

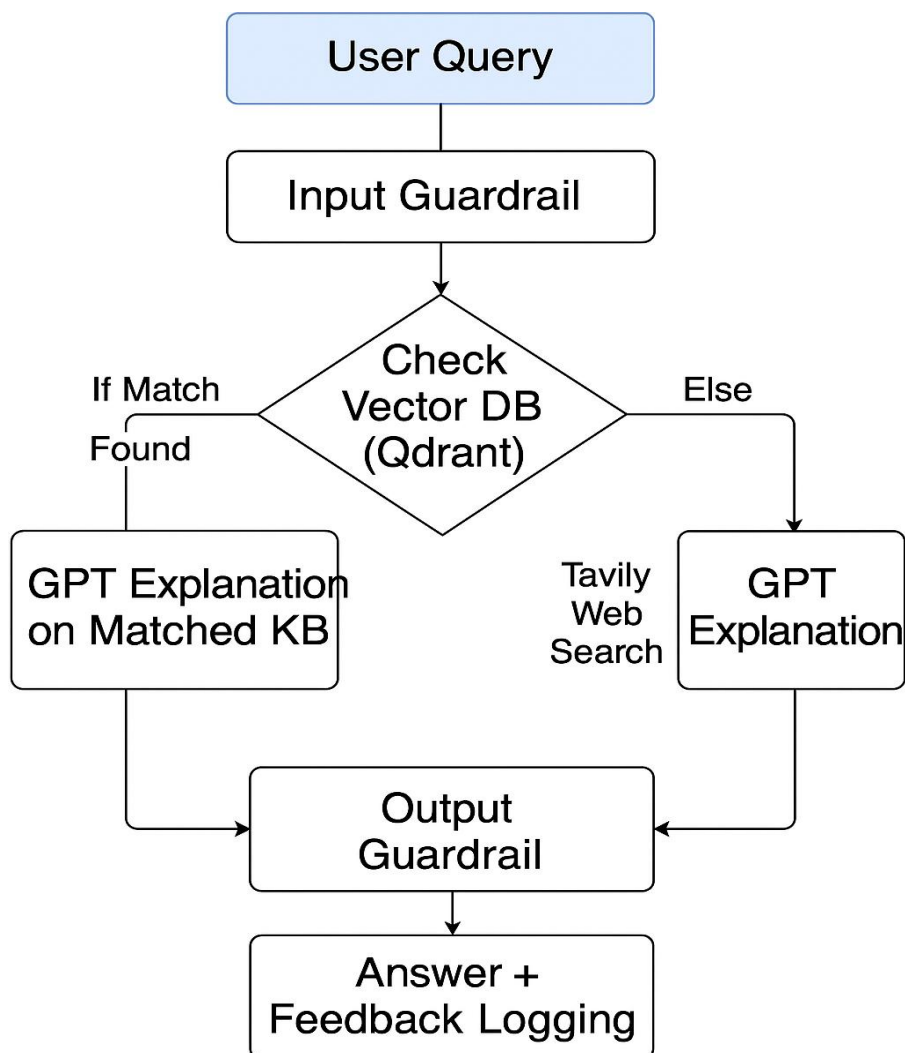
Final Proposal: Human-in-the-Loop Feedback-Based Math Agent

1. Project Overview

This project implements an **Agentic-RAG (Retrieval-Augmented Generation)** architecture to simulate a math professor capable of solving JEE-level math questions with step-by-step explanations. The agent intelligently routes the query through a knowledge base or web search, validates responses using guardrails, and incorporates human feedback for continuous improvement.

2. Architecture & Workflow

Flowchart Summary



Each query is evaluated through:

- **Input Guardrail:** Ensures math-only queries.
- **KB Check:** Uses Qdrant vector search with OpenAI Embedding.

- **Fallback:** Tavily API for web search when no KB match.
- **Explanation:** GPT-3.5 Turbo explains matched or searched content step-by-step.
- **Output Guardrail:** DSPy-based output filter for quality.
- **Feedback Loop:** UI lets users give thumbs up/down, stored in JSON logs.

3. Guardrails Description

To ensure that the Math Agent stays focused on educational math content, DSPy-based guardrails are implemented:

- **Input Guardrail:** Prevents the model from answering non-math or off-topic queries by rejecting them early.
- **Output Guardrail:** Validates that the generated explanation is safe, relevant, and free from hallucinations before returning it to the user.

This layered security ensures educational integrity and AI safety.

4. Knowledge Base Strategy

- **Dataset:** Filtered subset of JEEBench (math-only)
- **Format:** Each entry contains a math question and the correct answer (gold).
- **Embedding:** OpenAIEmbedding with Qdrant for fast similarity search.
- **Retrieval:** Top-1 similarity used to fetch relevant questions from KB.

Your Question:

Let α_1, α_2 be the roots of the equation $x^2 - 2x \sec \theta + 1 = 0$ and β_1, β_2 be the roots of the equation $x^2 + 2x \tan \theta - 1 = 0$.

Get Answer

✓ Answer:

To find the values of α_1 and β_1 , we need to solve the equation $x^2 - 2x \sec \theta + 1 = 0$. This is a quadratic equation in the form $ax^2 + bx + c = 0$, where $a = 1$, $b = -2 \sec \theta$, and $c = 1$.

The roots of a quadratic equation $ax^2 + bx + c = 0$ are given by the formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.

For the equation $x^2 - 2x \sec \theta + 1 = 0$, we have $a = 1$, $b = -2 \sec \theta$, and $c = 1$. Plugging these values into the formula, we get:

$$\alpha_1 = \frac{2 \sec \theta + \sqrt{(-2 \sec \theta)^2 - 4(1)(1)}}{2(1)}$$

$$\beta_1 = \frac{2 \sec \theta - \sqrt{(-2 \sec \theta)^2 - 4(1)(1)}}{2(1)}$$

Since $\alpha_1 > \beta_1$, we can conclude that α_1 is the larger root and β_1 is the smaller root.

Similarly, to find the values of α_2 and β_2 , we need to solve the equation $x^2 + 2x \tan \theta - 1 = 0$. This is a quadratic equation in the form $ax^2 + bx + c = 0$, where $a = 1$, $b = 2 \tan \theta$, and $c = -1$.

Using the quadratic formula, we can find the roots α_2 and β_2 for this equation.

Since $\alpha_2 > \beta_2$, we can conclude that α_2 is the larger root and β_2 is the smaller root.

To find $\alpha_1 + \beta_2$, we need to add the larger root of the first equation (α_1) to the smaller root of the second equation (β_2).

$$\text{Therefore, } \alpha_1 + \beta_2 = \frac{2 \sec \theta + 2 \tan \theta}{2} = \sec \theta + \tan \theta = \frac{1}{\cos \theta} + \frac{\sin \theta}{\cos \theta} = \frac{1 + \sin \theta}{\cos \theta} = -\tan \theta.$$

Therefore, the correct answer is (C) $-\tan \theta$.

Query: Let $\frac{\pi}{6} < \theta < \frac{\pi}{12}$. Suppose α_1 and β_1 are the roots of the equation $x^2 - 2x \sec \theta + 1 = 0$ and α_2 and β_2 are the roots of the equation $x^2 + 2x \tan \theta - 1 = 0$. If $\alpha_1 > \beta_1$ and $\alpha_2 > \beta_2$, then $\alpha_1 + \beta_2$ equals (A) $2(\sec \theta - \tan \theta)$ (B) $2 \sec \theta$ (C) $-2 \tan \theta$ (D) 0

InputValidator Response: Yes

Matched Score: 0.97608113

Matched Content: Q: Let $\frac{\pi}{6} < \theta < \frac{\pi}{12}$. Suppose α_1 and β_1 are the roots of the equation $x^2 - 2x \sec \theta + 1 = 0$ and α_2 and β_2 are the roots of the equation $x^2 + 2x \tan \theta - 1 = 0$. If $\alpha_1 > \beta_1$ and $\alpha_2 > \beta_2$, then $\alpha_1 + \beta_2$ equals

(A) $2(\sec \theta - \tan \theta)$

(B) $2 \sec \theta$

(C) $-2 \tan \theta$

(D) 0

A: C

KB raw answer: Q: Let $\frac{\pi}{6} < \theta < \frac{\pi}{12}$. Suppose α_1 and β_1 are the roots of the equation $x^2 - 2x \sec \theta + 1 = 0$ and α_2 and β_2 are the roots of the equation $x^2 + 2x \tan \theta - 1 = 0$. If $\alpha_1 > \beta_1$ and $\alpha_2 > \beta_2$, then $\alpha_1 + \beta_2$ equals

(A) $2(\sec \theta - \tan \theta)$

(B) $2 \sec \theta$

(C) $-2 \tan \theta$

(D) 0

A: C

High similarity KB match, using GPT for step-by-step explanation...

Answer Source: KB

OutputValidator Response: Yes

5. Web Search Fallback Strategy

If no match is found in the vector DB or the similarity score is low, the agent automatically performs a web search using the Tavily API.

- **API:** Tavily (Basic Search)
- **Explanation:** GPT-3.5 uses search result to generate a valid answer.
- **Filtered by:** Output guardrail to maintain quality.

Math Tutor Agent Dashboard ⇌

[Ask a Question](#) [View Feedback](#) [Benchmark Results](#)

Ask a Math Question

Enter any math question below. The agent will try to explain it step-by-step.

Your Question:

Let $f(x) = \ln(\sin x) + \ln(\tan x)$ $f(x) = \ln(\sin x) + \ln(\tan x)$. Find the domain of the function $f(x)$ in the interval $(0, \pi)$.

[Get Answer](#)

Answer:

To find the domain of the function $f(x) = \ln(\sin x) + \ln(\tan x)$ in the interval $(0, \pi)$, we need to consider the restrictions on the natural logarithm function and the trigonometric functions involved.

1. The natural logarithm function $\ln(x)$ is defined only for positive real numbers. Therefore, for $\ln(\sin x)$ to be defined, the argument $\sin x$ must be positive. This means that $\sin x > 0$ in order for $\ln(\sin x)$ to be defined.
2. The tangent function $\tan x$ is defined for all real numbers except for the values where the cosine function $\cos x$ is equal to zero. This means that $\tan x$ is undefined when $\cos x = 0$, which occurs at $x = \frac{\pi}{2}$.
3. Combining the above information, we need both $\sin x > 0$ and $x \neq \frac{\pi}{2}$ for the function $f(x)$ to be defined.
4. In the interval $(0, \pi)$, the sine function is positive in the first and second quadrants, and the tangent function is defined for all values except $x = \frac{\pi}{2}$.
5. Therefore, the domain of the function $f(x) = \ln(\sin x) + \ln(\tan x)$ in the interval $(0, \pi)$ is $(0, \frac{\pi}{2}) \cup (\frac{\pi}{2}, \pi)$, excluding the point $x = \frac{\pi}{2}$ where the tangent function is undefined.

```

🔑 Loaded OPENAI_API_KEY: ✅ Found
🔵 Query: Let  $f(x) = \ln(\sin x) + \ln(\tan x)$ . Find the domain of the function  $f(x)$  in the interval  $(0, \pi)$ .
🔴 InputValidator Response: Yes
🔵 Matched Score: 0.83587754
🔴 Matched Content: Q: For  $x \in \mathbb{R}$ , let  $\tan^{-1}(x) \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$ . Then what is the minimum value of the function  $f: \mathbb{R} \rightarrow \mathbb{R}$  defined by  $f(x) = \int_0^x \tan^{-1} t \frac{e^{(t-\cos t)}}{1+t^{2023}} dt$ ?
A: 0
🟢 KB raw answer: Q: For  $x \in \mathbb{R}$ , let  $\tan^{-1}(x) \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$ . Then what is the minimum value of the function  $f: \mathbb{R} \rightarrow \mathbb{R}$  defined by  $f(x) = \int_0^x \tan^{-1} t \frac{e^{(t-\cos t)}}{1+t^{2023}} dt$ ?
A: 0
🟢 High similarity KB match, using GPT for step-by-step explanation...
🟡 Answer Source: KB
🔴 OutputValidator Response: No
🟡 Final answer failed validation – retrying with web content...

```

6. Human-in-the-Loop Feedback

Users can rate each answer using thumbs up/down in the Streamlit UI.

- Logged as JSON files in `logs/feedback_log.json`
- **Each log includes:** question, answer, feedback status
- Feedback is used to refine future outputs and assess agent quality

Sample Log Entry:

```

{
  "question": "Evaluate  $\int \sin(x) dx$ ",
  "answer": "The integral is  $-\cos(x) + C$ ",
  "feedback": "positive"
}

```

7. Benchmarking on JEEBench

- **Dataset:** 236 math questions from JEEBench
- **Method:** Custom benchmarking tool in Streamlit
- **Strategy:** Compare predicted answer with gold label
- **Accuracy:** 66% (33 correct out of 50 questions)

Math Tutor Agent Dashboard

[Ask a Question](#) [View Feedback](#) [Benchmark Results](#)

Benchmark Accuracy Report

Benchmarking from 236 math questions

Select number of math questions to benchmark



[Run Benchmark Now](#)

✓ Done! Accuracy: 66.00%

Accuracy

66.00%

	Question	Expected	Predicted	Correct	TimeTakenSec
0	Let $\theta = \frac{\pi}{6}$ and $\theta = \frac{\pi}{12}$. Suppose α_1 and β_1 are the roots of the equation $x^2 - 2x + \cos \theta = 0$. Find the value of $\alpha_1^2 + \beta_1^2$.	C	To find the values of α_1 and β_1 , we need to solve the equation $x^2 - 2x + \cos \theta = 0$.	<input checked="" type="checkbox"/>	5.61
1	A debate club consists of 6 girls and 4 boys. A team of 4 members is to be selected from this club. In how many different ways can the team be selected such that there are at least 2 girls in the team?	A	To solve this problem, we need to consider the different scenarios for selecting the team with at least 2 girls.	<input checked="" type="checkbox"/>	4.39
2	Let $S = \{x \in \mathbb{R} : x \neq 0, \frac{1}{x} \in \mathbb{Z}\}$. The sum of all distinct solutions of the equation $\sqrt{3} \sec x + \csc x + 2(\tan x - \cot x) = 0$, where $x \in S$, is	C	To solve the given equation $\sqrt{3} \sec x + \csc x + 2(\tan x - \cot x) = 0$, we first need to simplify the equation.	<input checked="" type="checkbox"/>	16.86

8. Deliverables

- PDF Proposal
- Streamlit App Source Code
- ``rag/query_router.py``, ``app/streamlit.py``, ``app/benchmark.py``
- Feedback Logs
- Benchmark Results
- Demo Video showcasing:
 - Agentic routing
 - Feedback logging
 - Benchmarking