

Agentic AI for Medical Imaging and Diagnosis Support

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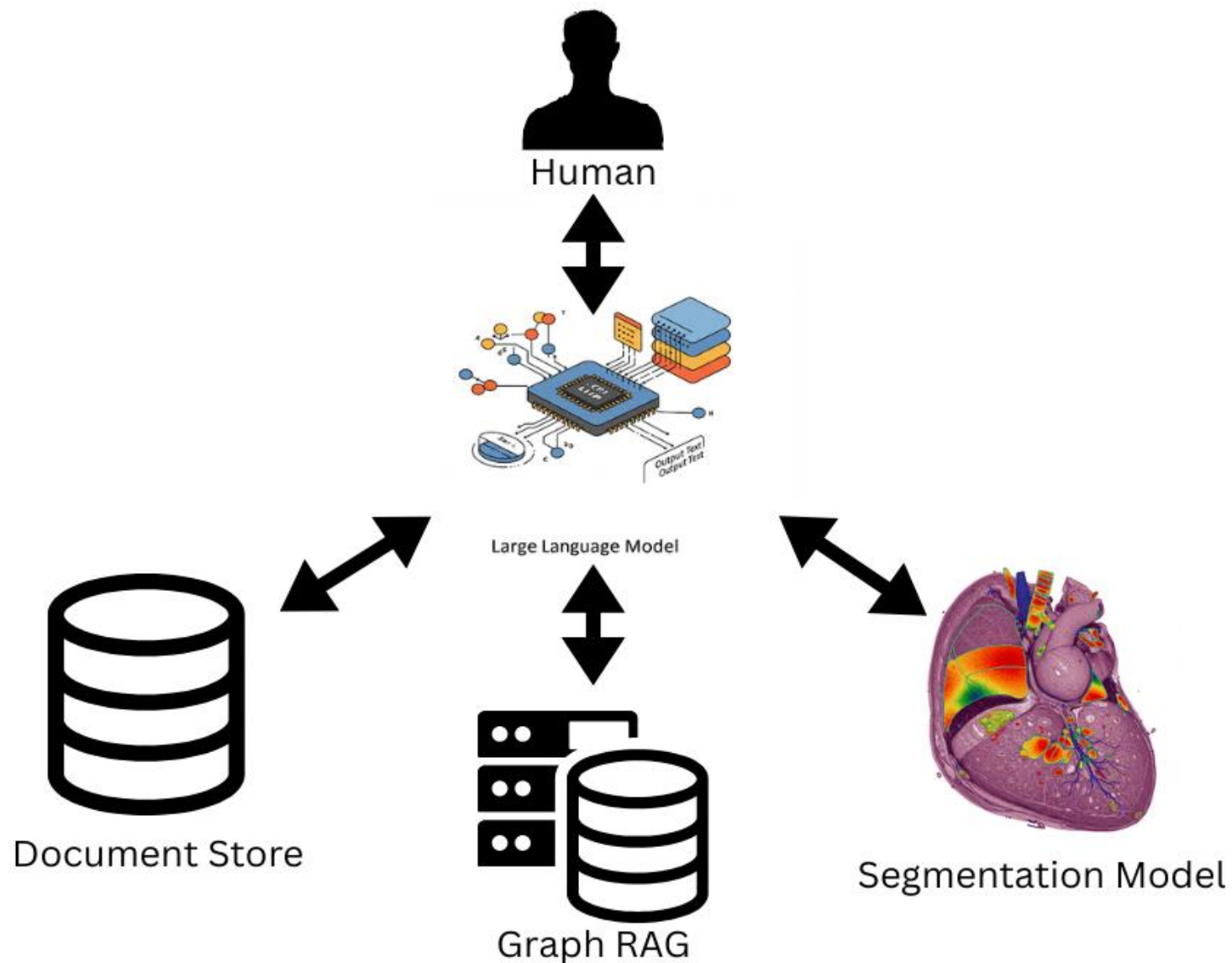
Introduction

Research objectives:

- Develop an AI system for medical image segmentation
- Integrate LLMs for knowledge retrieval and decision support

Research questions:

- Can Unet and LLMs improve medical image segmentation accuracy and ease of use?
- Can the proposed system enhance decision-making for healthcare professionals?



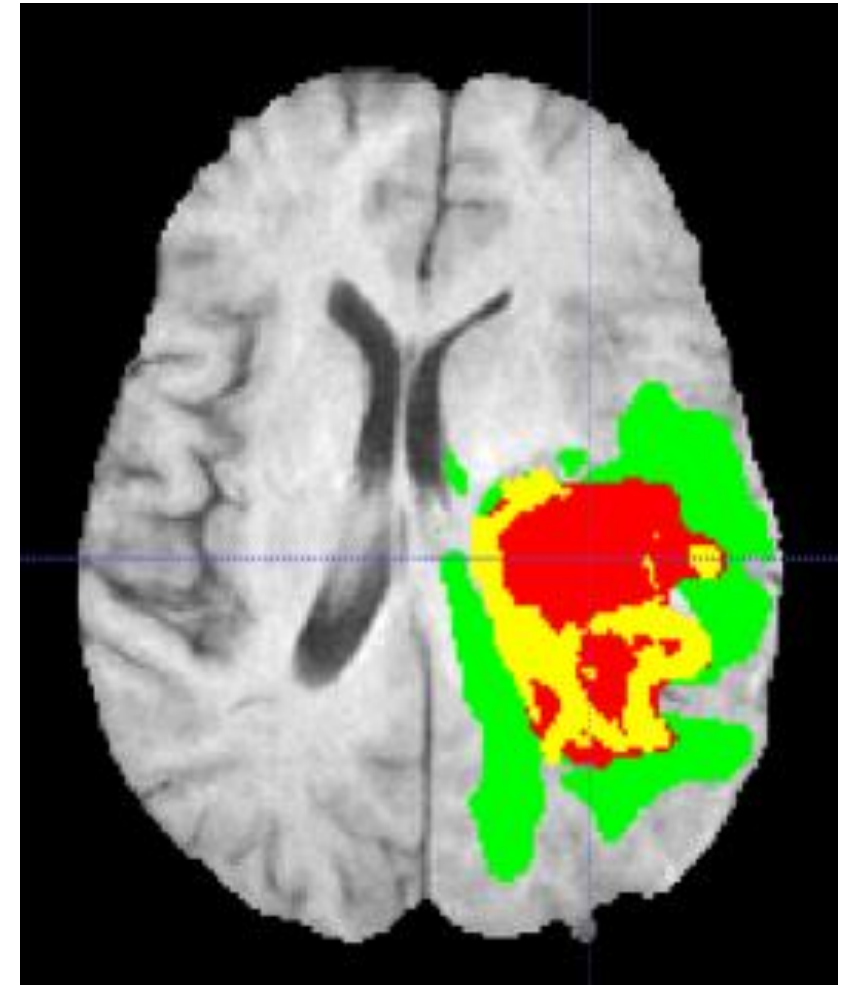
Research Hypothesis

Research Hypotheses:

- Null Hypothesis (H0): No significant difference in segmentation accuracy between proposed AI system and traditional methods.
- Alternative Hypothesis 1 (H1): Proposed AI system significantly improves segmentation accuracy.
- Alternative Hypothesis 2 (H2): Proposed AI system improves segmentation accuracy and provides better knowledge retrieval and decision support.

Metrics for Hypothesis Testing:

- Segmentation Accuracy: Dice coefficient, IoU, Hausdorff distance
- Knowledge Retrieval: F1-score, BLEU score, Meteor score
- Decision Support: User feedback, Clinical impact



Brain Tumor Segmentation

Proposed Core Algorithm (Segmentation)

Architecture

- Backbone: UNet (U-Net skip connections)
- Attention: Spatial/channel attention gates (focus on ROI)

Dataset: Kaggle_3m (CT/MRI scans)

- Preprocess: Normalize intensity; augment with flips, rotations; patch extraction, and random blur.
- Mask Format: Pixel-wise annotations (e.g., tumors, organs)

Training Phase

- Loss: Hybrid (Dice + BCE). Focal Loss if necessary.
- Hyperparameters: LR = $3e-4$ (AdamW), Batch size = 16

Attention Mechanism

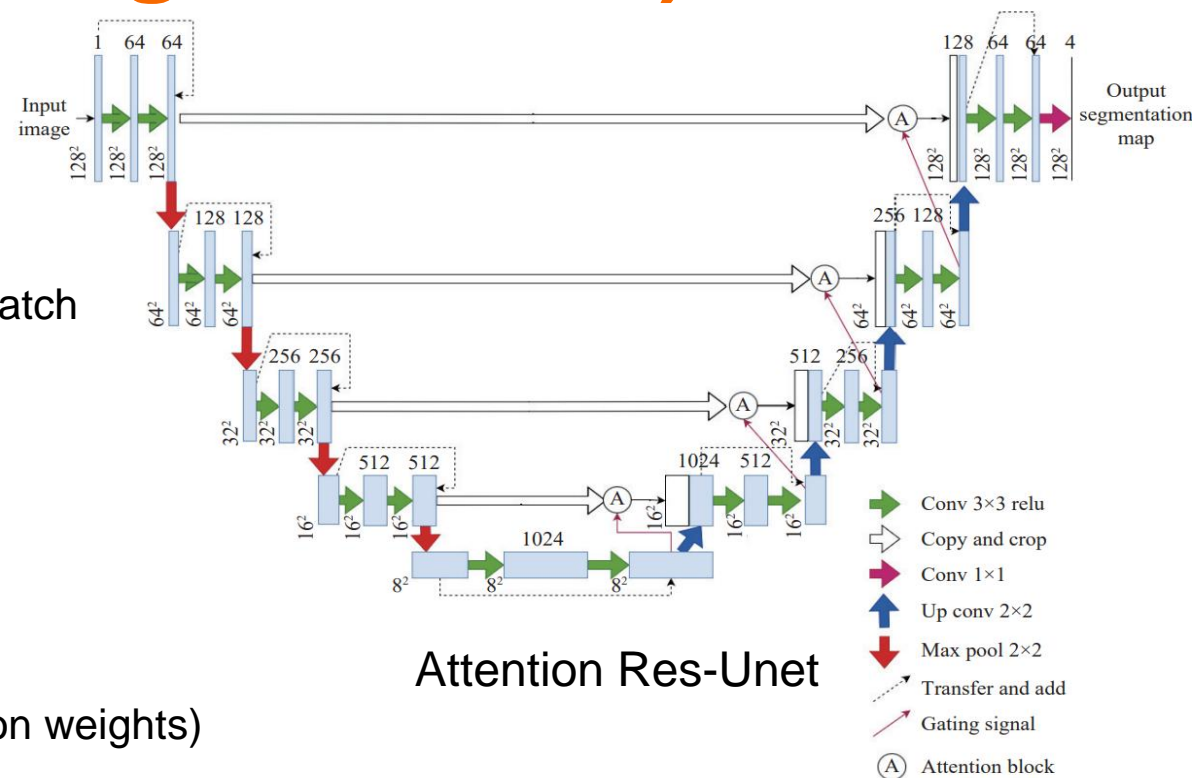
- Guidance: Multi-scale feature fusion (skip connections + attention weights)

Training Strategy

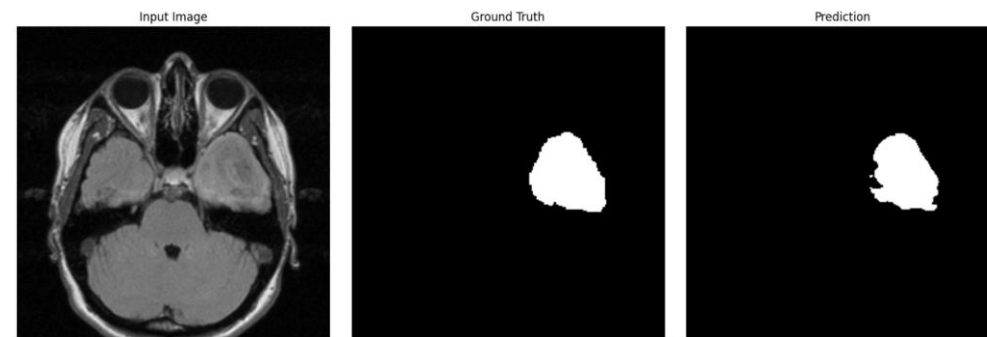
- Techniques: Mixed precision (FP16) + gradient clipping
- Regularization: Early stopping (Dice plateau), Weight decay (L2)

Evaluation

- Metrics: Dice score, Binary Cross Entropy, Focal Loss.
- Goal: Robust segmentation with minimal false positives



Attention Res-UNet



Kaggle_3m Dataset

Proposed Core Algorithm (LLM Distillation)

Architecture

- Student: LLaMA 3.2 3B (fine-tuned \rightarrow distilled).
- Teacher: Frozen LLaMA 3.1 8B (logits/CoT guidance).

Dataset: HPAI-BSC/MMLU-medical-cot-llama31

- Preprocess: QA \rightarrow instruction prompts
- Tokenize: LLaMA-3 tokenizer (pad/truncate).

Fine-Tuning Phase

- Loss: Causal LM (supervised).
- Hyperparams: LR=1e-5, memory-optimized batch size.

Distillation Phase

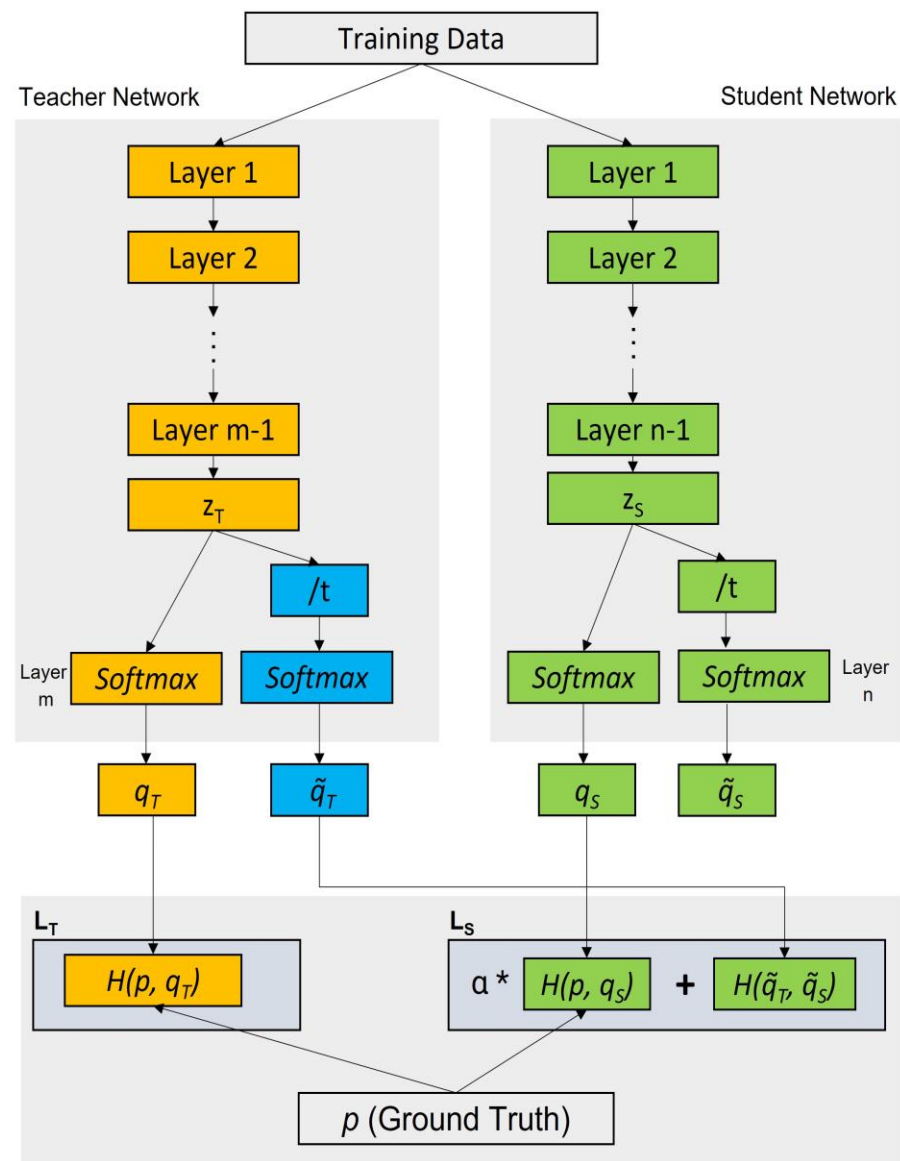
- Hybrid Loss: Cross-entropy (ground truth) + KL-divergence.
- Dynamic Weighting: SFT (70%) + Teacher (30%).

Training Strategy

- Progressive distillation (SFT \rightarrow distillation focus).
- FP16/Flash Attention + dropout/weight decay.

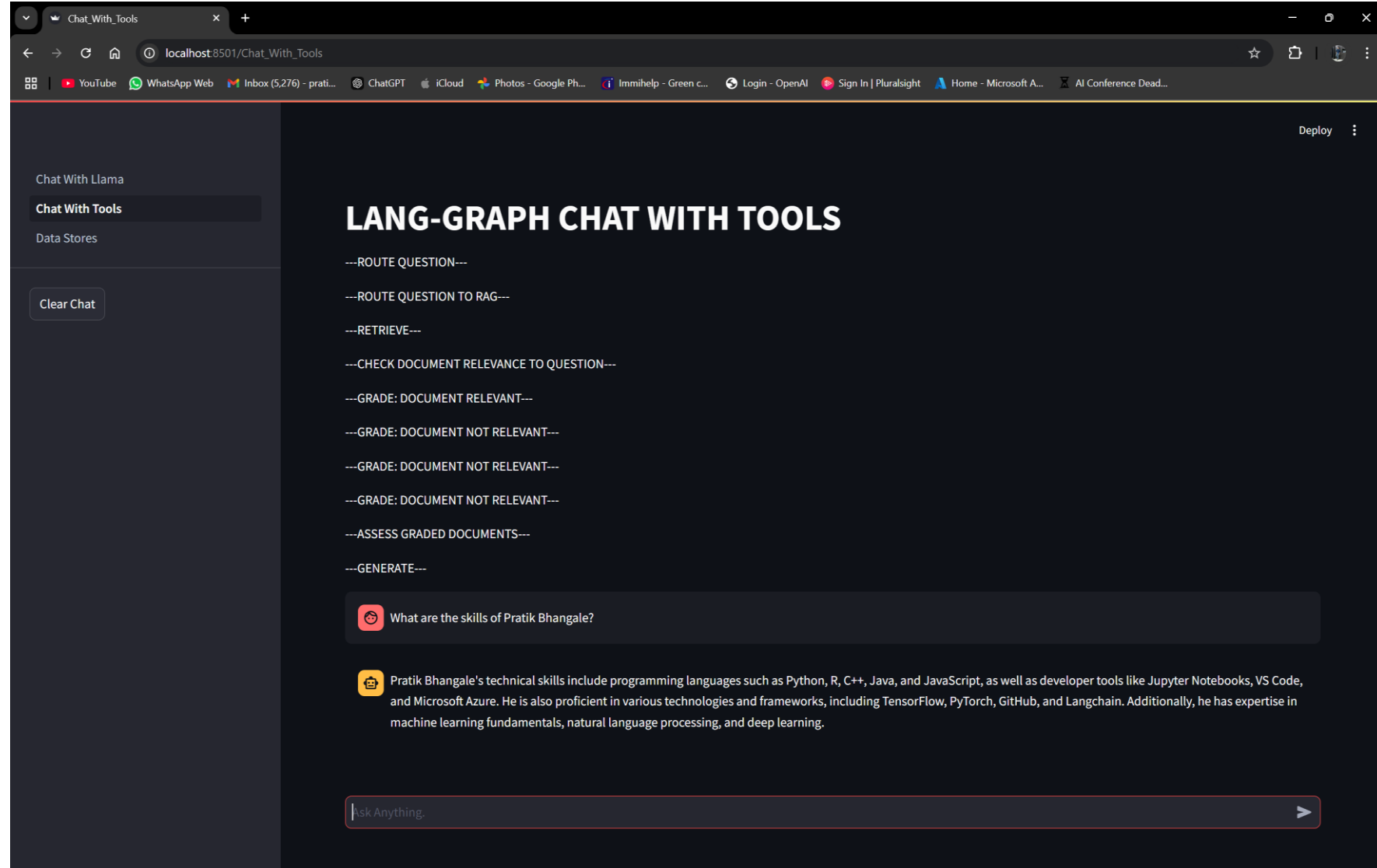
Evaluation

- Metrics: Perplexity and Meteor.
- Goal: 3B model with 8B-level medical reasoning, lower inference cost.



Combined System

- LangGraph + Streamlit: Interactive website integrating distilled LLaMA model with Attention ResUNet model and RAG.
- RAG databases: Case studies + Graph RAG for contextual retrieval.
- Attention ResUNet model: Tool for LLM agent to Analyse images for Brain Tumors.



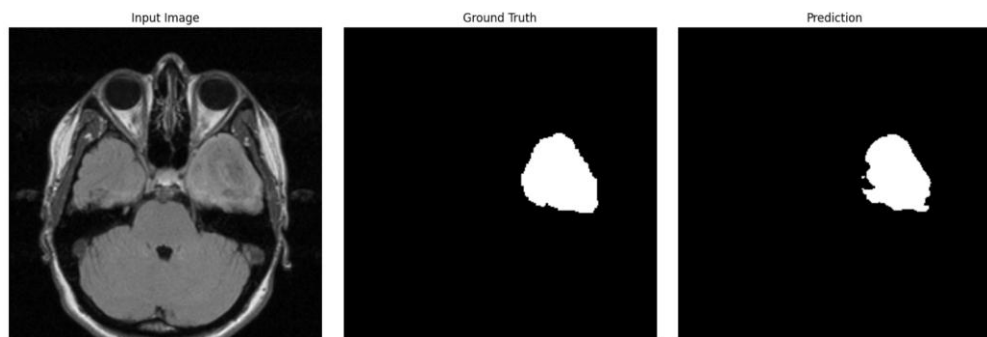
Baseline Results

Unet Baseline

Train Loss: 0.0383

Val Loss: 0.1056

$$\text{Loss} = (0.5 * \text{BCE}) + (0.5 * \text{Dice})$$



Kaggle_3m

Distillation Baseline

METEOR Score: 32.74%

Perplexity: 12.89

Split (1)
train · 4.32k rows

Q Search this dataset

system_prompt string · classes	question string · lengths	response string · lengths
You are an... 100%	1.18k · 1.72k 15.3%	1.2k · 1.46k 26.7%

You are an expert medical assistant named Aloe, developed by the High Performance Artificial Intelligence Group at Barcelona Supercomputing Center(BSC). You are to be a helpful, respectful, and honest assistant.

Presented with a medical question accompanied by multiple choices, your objective is to identify the correct response employing a systematic strategy. Start by summarizing the essence of the query, then meticulously assess each option in isolation. Conclude by employing a logical and sequential reasoning process to determine the correct answer. Clarify the selected option at the end.

Hawthorne rolled over in bed and looked around the room. He let out a breath. His eyes were half-closed as he shoved the covers back from his bed, and moved towards the door. He knew that he had to check on Kate, if he did nothing else. She was ill, with a heart problem, and he worried about her all the time. They both lived in a home for orphans, and he had since his parents had died, when he was the age of four. He had taken care of Kate as if she were his sister ever since. He wandered to her room sitting himself by her on her bed, shoving her hair from her face. She moved on the bed as he pulled her into his arms. "Kate." He said into her ear, "It's time to wake up." He pressed a kiss to her head, and her eyes opened. "Hawthy?" She said, her nickname for him moving from her lips. "Yea," He moved her hair. "I want to go outside today," she said, and he nodded in response. "If you are up to it, I won't stop you", he told her, and she smiled. "Thanks Hawthry", she said. It wasn't long until she fell back to sleep. What is wrong with the girl?

To determine what is wrong with the girl, Kate, let's analyze the information provided in the passage:

1. The passage states that "She was ill, with a heart problem." This directly indicates the nature of Kate's health issue.
2. Hawthorne's concern for Kate's health and his careful attention to her suggest that her condition is serious enough to warrant constant monitoring.
3. Kate's ability to quickly fall back asleep after a brief conversation with Hawthorne implies that she is not feeling well and lacks the energy to stay awake for long periods.

Given these points, let's examine the answer choices:

- A. She has the flu. - There is no mention of flu-like symptoms such as fever, cough, or body aches.
- B. She has a heart problem. - This is directly stated in the passage as the reason for Hawthorne's concern and Kate's illness.
- C. She has diabetes. - There is no mention of symptoms or management related to diabetes, such as monitoring blood sugar levels or administering insulin.
- D. She has a cold. - Similar to option A, there is no indication of typical cold symptoms such as congestion, sore throat, or cough.

Based on the information provided in the passage, the correct answer is the one that directly matches the stated health issue.

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Conclusion

- Successful AI Integration: The proposed system combines Attention Res-UNet for precise medical image segmentation and a distilled LLaMA model for enhanced knowledge retrieval and decision support.
- Improved Accuracy & Efficiency: Segmentation: Achieved strong Dice and IoU scores with minimal false positives.
- Knowledge Retrieval: Competitive METEOR and Perplexity scores, enabling better clinical decision-making.
- Potential Clinical Impact: Supports healthcare professionals in diagnosis. Reduces manual workload while improving diagnostic reliability.
- Future Work: Expand dataset diversity for better generalization. Optimize model efficiency for real-time applications. Validate in real-world clinical settings.

RIT

Thank You.