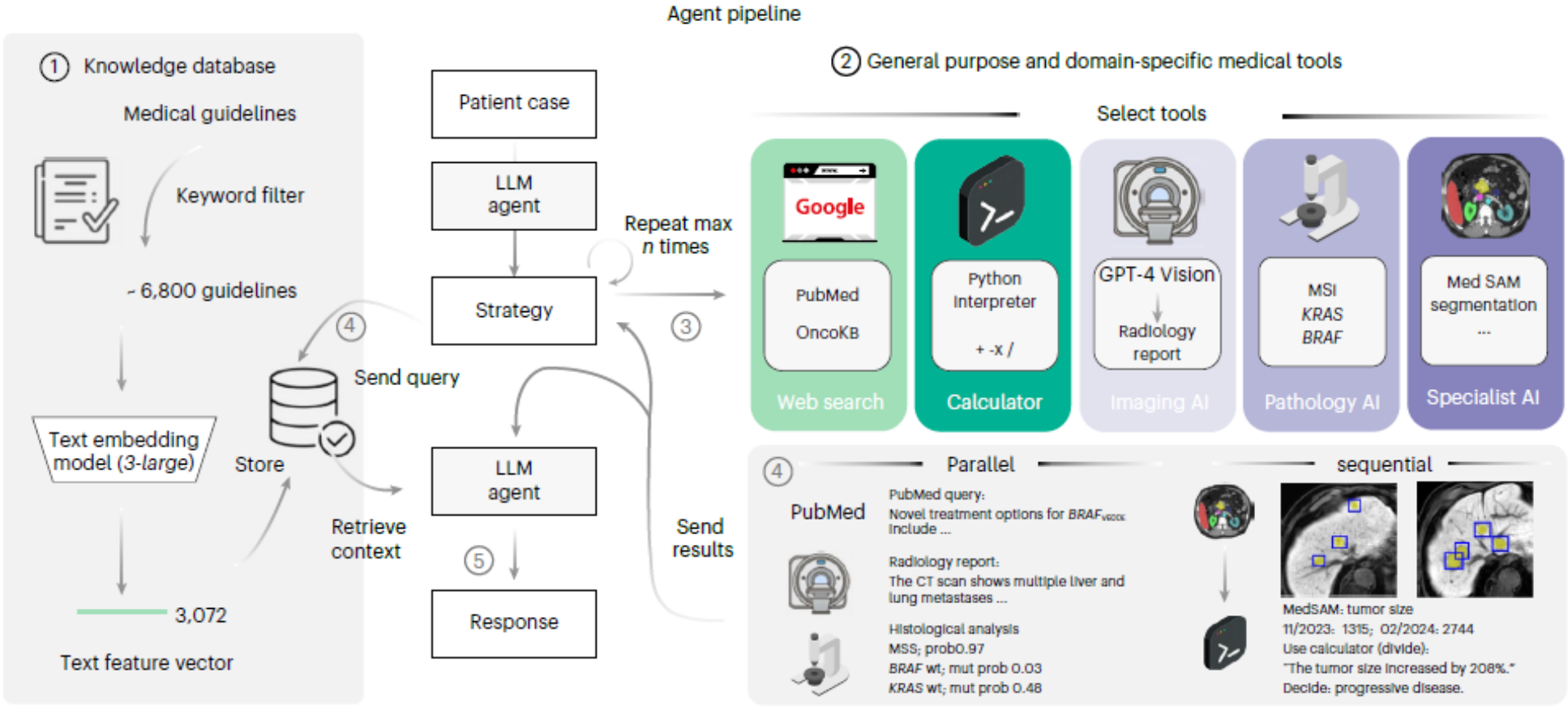
Leverages LLM reasoning capability for autonomous decision-making

Integrates multiple data modalities

Utilizes validated advanced computational methodologies

Implements guardrails for safer responses

Example of LLM Agents for Clinical Decision Support



Ferber, D., El Nahhas, O.S.M., Wölflein, G. et al. Development and validation of an autonomous artificial intelligence agent for clinical decision-making in oncology. Nat Cancer 6, 1337–1349 (2025). https://doi-org.ezproxy.medma.uni-heidelberg.de/10.1038/s43018-025-00991-6

LLMs are not perfect but they provide building blocks for robust medical applications

Guardrails for response safety

Regulatory-Compliant Systems

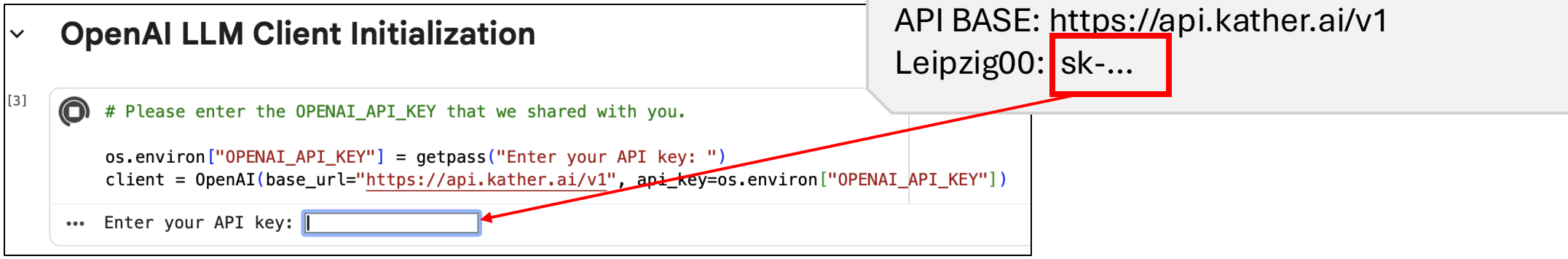
Trustworthy and Fair Systems

Clinically-relevant applications

Evaluation and Validation of Systems

Hands on exercise

- Please save a copy of the Google Colab: https://tinyurl.com/4dxm83ev
- Setting up the LLM API Client:



- We recommend working in pairs ☺