



MEDical Question Answering For Multimodal And Generative telemedICine - MEDIQA MAGIC For Dermatology

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Task Description: Develop an AI-powered tool to generate automated, natural language dermatological responses based on textual health queries and accompanying images.

Objective: To develop an AI-driven system that generates accurate, context-aware dermatological responses from user queries and images.

Submission: Springer Journal of Intelligent Information Systems

Highlights

The proposed research aims to achieve the following:

Multimodal Input Integration: Enable **text and image-based** queries for context-aware dermatology QA.

Enhanced Response Generation: Use **LLMs with Chain of Thought(CoT)** reasoning for accurate and interpretable natural language responses.

Factually Accurate Knowledge Base: Integrate a **multimodal Knowledge Graph(KG)** for precise & context-aware responses.


Identified Research Gaps

- Dataset Limitations:** A lack of dermatologist-annotated medical images **limits model performance**. The MEDIQA-M3G dataset, with only 350 annotated responses, is **insufficient** for robust training.
- Misdiagnosis of Diseases:** Existing models often misdiagnose(rely on fine-tuned LLMs and zero-shot inference), leading to **hallucinations** and **unreliable** responses.
- Lack of Interpretability:** Current systems fail to provide transparent reasoning, making responses **unaccountable** due to **weak reasoning** capabilities.

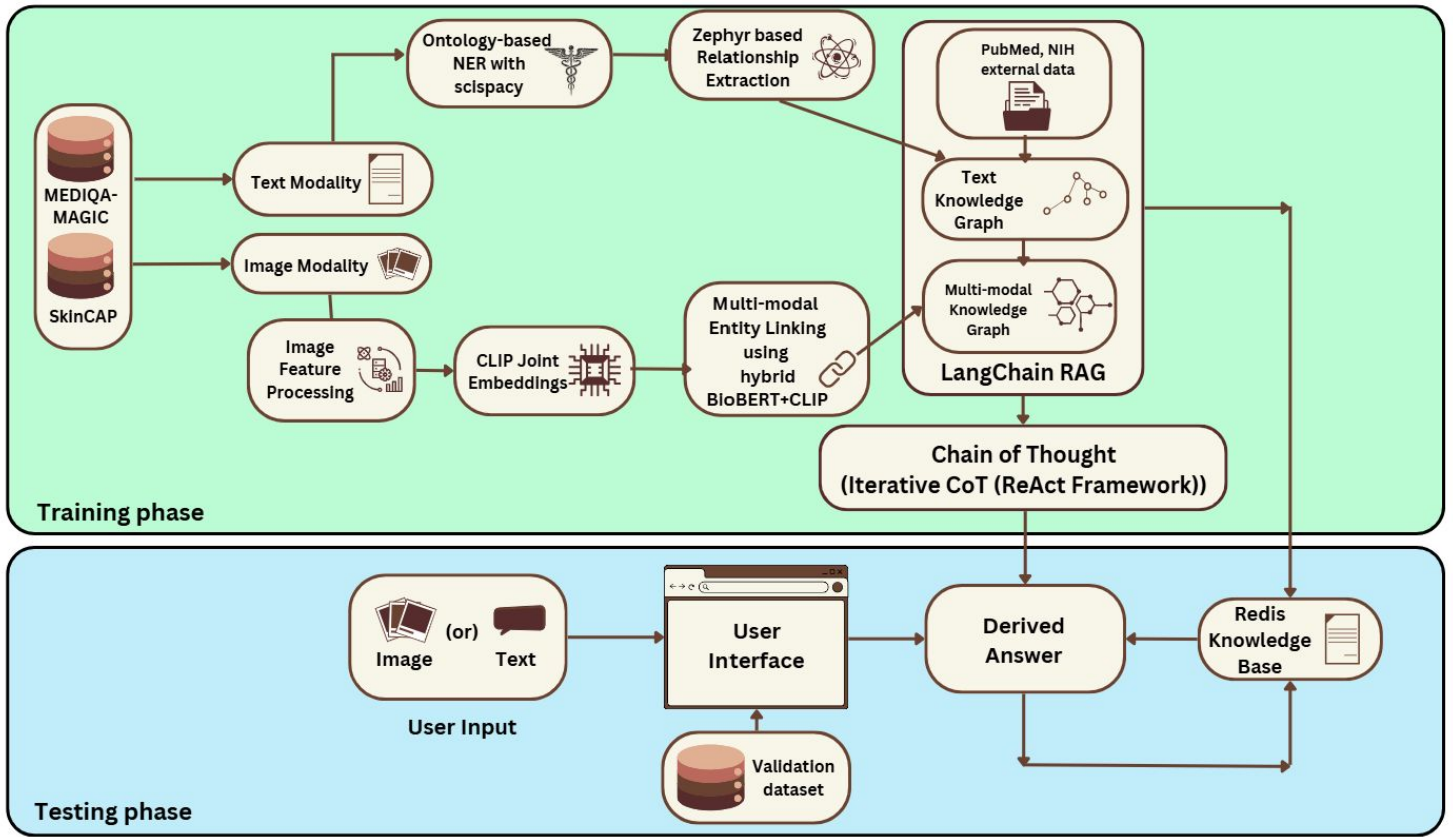
Data set Description

Dataset	No. of Annotated Data
MEDIQA-MAGIC	265
SkinCAP	4000

Dataset Summary

Image	Query	Response
	10cx1if this spread of my hand to my lip and face it come and go it painful itch swollen and it look like tiny blisterspimples please help	I need to know if it is warm and hard to touch, is it spreading? Have you applied something after which it happened? It can be dermatitis or infection, though it looks more like dermatitis so starting the treatment for same. Wash the face with mild soap, apply moisturizer. Use sun protection. Apply the cream which i have added twice daily for 2 weeks. Take an antihistamine and painkiller on an as needed basis. Take tab for 5 days in the morning after breakfast.

Methodology



- Data processing is performed using ontology-based **Named Entity Recognition** to extract medical entities.
- Entity relationships** are extracted using Zephyr-7b to link text entities with image features and construct a text-based **Knowledge Graph** representing medical concepts as triplets.
- Multimodal embeddings** are generated using a fine-tuned CLIP model to align text and image modalities to form a multimodal knowledge graph.
- Medical knowledge retrieval is enabled through a **multimodal and graph-based Retrieval-Augmented Generation** module.
- Session-based iterative Chain-of-Thought reasoning** is applied for coherent and logically structured responses.
- An interactive system presents responses effectively for telemedicine support.

Performance

Metric	Without KG	Text KG	Multimodal KG
BERT Score	0.739	0.812	0.859
Contextual Rel	0.55	0.72	0.74
Groundedness	0.65	0.77	0.81

Evaluation metrics for configurations :


Without knowledge graph(KG), with knowledge graph, and with multimodal knowledge graph

Model Name	Methodology	BERT Score
Proposed System	Multimodal Knowledge Graph and Graph RAG	0.867
VisionQAeries [6]	Fine-tuning Small Vision Language Models (Moondream, TinyLLaVA)	0.848
IRLab@IIT_BHU [1]	Generation-based LLM and Classification with BiLSTM + MLP	0.839
YuanAI [8]	Parameter-efficient fine-tuning of Llama3 and Gemini	0.835

Comparison of BERT Scores across existing models

Inferences


- Improved Accuracy with Multimodal KG and Reasoning** – The integration of **KG, CoT Reasoning, and fine-tuned CLIP embeddings** significantly enhances the accuracy and contextual understanding of telemedicine responses, outperforming baseline models with a **6% improvement** in BERT Score.
- Scalability and Future Research Potential** – The **dynamic KGs in a Graph RAG pipeline** offer real-time adaptability to evolving medical data, making the system scalable to **other medical domains** beyond dermatology for enhanced fact-based, interpretable medical responses.



query
What could be the possible causes for the redness, flaking, and patches on my scalp?

response:
There are many possible reasons for this kind of scalp issue, and it's not always clear without a closer look. It could be something as simple as dryness or buildup, or it could be related to common scalp conditions like irritation, flaking, or inflammation that sometimes happen for different reasons. Sometimes these things clear up on their own, but other times they might need special care or products. If it doesn't improve or seems to get worse, it's a good idea to check with a healthcare provider, who can help figure out what's going on and suggest the right treatment, which could include topical products, shampoos, or other medications depending on what they find.

Without Knowledge Graph



query
What could be the possible causes for the redness, flaking, and patches on my scalp?

response:
This scalp condition could result from several causes:
1. Dandruff (Seborrheic Dermatitis): Characterized by white flakes and mild redness, often triggered by yeast overgrowth, stress, or hair products.
2. Psoriasis: A chronic condition with thick, silvery scales and red patches that may extend beyond the scalp.
3. Fungal Infection (Tinea Capitis): Causes itchy, scaly, sometimes ring-like patches, and potential hair loss.
4. Eczema (Atopic Dermatitis): Involves inflamed, itchy skin due to dryness, allergens, or immune response.
Next Steps:
A healthcare provider should evaluate the scalp to confirm the diagnosis. Treatment options may include:
Topical corticosteroids for inflammation.
Anti-dandruff shampoos (ketoconazole, selenium sulfide, zinc pyrithione).
Topical antifungals if fungal infection is suspected.
Systemic medications for severe or resistant cases.

With Knowledge Graph and Multimodal Graph RAG