

MathBot – A Complete Maths Problems Solver

Dissertation

submitted in partial fulfilment of the requirements
for the degree of

Master of Technology

by

Rahul Tiwari
Roll No: 2303res49

under the guidance of

Mr. Manish Kumar Acharya



**INDIAN INSTITUTE OF
TECHNOLOGY, PATNA**

2024-2025

Acknowledgments

I express my sincere gratitude towards my guide **Mr. Manish Kumar Acharya** for his constant help, encouragement and inspiration throughout the project work. Without his invaluable guidance, this work would never have been a successful one. Last, but not the least, I would like to thank the whole **IIT Patna** family which made this programme and my learnings a memorable one.

Rahul Tiwari
IIT PATNA
Dec 12, 2024

Abstract

Like the way **elementary school** kids are taught to learn to solve **Natural Language**-based math word problems, I will be training a deep learning system to solve same problems. These elementary school words problems involve one or more algebraic equations comprising of any combination of four arithmetic operations, namely addition, subtraction, multiplication and division.

The goal of the system would then be to understand the arithmetic operation from the language context and then provide a equation for it and finally providing the solution based on the developed equation, once the solution is provided we will try to check the correctness based on the **RLHF technique/LLM model** and if the solution provided is correct then the same solution will be provided by the Model, if not then the correct solution will be provided by feedback from the LLM Model and the MathBot will be re-trained on such problems to improve its accuracy on incorrect problems.

I will collect the datasets of problems from various Elementary Level school books in the form of direct text-problems and the Images data to train for Text extraction from Images as well. Once the data is collected, I will try to train the **transformer-based deep learning model** on the training data.

There have been many semantic parsers and rule-based math word problem solvers, but application of any learning algorithm to reduce **Natural Language** based math problems into equations is a topic of recent research. In this project, I will show that the use of deep learning based natural language processing techniques, such as, **Recurrent Neural Networks** and **Transformers (Pre-Trained Models)**, can help build such a Chatbot Based learning system.

Introduction

Generative AI It is a subset of traditional ML. The ML algorithms that work behind generative AI do so by exploiting the statistical patterns present in the massive datasets of content that was originally generated by humans. **LLMs Definition** LLMs (Large Language Models) are generative AI models specifically designed to understand text. All LLMs are powered by the Transformer (Google, 2017) architecture. They are designed to take in input text and repeatedly generate the next token or word that appropriately “completes” the input text.

For example: an LLM can be given the input:

Where is Ganymede located in the solar system? In response, the LLM might generate the following output: Ganymede is a moon of Jupiter and is in the solar system within Jupiter’s orbit. Here, the model essentially completed the given input by repeatedly generating the next word or token that fits appropriately. These models have abilities beyond just language and can break down complex tasks, reasoning and problem solving. It is commonly accepted that as the size (in terms of number of parameters) of an LLM increases, so does its understanding of language. At the same time, it is also true the smaller models can be fine-tuned to perform well on specific tasks

Examples (Foundation/Base Models)

- BERT (Google, 2018)
- GPT (OpenAI, 2018)
- BLOOM (BigScience Warehouse, 2022)
- FLAN-T5 (Google, 2023)
- PaLM (Google, 2022)
- LLaMA (Facebook, 2023)

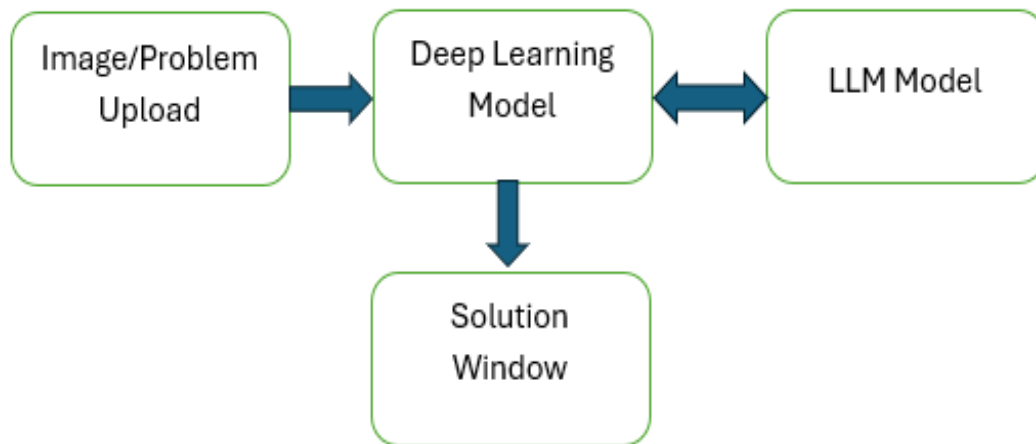
Use Cases

- Chatbots.
- Text summary (articles, files).
- Translation (traditional human language to human language, or from natural language to code).
- Named Entity Recognition.
- More complex tasks which require invoking external tools (answering fact-based queries using Google’s Search API).

High Level Architecture Diagram

(Might change a little bit in Final project)

Architecture Diagram: As of now below will be the major components of the MathBot.



Image/Problem Upload: The window where you can upload your problem in text format or upload an Image of it, and in case of Image will be converted into text.

Deep Learning Model: The base or primary model which will be trained on elementary level problems to understand and provide step by step solutions with clear explanations, it might be optional.

LLM Model: The LLM Model which is being used here to help in getting the correct output and if needed the output of LLM will be feedback to the Deep Learning model for re-training purpose.

Solution Window: The context area or the window where the solution with clear explanations and Final Answer will be displayed.

Current Progress

Image/Problem Upload: The window where you can upload your problem in text format or upload an Image of it, and in case of Image will be converted into text.

Current Progress:

Have used **streamlit** library to create the Front Screen or the Context Window where the user will try to write or upload the problem. Below is the screenshot for the same.

Your Personal Maths Problems Solver



Hi, I'm a Math Chatbot who can answer all your maths questions

Enter your question:

Get Answer

Deep Learning Model: The base or primary model which will be trained on elementary level problems to understand and provide step by step solutions with clear explanations.

Current Progress: The Data Preparation is still In Progress and various NCERT books and supporting materials where I can get problems with correct solutions is being prepared accordingly. I am planning to use either training the RNN Model from scratch or will use one or the other open-source pre-trained Models available to do the needful and train it accordingly. **Current Dataset** is attached [here](#) which I will be using for LLM fine-tuning.

LLM Model: The LLM Model which is being used here to help in getting the correct output and if needed the output of LLM will be feedback to the Deep Learning model for re-training purpose.

Current Progress: Have finalized the **Google's Gemma-2 Model** for it and developed the LLM app accordingly where further I will fine-tune it using LoRA/QLoRA techniques on the prepared data to achieve better accuracy and correctness in terms of solutions and results. This has already been deployed on StreamLit Cloud Platform and is available to use for public as well. Further planning to integrate with **Telegram** and making it a **Conversational Chatbot** which can be used by students, teachers to solve their complex problems.

Solution Window: The context area or the window where the solution with clear explanations and Final Answer will be displayed. Below is the screenshot for it with sample Maths question asked to the LLM app.

Your Personal Maths Problems Solver



Hi, I'm a Math Chatbot who can answer all your maths questions

Enter your question:

Solve for X, y:

$$X + y = 10$$

$$X - y = 4 ?$$

Get Answer



Solve for X, y:

$$X + y = 10 \quad X - y = 4$$

✓ Complete!

✓ Complete!

Response:

$$X = 7, Y = 3$$

LLM APP Link: [MathBot - Try It Yourself](#)