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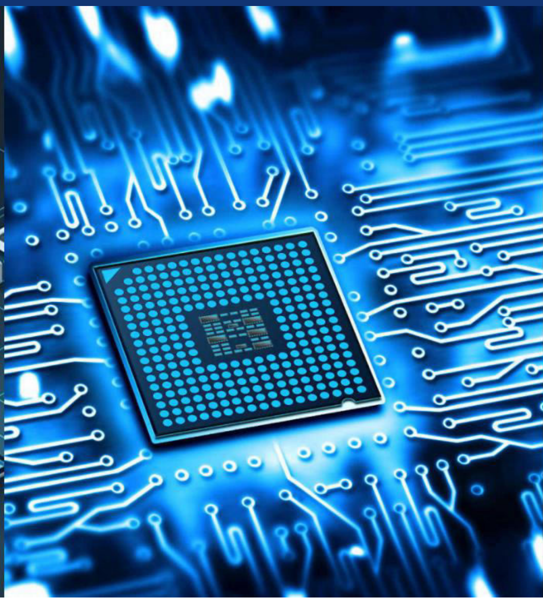


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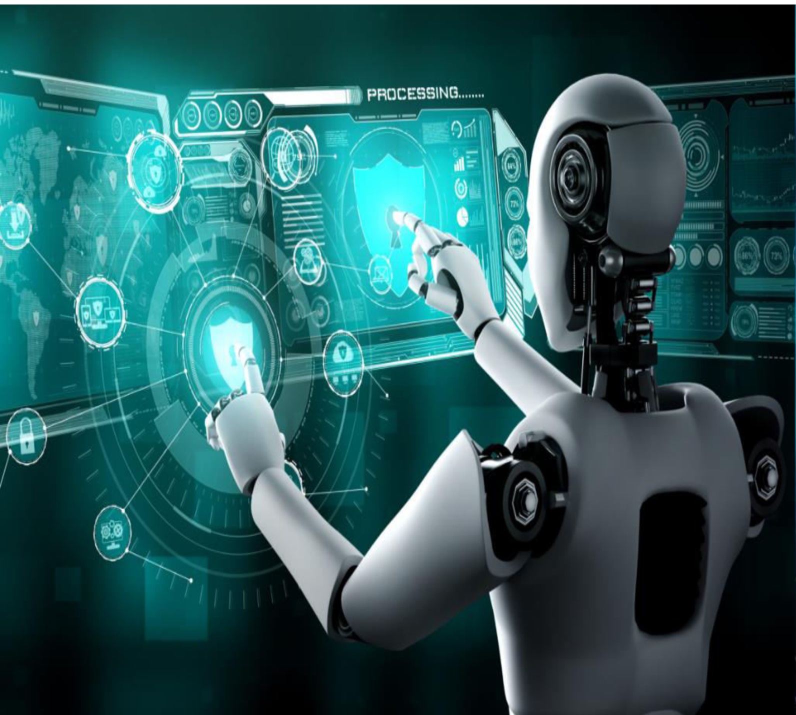

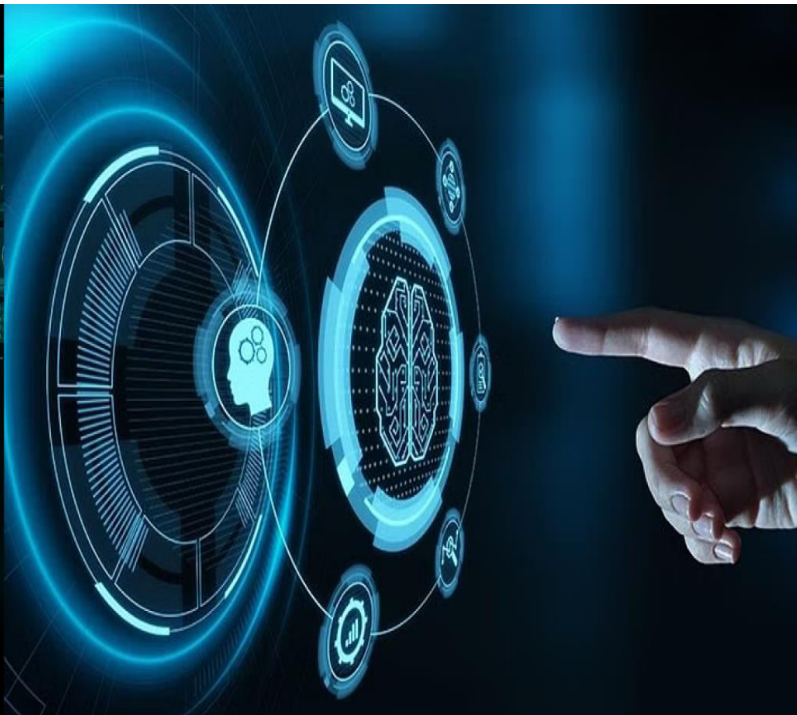

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Chat GPT Accuracy Enhancer

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ABSTRACT: Mathematics, being the cornerstone of science and engineering, often presents challenges in input representation and conceptual visualization— especially in digital environments. This project presents a multi-functional mathematical assistant that seamlessly integrates symbolic computation with machine learning-powered image recognition. The assistant is capable of interpreting manual mathematical input and image-based equations, converting them into editable LaTeX and SymPy formats. By combining the strengths of symbolic com- putation engines like SymPy with LaTeX OCR models, the system enables users to perform integration, differentiation, solve linear equations, and pose general math-related queries with remarkable ease and accuracy. The interface is modular, dynamic, and user-centric, designed to cater to students, educators, and professionals alike. This assistant is not only a com-putational tool but also an educational aid that enhances mathematical understanding and productivity in both academic and real-world settings.

KEYWORDS: Symbolic Computation, SymPy, LaTeX OCR, Integration, Differentiation, Lin- ear Equations, AI-Powered Math Solver, Natural Language Processing, Math Visualization, Automated Equation Solver, Mathematical Expression Recognition, Educational Technol- ogy, Multimodal Input System, Math Assistant, Image-to-Latex Conversion

I. INTRODUCTION

The digital transformation of education and research has highlighted the need for intuitive and intelligent systems that can bridge the gap between handwritten mathematical problems and digital computation. Traditional computer algebra systems (CAS) often require users to input expressions in rigid, syntax-bound formats, creating a steep learning curve for begin- ners. Meanwhile, advances in machine learning have enabled image recognition models that can interpret complex mathematical notation from images.

This project aims to combine these paradigms into a unified mathematical assistant that of- fers:

- Symbolic computation through manual input using SymPy.
- Mathematical interpretation of images using LaTeX OCR models.
- Editable input/output fields with real-time updates.
- Clean, LaTeX-formatted outputs suitable for academic or professional use.

By dividing the assistant into four functional modules—Integration, Differentiation, Lin- ear Equation Solver with Graphs, and General Query Handler—the project delivers a well- rounded experience tailored to various use cases in mathematical education and application. This assistant enables seamless interaction between traditional input styles and

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modern digital computation, offering solutions with both symbolic accuracy and visual clarity.The projects long-term vision includes making mathematical learning more inclusive and interactive by supporting voice-based inputs, mobile interfaces, and explainable step-by-step solutions pow- ered by AI.

OBJECTIVE

- To enable mathematical expression input using both text and image formats.
- To perform symbolic operations like integration and differentiation.
- To solve linear equations in one, two, or three variables.
- To visualize mathematical solutions, particularly graphs for linear equations.
- To support general queries about mathematical concepts and computations.

II. LITERATURE REVIEW

2.1 EXISTING SYSTEM

Paper 1: Mathematical Capabilities of ChatGPT Authors: Simon Frieder, Luca Pinchetti, Alexis Chevalier, Ryan-Rhys Griffiths, Tommaso Salvatori, Thomas Lukasiewicz, Philipp Christian Petersen, Julius Berner Publisher: arXiv, Preprint published in Jan- uary 2023 This paper evaluates the mathematical capabilities of two iterations of Chat- GPT (January 2023 versions) and GPT-4, using novel datasets named GHOSTS and miniGHOSTS. These datasets test the models' ability to handle graduate-level math- ematics, providing insight into how well ChatGPT and GPT-4 perform mathematical tasks like computa- tional questions, proof completions, and solving complex inte- grals. The results show that while ChatGPT can act as a mathematical assistant for basic queries, its performance deteriorates with more advanced mathematical tasks. GPT-4 performs better but still struggles with graduate-level questions and complex reasoning.

Pros:

- Introduced two new datasets (GHOSTS and miniGHOSTS) to benchmark ad- vanced mathematical capabilities.
- GPT-4 shows improvement over earlier versions of ChatGPT, performing reason- ably well on undergraduate-level math.
- Comprehensive analysis of model strengths and limitations, offering in- sights for improving AI's mathematical reasoning.

Cons:

- GPT-4 and ChatGPT are still far from matching human graduate-level perfor- mance in mathematics.
- The models often fail in tasks requiring deep insight and original solutions, like Olympiad problems or graduate-level proofs.
- Performance metrics are significantly lower compared to models specifically trained for mathematics, like Minerva (mathematical capabilities).

Paper 2: Evaluating the Logical Reasoning Capability of ChatGPT Authors: Han- meng Liu (Westlake University), Ruoxi Ning (Zhejiang University), Zhiyang Teng (Nanyang Technological University), Jian Liu (Fudan University), Qiji Zhou, Yue Zhang (Westlake University) Publisher: arXiv, Preprint published in May 2023 This paper in- vestigates the logical reasoning capabilities of ChatGPT and GPT-4, comparing their performances on various logical reasoning datasets such as LogiQA, Re- Clor, and AR-LSAT. The authors explore tasks like multichoice reading comprehension and nat- ural language inference (NLI), which test logical reasoning ability. The findings re- veal that both models perform reasonably well on established datasets but struggle with newly released and out-of-distribution datasets, where performance drops signifi- cantly. While GPT-4 surpasses ChatGPT in most logical tasks, logical reasoning re- mains a challenge for both models.

Pros:

- **Comprehensive evaluation:** Tests the logical reasoning abilities of both Chat- GPT and GPT-4 on multiple benchmarks.

Introduction of LogiEval Dataset: A new dataset to further benchmark AI mod- els in logical

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reasoning.Improved performance with GPT-4: GPT-4 consistently performs better than Chat- GPT, especially in well-known datasets like LogiQA and ReClor.

Cons:

- **Struggles with out-of-distribution data:** Both models experience significant drops in performance when faced with new or out-of-distribution datasets.
- **Challenges with natural language inference:** Despite improvements, both mod- els show weaknesses in tasks requiring advanced logical reasoning, especially in NLI tasks.

III. LIMITATIONS IN EXISTING SYSTEM

1. **Lack of Symbolic Computation:**

   Most AI language models, including Chat- GPT, rely on pattern recognition and prob- abilistic techniques to generate text, which works well for general language tasks. However, mathematics requires precise symbolic computation and step-by-step logi- cal reasoning, which these models are not inherently designed to perform. This leads to incorrect answers, especially in complex mathematical problems.

2. **Inconsistent Handling of Mathematical Queries:**

   As observed in multi- ple experiments and supported by the research, ChatGPT strug- gles with consis- tency when handling similar mathematical queries. It may provide correct answers to simpler problems but fails to address more complex or nuanced queries. This inconsistency reduces the reliability of AI as a tool for mathematical learning or assistance.

3. **Ambiguity in Responses:**

   When faced with mathematical problems, Chat- GPT tends to provide answers that are vague or incomplete. For instance, it may skip key steps in the solution process or offer general explanations without detailed breakdowns. This lack of clarity can be confusing for users, especially those seeking precise assistance with academic or professional mathematical tasks.

4. **Limited Contextual Understanding in Word Problems:**

   Research has shown that AI models like ChatGPT often misinterpret mathematical word prob- lems due to their inability to fully understand the context and logic behind them. This limitation is particularly problematic for more advanced mathematical in- queries, where contextual understanding is key to providing an accurate solution.

5. **Dependence on Training Data:**

   The performance of AI systems like Chat- GPT is heavily dependent on the quality of the training data they receive. If the training data lacks sufficient mathematical content or examples, the model will struggle to provide correct solutions, especially for niche or specialized mathematical queries.

RESEARCH

In addition to these papers, we also conducted our own tests on ChatGPT by posing a variety of math related questions. In several instances, the system provided incorrect or incomplete answers, as demonstrated by the screenshots attached (refer to Appendix). For example, when asked about solving integrals or algebraic equations, ChatGPT either gave the wrong solution or failed to provide the correct steps in solving the problem, illustrating its current limitations in this domain.

Training Data: ChatGPT is trained on large amounts of internet text but not specifi- cally on mathematical concepts or problem-solving datasets, which limits its effective- ness in solving complex math problems.

Architecture of GPT: The GPT model is primarily designed for natural language understanding and

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generation, not formal mathematical reasoning. As a result, it strug- gles to produce precise results for math-based tasks.

Probabilistic Nature: ChatGPT operates as a probabilistic generative model, which can lead to inaccurate results in tasks that require high precision, such as mathematics, where exact answers are essential.

IV. SYSTEM DESIGN AND ARCHITECTURE

This project presents a comprehensive AI-powered mathematical assistant designed to per- form symbolic computations, visualize equations, and process both textual and image-based mathematical input. The system is divided into **four major sections**, each addressing differ- ent mathematical operations and input modes to ensure flexibility, interactivity, and accuracy.

1. **Integration Module:** This section handles symbolic integration. Users can input ex- pressions manually using **SymPy syntax** or upload an image containing mathematical expressions. The image input is processed using a **LaTeX OCR model** that extracts the mathematical content in LaTeX format. The LaTeX is then converted to SymPy-compatible syntax, allowing further editing and manipulation. The final output is ren- dered in **LaTeX format** for display.
2. **Differentiation Module:** Similar to the integration module, this section facilitates symbolic **differentiation**. It supports manual input in SymPy format and also allows users to upload mathematical expression images. The OCR pipeline extracts LaTeX from images, which is then converted to SymPy syntax. Both input formats are ed- itable, and the final derivative is displayed in LaTeX form for easy readability and presentation.
3. **Linear Equation Solver:** This section solves **linear equations** with **one, two, or three variables**. It not only provides the solutions but also **visualizes the equations graphically** wherever applicable. This allows users to understand the nature of the solutions and the relationship between variables in a more intuitive way.
4. **General Query Interface:** A general-purpose assistant capable of answering **math- ematics related textual queries** and **solving simple mathematical problems**. This includes arithmetic questions, definitions, conceptual explanations, and symbolic ma- nipulations outside the specific scope of integration, differentiation, or linear equations.

4.1SYSTEM COMPONENTS

- **User Interface:** Interactive and user-friendly frontend supporting manual input and image upload.
- **OCR Engine:** Converts mathematical images to LaTeX using a pretrained LaTeX OCR model.
- **LaTeX-to-SymPy Converter:** Parses LaTeX and converts it into executable SymPy expressions.Symbolic Engine: Based on SymPy, performs integration, differentiation, and equation solving.
- **Graph Module:** Uses Python plotting libraries (e.g., Matplotlib or Plotly) to render graphs for linear equations.
- **Query Handler:** Natural language processing module for understanding and respond- ing to textual math queries.

4.2 USE CASE

- User inputs a mathematical expression manually using SymPy syntax.
- User uploads an image of a mathematical expression.
- System extracts LaTeX from the image using a LaTeX OCR model.
- LaTeX is converted into editable SymPy syntax.
- User can edit both LaTeX and SymPy expressions before processing.
- User selects the Integration module to compute the integral of the expression.
- User selects the Differentiation module to compute the derivative of the expression.
- User selects the Linear Equation Solver module to solve equations with 1, 2, or 3 variables.
- System displays the solution in LaTeX format.
- For 1 or 2 variable equations, system generates a graph of the equations.
- User enters a natural language query or a simple math question.

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- System interprets the query using NLP and responds with explanations or calculations.
- System allows interactive editing of inputs for better understanding and learning.
- User receives symbolic and visual output based on the selected operation.

4.3 IMPLEMENTATION DETAIL

- **Technologies Used:** Python, SymPy, LaTeX, OpenCV, Matplotlib, recognition mod- els.
- **Backend:** Handles symbolic computation, LaTeX conversion, and logic processing.
- **Frontend:** Developed with a lightweight UI framework to support real-time editing and rendering.
- **Libraries:** SymPy for computation, pytesseract or TrOCR for OCR, Plotly/Matplotlib for visualization.

V. WORK FLOW

The system is structured into four main sections: Integration, Differentiation, Linear Equa- tions, and General Query. Both the Integration and Differentiation sections accept manual input in SymPy format or image input processed via a LaTeX OCR model. The extracted LaTeX is converted to editable SymPy syntax, and results are displayed in LaTeX format. The Linear Equations section supports solving equations with one, two, or three variables and visualizes results through 2D graphs or a 3D view. The General Query section distin- guishes between math-related and general text inputs—math queries are processed using a math solver, while other inputs are handled by the ChatGPT API. This modular design al- lows for seamless symbolic computation and natural language understanding.

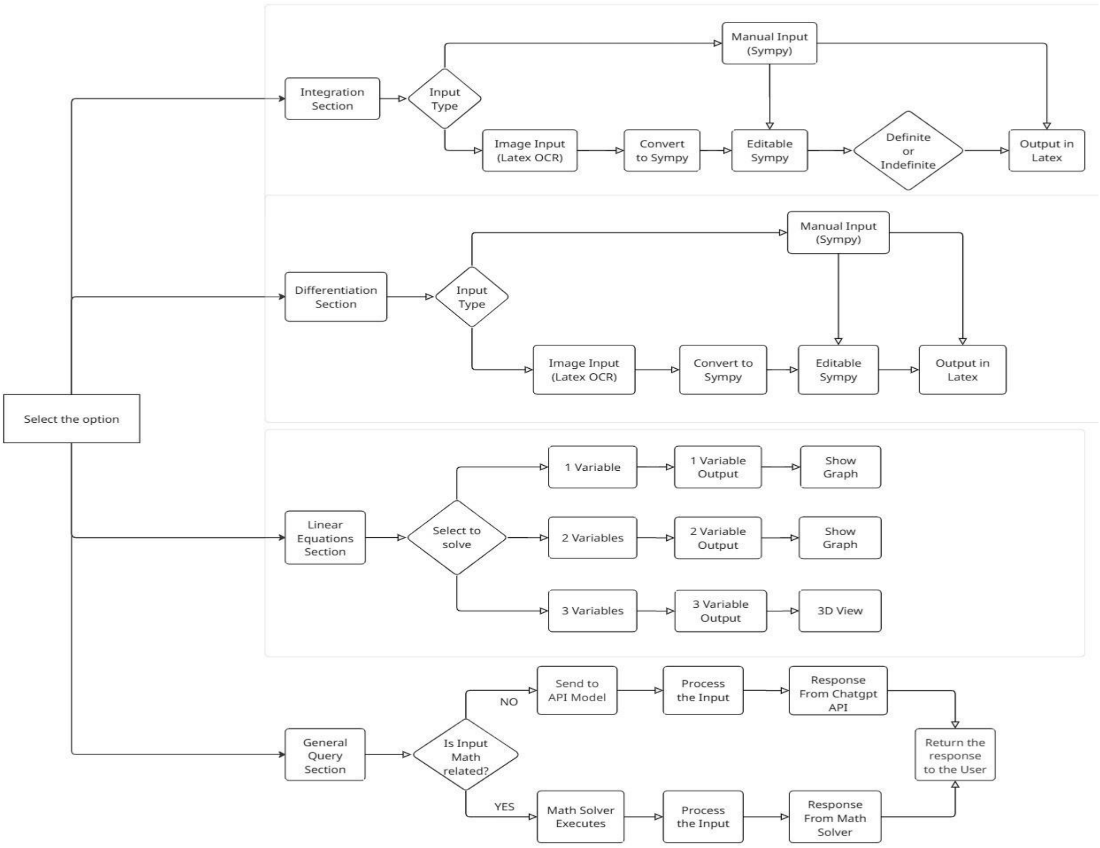

Figure 1: System Flowchart

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V. EVALUATION AND RESULT

The system was tested with various mathematical inputs including handwritten integrals, derivatives, and linear equations. The OCR accuracy was observed to be high for printed text and reasonably accurate for handwritten inputs. Symbolic outputs were validated using benchmark problems. User feedback indicated improved engagement and understanding due to the systems interactive nature.

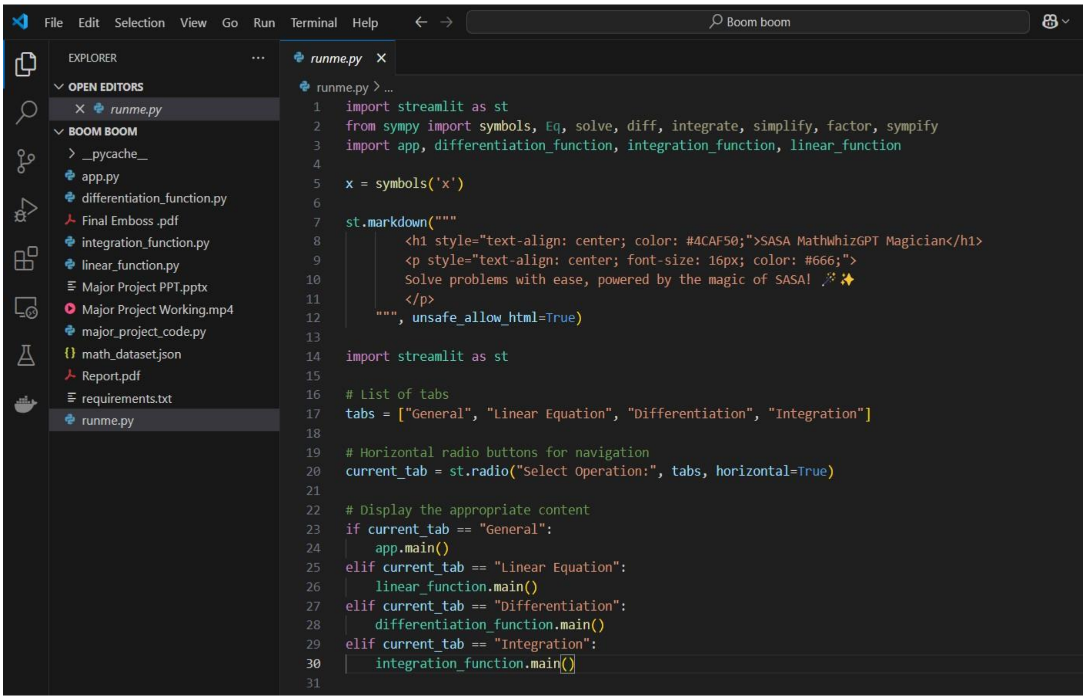

Figure 2: Sample Code

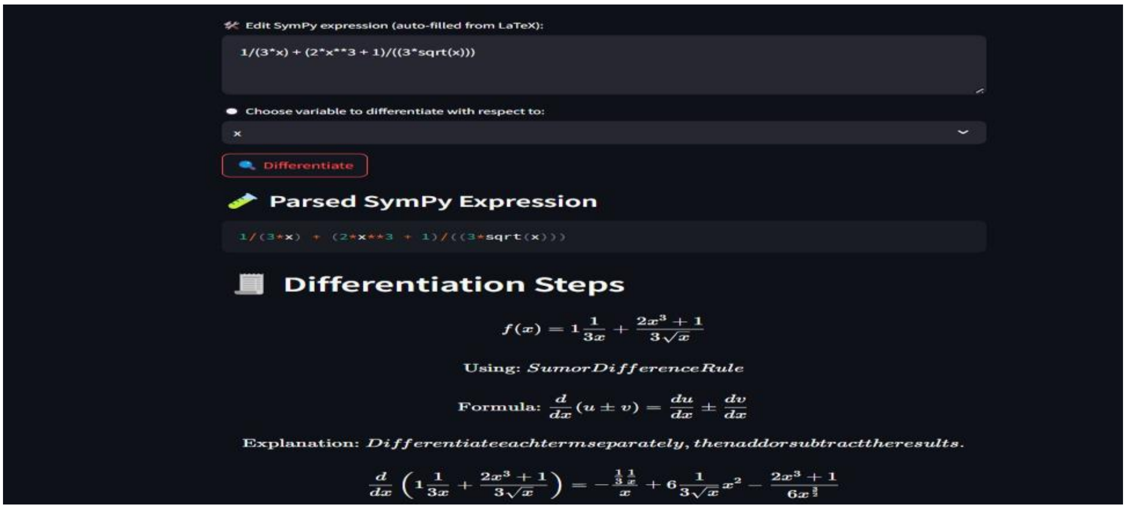

Figure 3: Sample output of Differentiation

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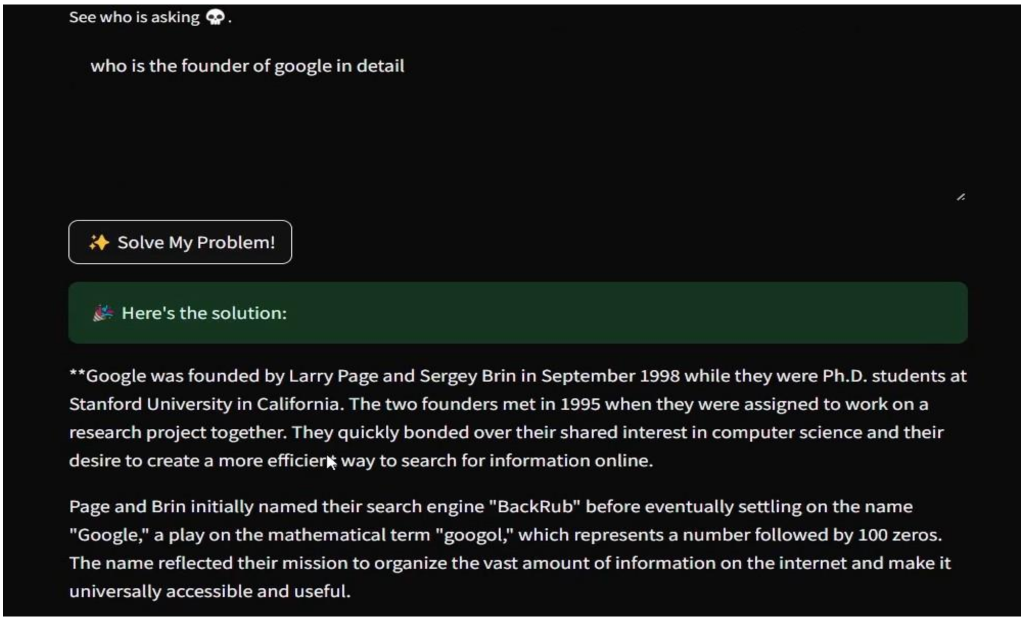

Figure 4: Sample output of General text query

VI. DISCUSSION

Enhancing ChatGPTs accuracy involves improving data quality and diversity, refining its architecture, and fine-tuning the model on domain-specific datasets. Incorporating user feed- back, improving contextual understanding, and reducing hallucinations are crucial for reli- ability. Bias mitigation, real-time information integration, and advanced evaluation metrics further boost performance. Additionally, allowing user customized training can make the model more precise and relevant to individual needs. These strategies collectively improve ChatGPT's accuracy, coherence, and adaptability.

VII. CONCLUSION

This research presents a comprehensive and modular symbolic mathematics assistant that leverages both manual and image-based inputs to perform complex mathematical operations such as integration, differentiation, and solving linear equations. The system's ability to convert image-based LaTeX input into editable SymPy expressions, along with real time visualization and multi-modal response handling, makes it highly adaptable for educational, academic, and research purposes. Furthermore, the integration of natural language processing allows users to engage with the system intuitively, making mathematical problem-solving more accessible and interactive. This work demonstrates the potential for combining OCR, symbolic computation, and language models to create intelligent and user friendly math-solving platforms.

VIII. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to all contributors who supported this project. Special thanks to the open-source communities behind SymPy, LaTeX OCR, and OpenAI for providing the foundational tools and models that powered the development of this system. We also acknowledge the valuable feedback and guidance from mentors, educa- tors, and peers who helped refine the system architecture and use-case design throughout the course of this research.

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