Leveraging Large Language Models for Conceptualizing Health Economic Models: A Feasibility Study in Oncology

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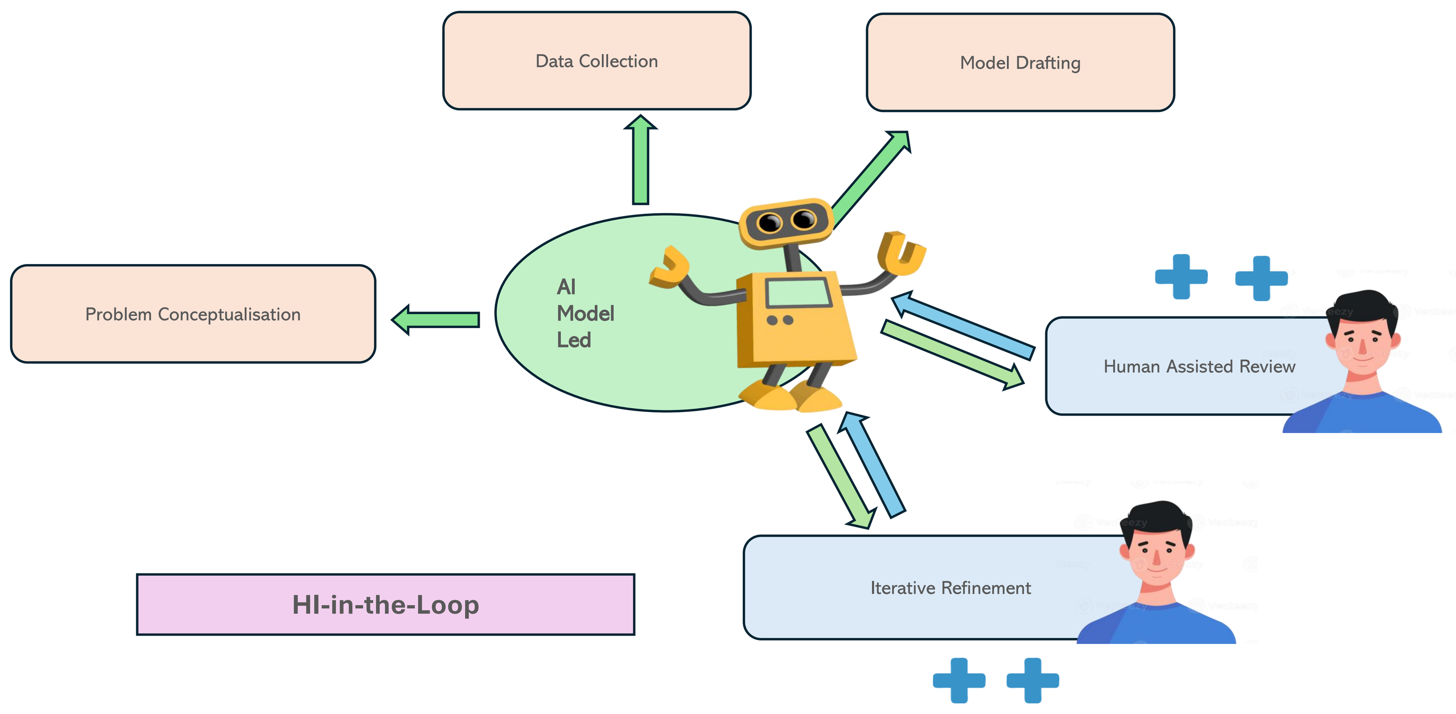
BACKGROUND

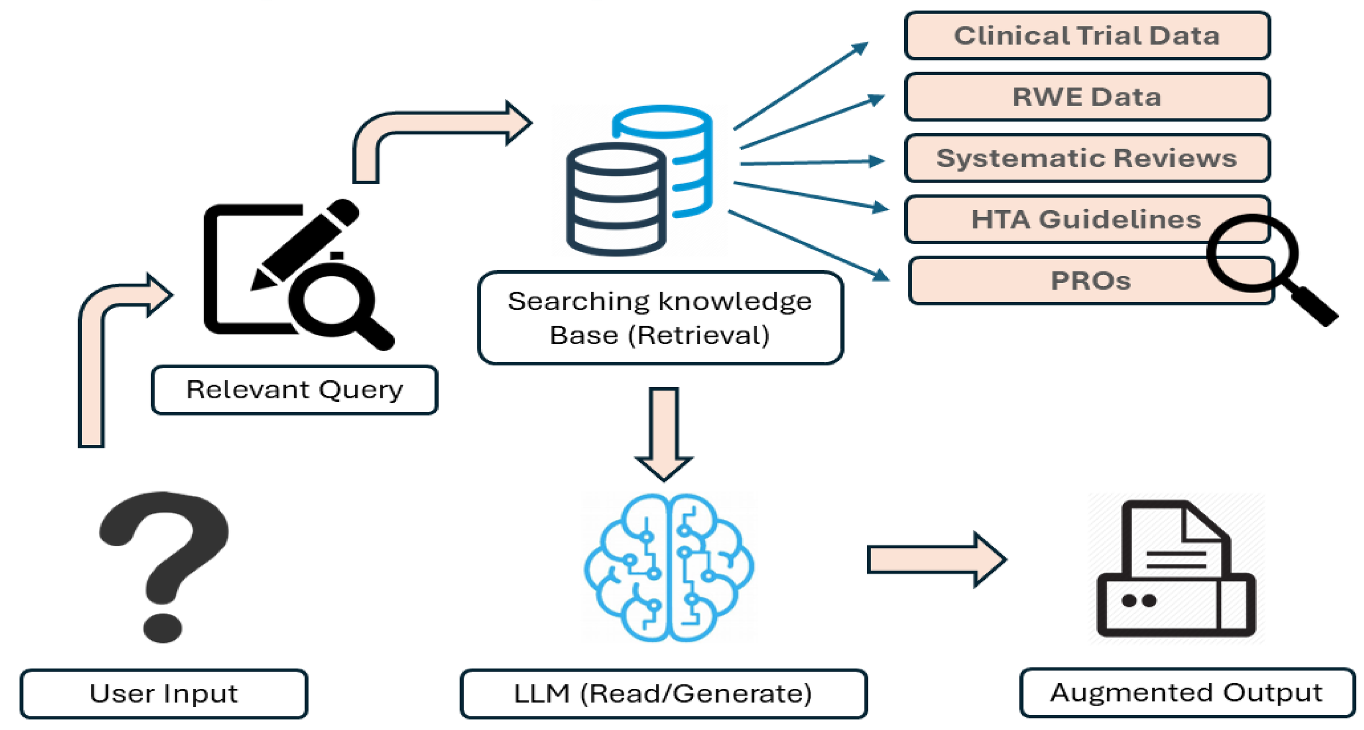
- **Context: Health economic modelling (HEM)**, crucial for assessing the cost-effectiveness of healthcare interventions, is a labour-intensive process requiring extensive expertise and time. However, advancements in **artificial intelligence (AI),** particularly with **large language models (LLMs) such as GPT-4**, offer new opportunities to streamline this process.
- **Aim:** We explore the feasibility of using LLMs for conceptualizing HEMs by leveraging advanced reasoning algorithms and prompt engineering techniques. A **proof-of-concept** exercise was undertaken and a **cost-effectiveness model for an anti-cancer therapy** in advanced breast cancer was developed using a **human intelligence (HI) in-the-loop approach (Fig. 1)**.

Figure 1 : Human in the loop approach to incorporating artificial intelligence



- Various reasoning algorithms using **prompt engineering**, such as Chain of Thought (CoT)[1], Tree of Thought (ToT), and CoT-Self-Consistency, were explored.
- To augment the knowledge base of the LLM with domain-specific data**, retrieval augmented generation (RAG)**[2] was employed. RAG database was populated with HEOR-related guidelines as well as disease specific documents to provide background and context. The framework was developed in Python along with **PostgreSQL** for database management (**Fig. 2**). The user input in the form of prompting techniques coupled with augmented knowledge base enabled the LLM to produce highly specific and **human-expert-like responses**.

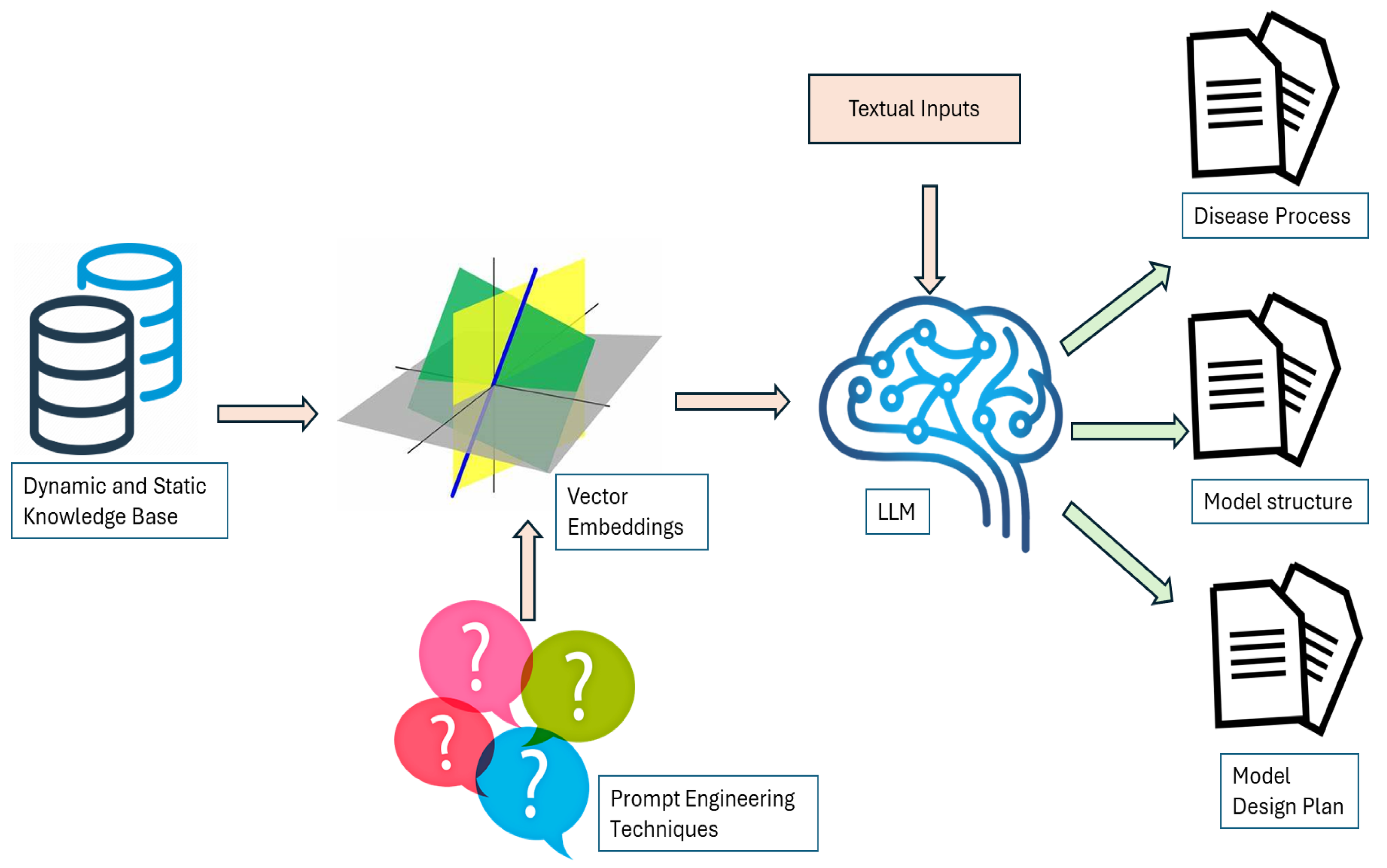
Figure 2: The working of RAG architecture with an LLM



IMPLEMENTATION

- **Static documents** pertaining to HEOR guidelines and **dynamic documents** related to disease-specific data was **uploaded to the database.**
- The said data was further **embedded as high-dimensional vectors** and stored in a vector database to be queried efficiently using **cosine similarity matching**.
- **CoT prompts** were designed emulating human-like thought process. The prompts were further supplemented by user inputs in text format to provide context to the LLM.
- The prompts, input and query were passed to the LLM which further queried the vector database to find the documents with the **highest similarity index.**
- The retrieved data was used by the LLM to conceptualize the problem question.
- The output was given in the form of **1) a disease process diagram, 2) model structure diagram,** and **3) model design plan.**

Figure 3: The workflow of the AI HEM conceptualisation tool



RESULTS

Figure 4: Disease process diagram produced by the AI

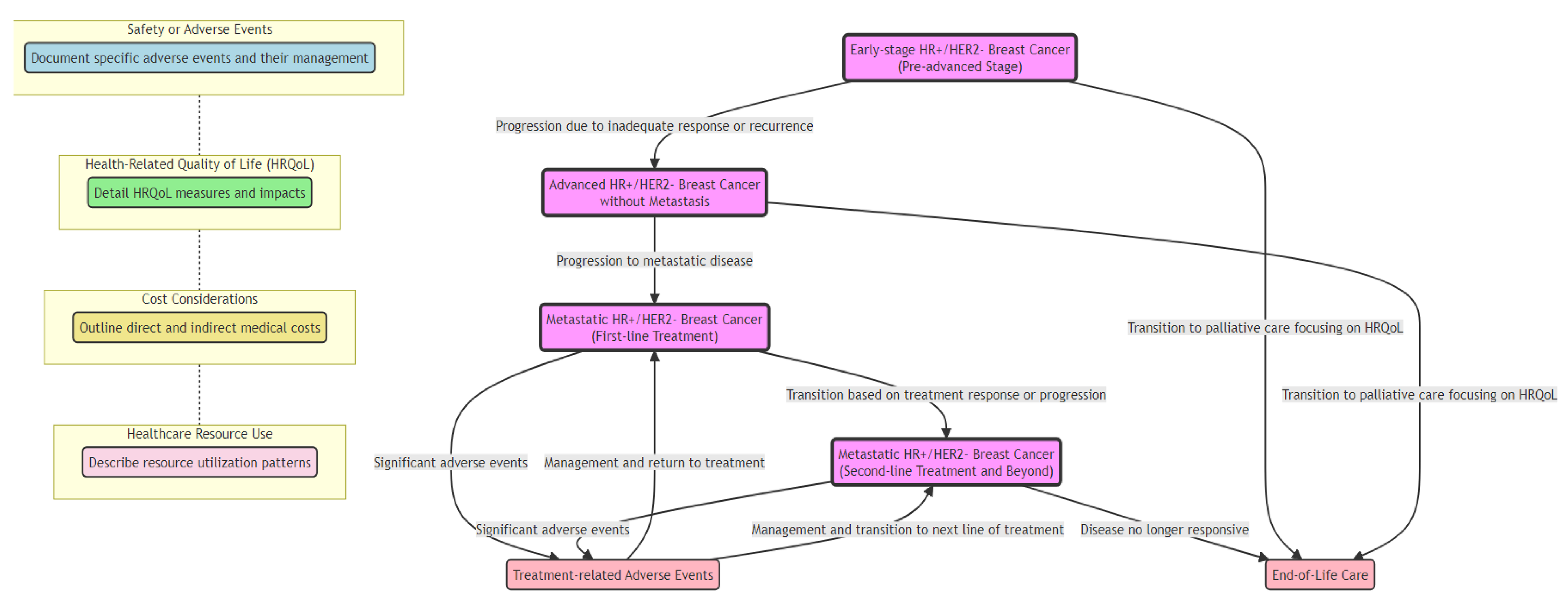
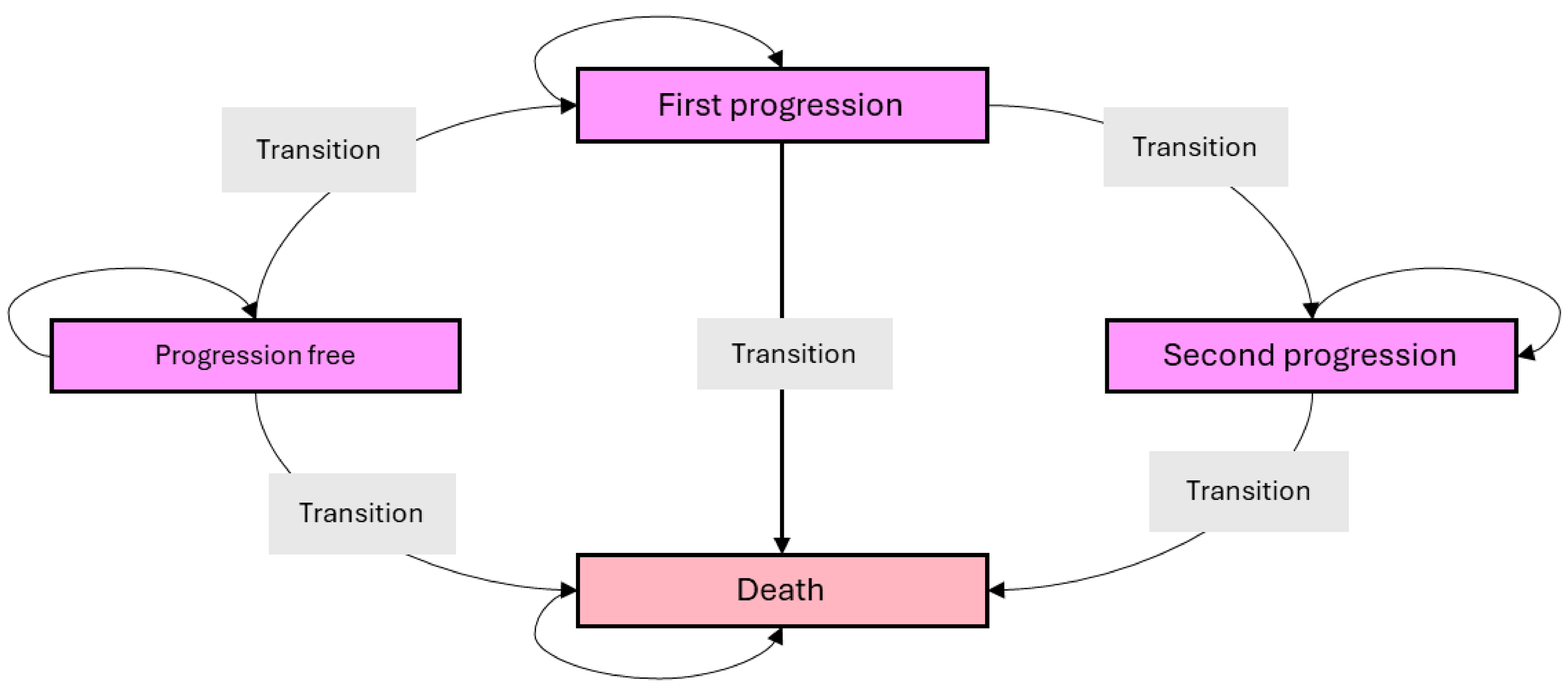


Figure 5: Model schematic produced by the AI



For the model structure, LLM suggested a Markov model with four health states: "Progression-Free Survival" (PFS), "First Progression," "Second Progression," and "Death." Key parameters and gaps were highlighted. The LLM recommended a natural history which was further refined using the HI-in-loop approach. The initial recommendation was promising and closely aligned with what human experts might have generated. However, a prime facie limitation would be the need for regular human review to ensure adherence to best practices.

References.

1. Sun, B. W. (2023). Towards Understanding Chain of Thought Prompting: An Empirical Study of What Matters.
2. Lewis, P., Perez, E., Piktus, A., Petroni, F., Karpukhin, V., Goyal, N., Lewis, M. (2021). Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks.

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