BRAUDE
College of Engineering, karmiel

Capstone Project Phase A
24-2-R-15

Interactive Mathematical Proof Verification System

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Motivation

Background LLMs like ChatGPT, can generate complex mathematical proofs.

Problem ChatGPT lacks the ability to verify these proofs.

Need A system to verify AI-generated proofs for accuracy.

Introduction

Study Focus

Address the challenge of verifying ChatGPT-generated mathematical proofs.

Objective

Create a system that verifies proofs generated by ChatGPT, verified through Agda.

Methodology

Utilizes ChatGPT’s API and Agda’s verification based on Intuitionistic and Homotopy Type Theories.

Outcome

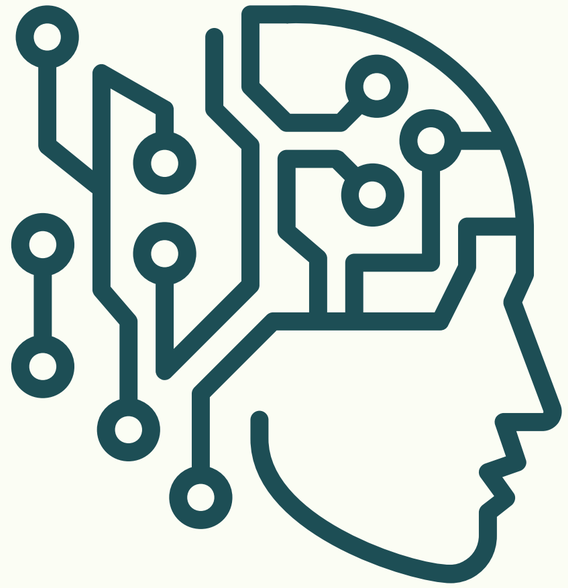
A system that reliably verifies ChatGPT-generated mathematical proofs.

Technologies and Theories

01 **Intuitionistic and Homotopy Type Theories**

02 **Agda**

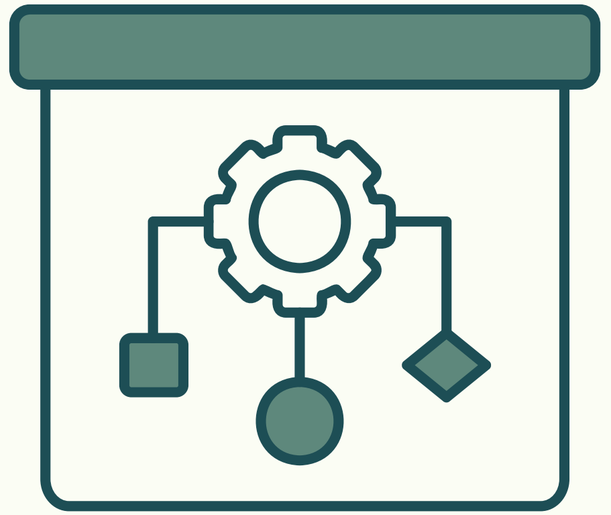
03 **ChatGPT**



Intuitionistic and Homotopy Type Theories

- Intuitionistic Type Theory:
  - Treats proofs as algorithms – proving something means constructing it step by step.

- Homotopy Type Theory:
  - Simplifies handling complex structures using the Univalence Axiom, treating equivalent objects as identical.



Agda

- What is Agda?
  - A dependently typed functional programming language
  - Used for writing and verifying formal proofs

- Why Agda?
  - Treats proofs as algorithms
  - Allows complex mathematical structures with precise verification

```
data ℕ : Set where
  zero . ℕ
  suc    ℕ → ℕ
```

```
_+_    ℕ → ℕ → ℕ
zero     n = n
suc m    n = suc (m + n)
```

ChatGPT

- What is ChatGPT?
  - A Large Language Model designed for natural language processing

- Why ChatGPT?
  - Generates human-like proofs from natural language inputs
  - Provides an API that will be used for communication with Agda

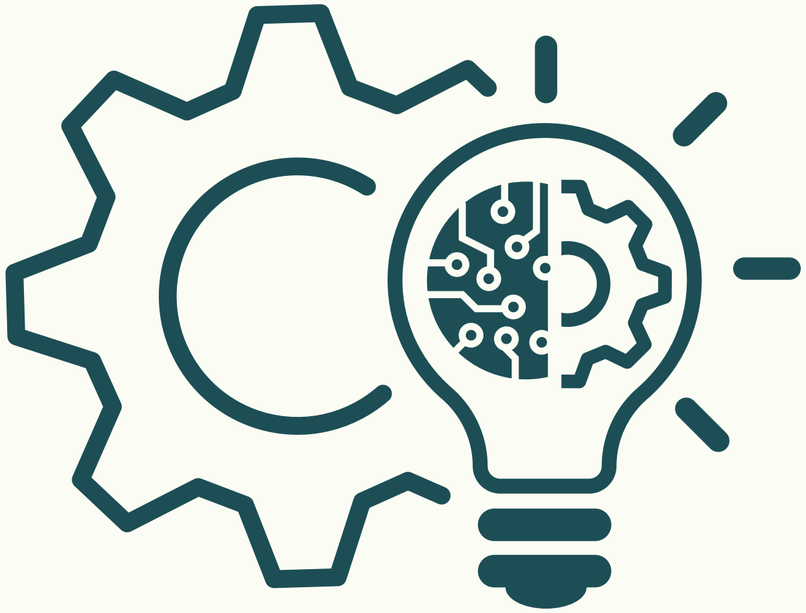
Research/Engineering Process

01 **Algorithm**

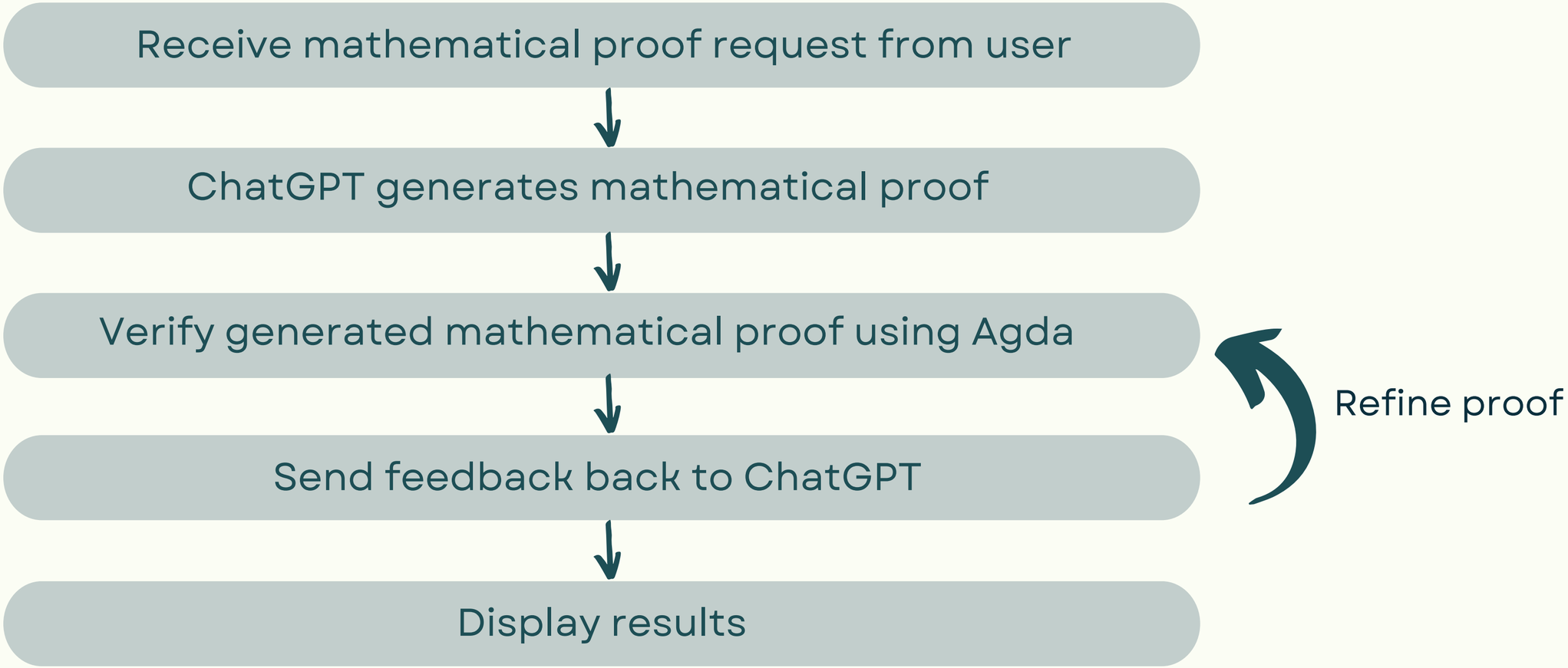
02 **Diagrams**

03 **Challenges**

04 **Prototype**

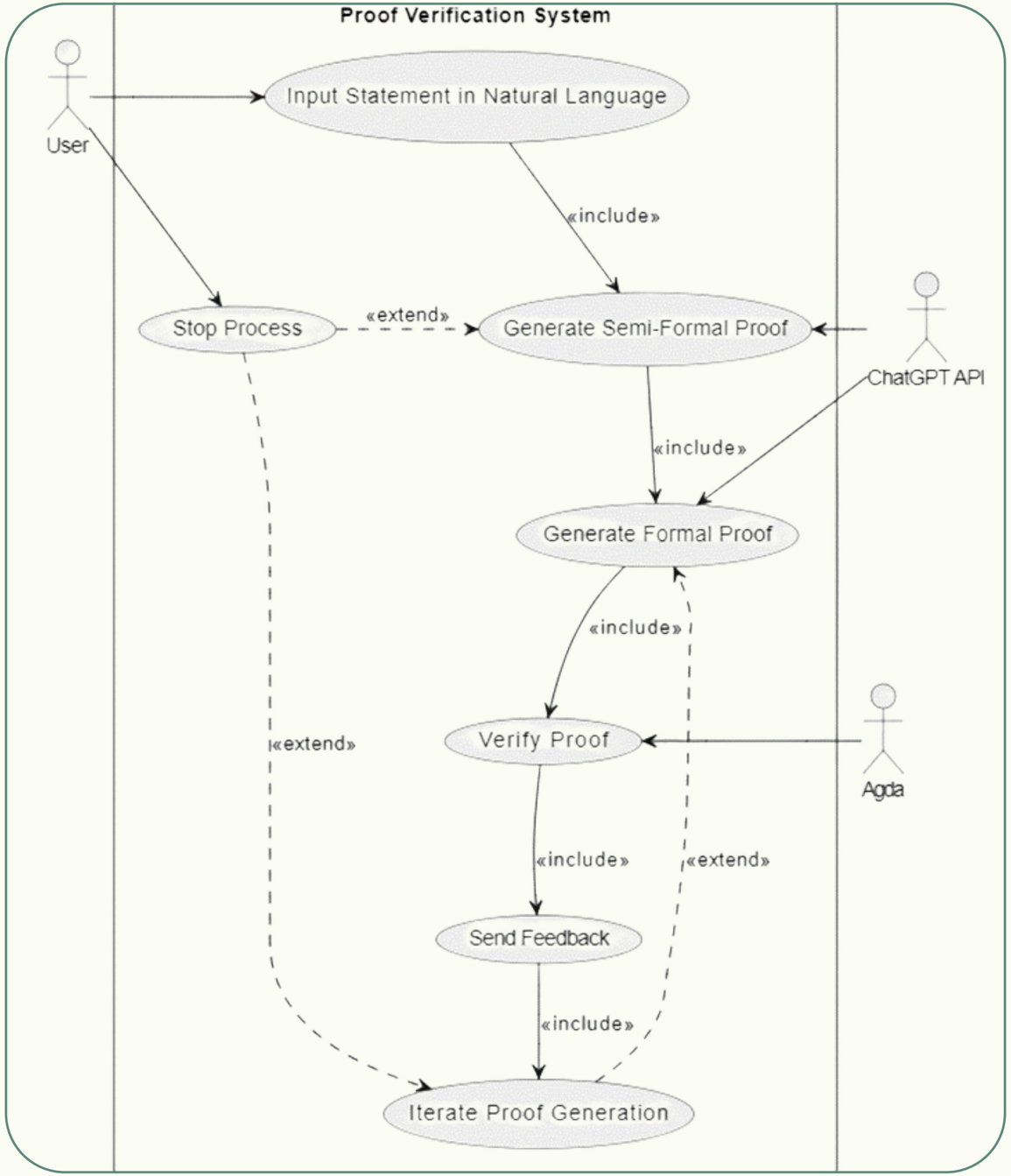


Algorithm


Receive mathematical proof request from user
ChatGPT generates mathematical proof
Verify generated mathematical proof using Agda
Send feedback back to ChatGPT
Display results
Refine proof

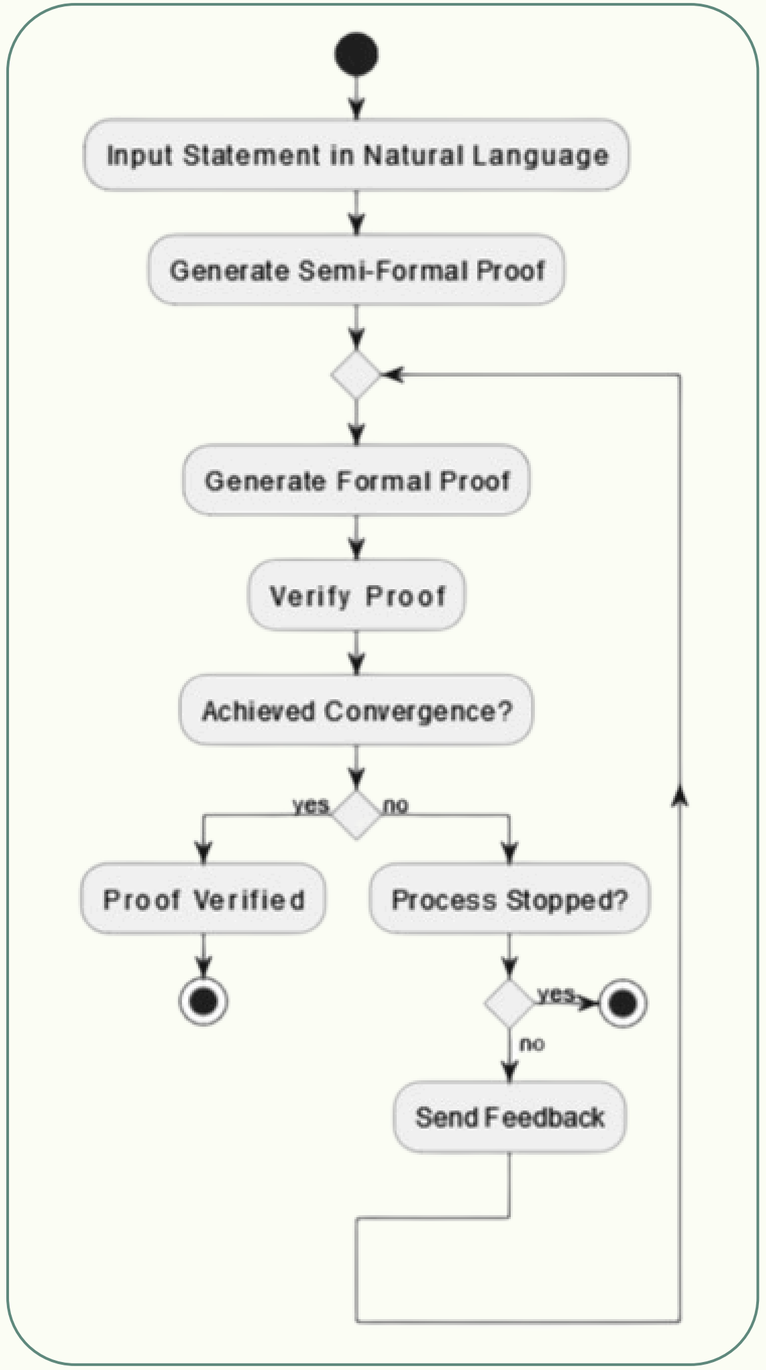
Diagrams

Use Case Diagram



Diagrams

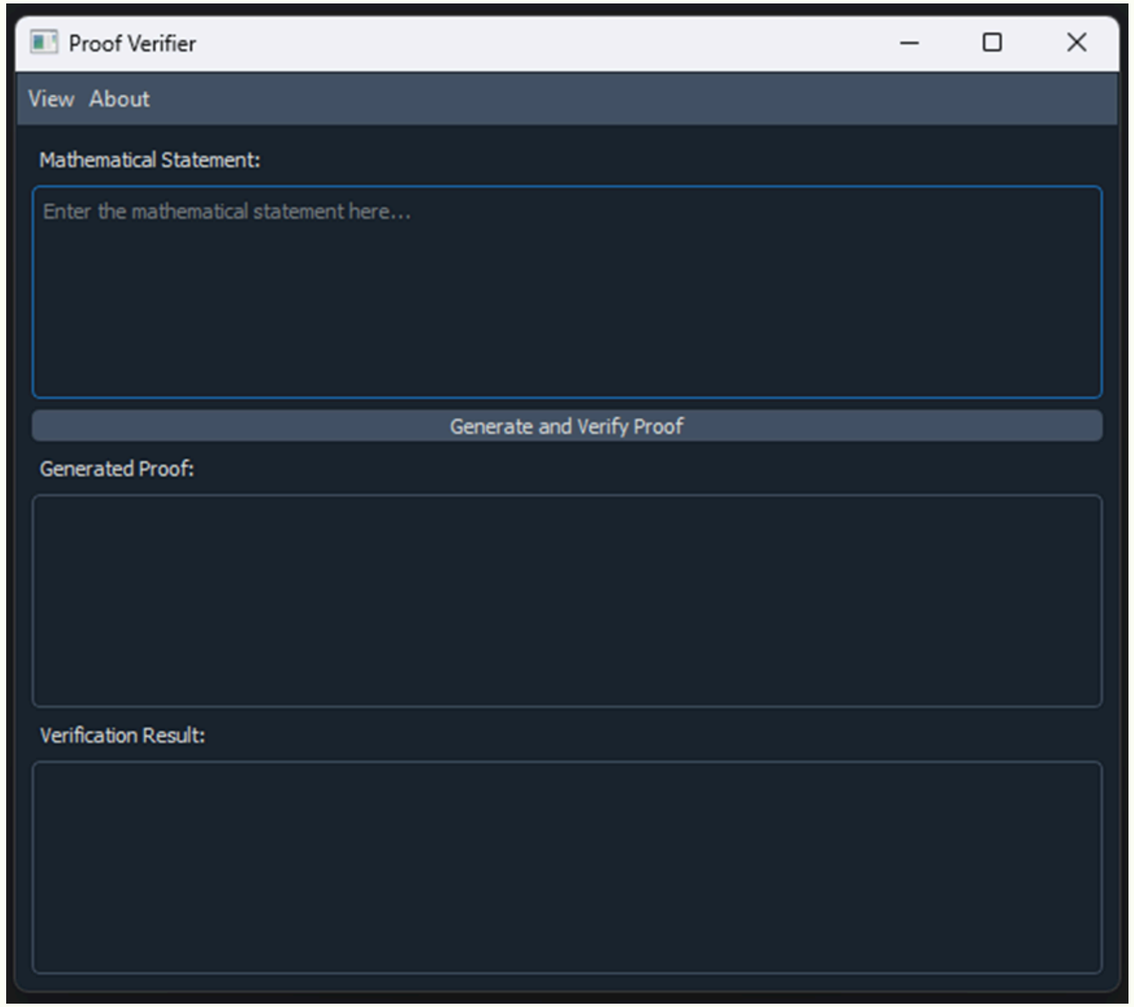
Activity Diagram



Challenges

- Non-Convergence
- Efficiency
- Smooth communication between ChatGPT and Agda
- Agda code

Prototype


Proof Verifier
View About
Mathematical Statement:
Enter the mathematical statement here...
Generate and Verify Proof
Generated Proof:
Verification Result:

Verification Plan

Test Case	Test Case Description	Expected Outcome
1	Input a valid natural language mathematical statement into ChatGPT	ChatGPT generates a semi-formal proof, which is translated into Agda code for verification
2	Proof verification fails due to incorrect input	The system provides feedback, and ChatGPT refines the proof
3	Input a large and complex proof statement	The system efficiently handles the input and completes verification within an acceptable time-frame

Verification Plan

Test Case	Test Case Description	Expected Outcome
4	Attempt to verify an invalid or incomplete proof	The system detects the errors, provides feedback, and does not falsely confirm validity
5	User interrupts the iterative refinement process	The system safely halts the refinement process, saving the current state of the proof
6	The maximum duration of the iterative process is reached	The system safely halts the refinement process, saving the current state of the proof

Expected Achievements

1. Successful Convergence of ChatGPT Generated Proofs
2. Increased Efficiency in Mathematical Proof Verification
3. Improved Trustworthiness of ChatGPT Generated Proofs

Thank You for Listening!