Working on Guaranteed Safe AI

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Views are my own. GSAI is fairly new and has lots of authors with internal disagreements.

I. What is Guaranteed Safe AI?

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Family of research agendas / AI safety strategies involving:

- **Proof certificates** over model outputs, not internals.
- **World models** and simulations therein.

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- Instead, we're interested in the code that the learned component is writing (i.e., a *blackbox approach*).
- We would like that code to be formally verifiable

Proof certs over model outputs: example

TODO

World models and simulations therein

TODO

Assumptions

- **Boxing/containment**: probably doesn't work with arbitrarily unboxing schemers
- **Swiss cheese**: "defense in depth"

Boxing/containment

- We're **micromanaging the interface** between the AI and the world.

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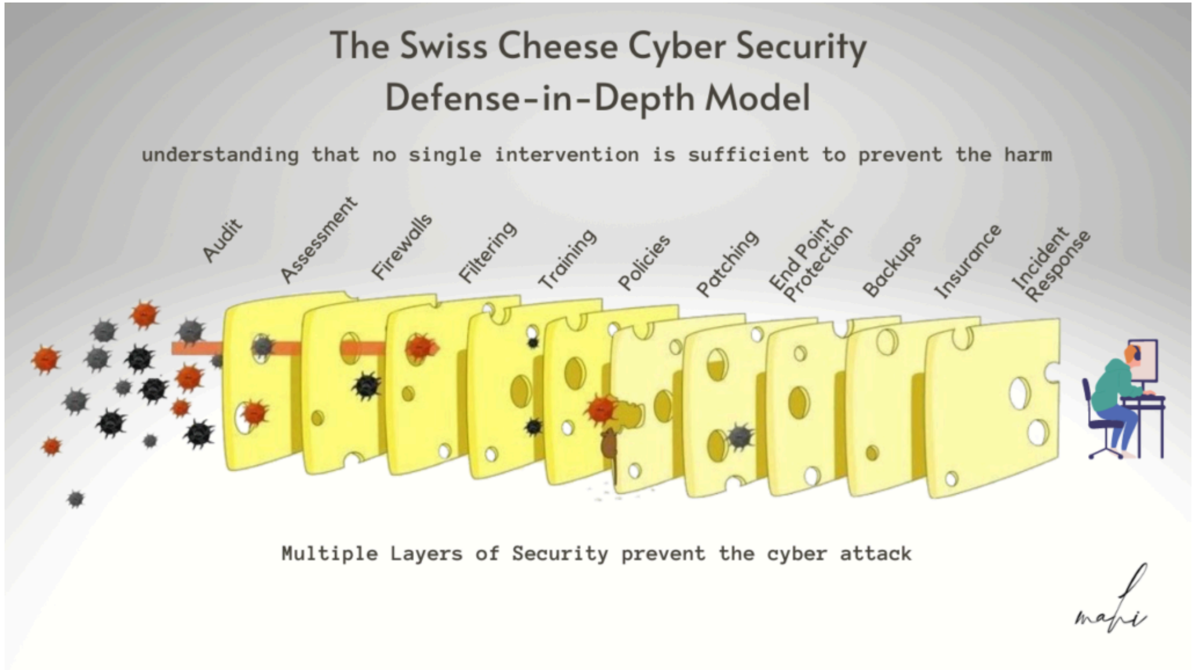
- But even formal methods would leave side channel attacks open for an ASI to exploit

Swiss cheese (defense in depth)



Main position paper

[Submitted on 10 May 2024 (v1), last revised 8 Jul 2024 (this version, v3)]

Towards Guaranteed Safe AI: A Framework for Ensuring Robust and Reliable AI Systems

David "davidad" Dalrymple, Joar Skalse, Yoshua Bengio, Stuart Russell, Max Tegmark, Sanjit Seshia, Steve Omohundro, Christian Szegedy, Ben Goldhaber, Nora Ammann, Alessandro Abate, Joe Halpern, Clark Barrett, Ding Zhao, Tan Zhi-Xuan, Jeannette Wing, Joshua Tenenbaum

Ensuring that AI systems reliably and robustly avoid harmful or dangerous behaviours is a crucial challenge, especially for AI systems with a high degree of autonomy and general intelligence, or systems used in safety-critical contexts. In this paper, we will introduce and define a family of approaches to AI safety, which we will refer to as guaranteed safe (GS) AI. The core feature of these approaches is that they aim to produce AI systems which are equipped with high-assurance quantitative safety guarantees. This is achieved by the interplay of three core components: a world model (which provides a mathematical description of how the AI system affects the outside world), a safety specification (which is a mathematical description of what effects are acceptable), and a verifier (which provides an auditable proof certificate that the AI satisfies the safety specification relative to the world model). We outline a number of approaches for creating each of these three core components, describe the main technical challenges, and suggest a number of potential solutions to them. We also argue for the necessity of this approach to AI safety, and for the inadequacy of the main alternative approaches.

Synergies with other agendas

- Cybersecurity
- Control

GSAIxCybersecurity

Similarities:

- Reducing *attack surface*
- Hardening infrastructure

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Differences:

- GSAI emphasizes *prevention* more than *detection*

GSAIxControl

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- Blackbox as opposed to whitebox
- Containment schemes as opposed to assuming alignment

GSAIxControl

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- Blackbox as opposed to whitebox
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Differences:

- Control emphasizes insider risk more than GSAI
- GSAI looks for formal proof and subtopics where that makes sense (i.e. where there is inductive structure to be exploited)

II. What is working on GSAI like (example projects)

FVAPPS

Formally Verified APPS, translating Hendrycks et al 2021 into a Lean benchmark

[Submitted on 8 Feb 2025]

Proving the Coding Interview: A Benchmark for Formally Verified Code Generation

Quinn Dougherty, Ronak Mehta

We introduce the Formally Verified Automated Programming Progress Standards, or FVAPPS, a benchmark of 4715 samples for writing programs and proving their correctness, the largest formal verification benchmark, including 1083 curated and quality controlled samples. Previously, APPS provided a benchmark and dataset for programming puzzles to be completed in Python and checked against unit tests, of the kind seen in technical assessments in the software engineering industry. Building upon recent approaches for benchmarks in interactive theorem proving, we generalize the unit tests to Lean 4 theorems given without proof (i.e., using Lean's "sorry" keyword). On the 406 theorems of 100 randomly selected samples, Sonnet correctly proves 30% and Gemini correctly proves 18%. We challenge the machine learning and program synthesis communities to solve both each general purpose programming problem and its associated correctness specifications. The benchmark is available at this https URL.

FVAPPS: Formally Verified APPS

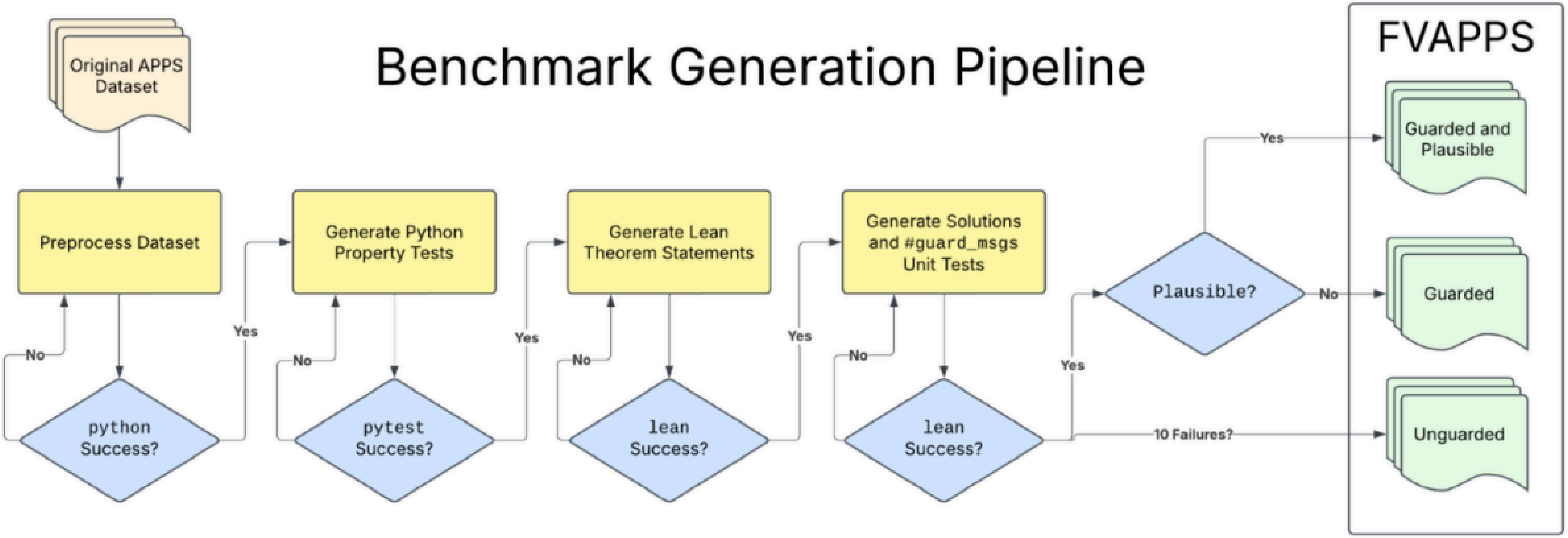
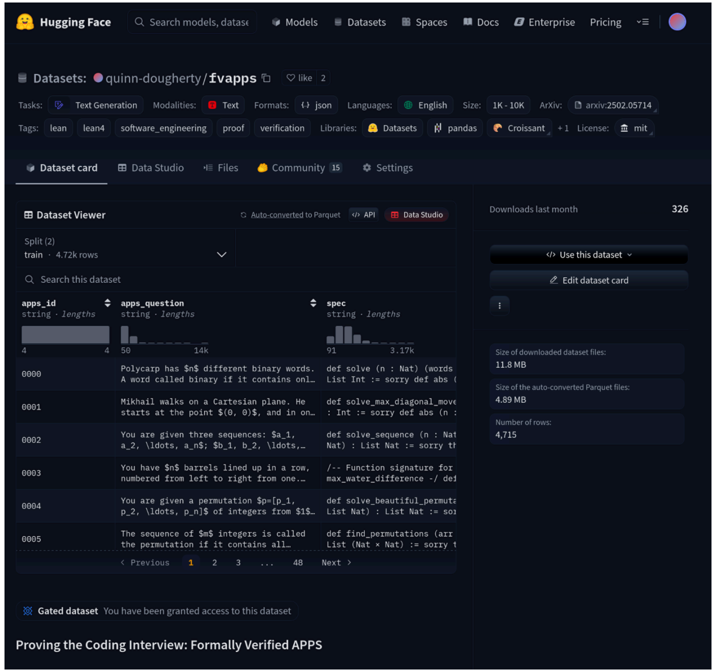


Fig. 1. Benchmark generation pipeline for creating coding interview theorem statements in Lean from APPS questions and solutions.

FVAPPS: Formally Verified APPS (on HuggingFace)



FVAPPS: Formally Verified APPS (example sample puzzle)

Now elections are held in Berland and you want to win them. More precisely, you want everyone to vote for you.

There are n voters, and two ways to convince each of them to vote for you. The first way to convince the i-th voter is to pay him p_i coins. The second way is to make m_i other voters vote for you, and the i-th voter will vote for free.

Moreover, the process of such voting takes place in several steps. For example, if there are five voters with $m_1 = 1$, $m_2 = 2$, $m_3 = 2$,

$m_4 = 4$, $m_5 = 5$, then you can buy the vote of the fifth voter, and eventually everyone will vote for you. Set of people voting for you will change as follows: $\{5\} \to \{1, 5\} \to \{1, 2, 3, 5\} \to \{1, 2, 3, 4, 5\}$.

Calculate the minimum number of coins you have to spend so that everyone votes for you.

FVAPPS: Formally Verified APPS (example sample)

```
def solve_elections (n : Nat) (voters : List (Nat ×
Nat)) : Nat := sorry
```

```
theorem solve_elections_nonnegative (n : Nat) (voters :
List (Nat × Nat)) : solve_elections n voters ≥ 0 := sorry

theorem solve_elections_upper_bound (n : Nat) (voters :
List (Nat × Nat)) : solve_elections n voters ≤ List.foldl
(λ acc (pair : Nat × Nat) => acc + pair.2) 0 voters :=
sorry

theorem solve_elections_zero_votes (n : Nat) (voters :
List (Nat × Nat)) : (List.all voters (λ pair => pair.1 =
0)) → solve_elections n voters = 0 := sorry
```

```
theorem solve_elections_single_zero_vote :
solve_elections 1 [(0, 5)] = 0 := sorry
```

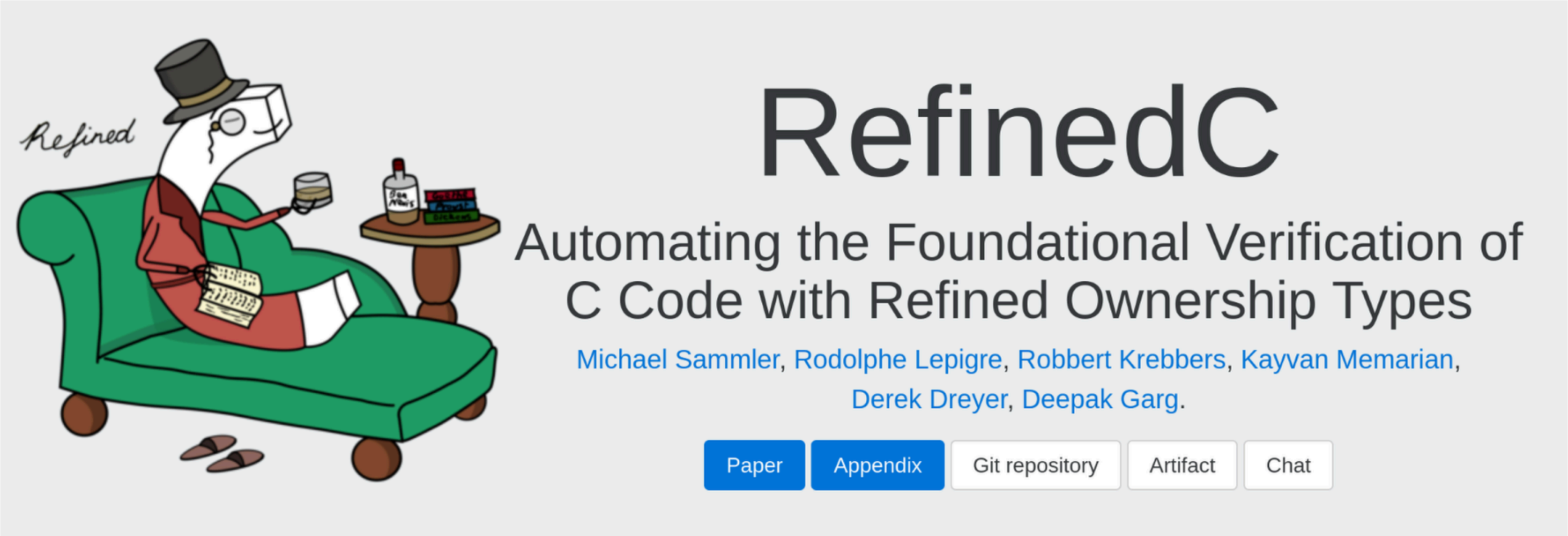
FVAPPS: Formally Verified APPS (for synthetic data)

A benchmark with tool use as ground truth can be a **synthetic data pipeline**

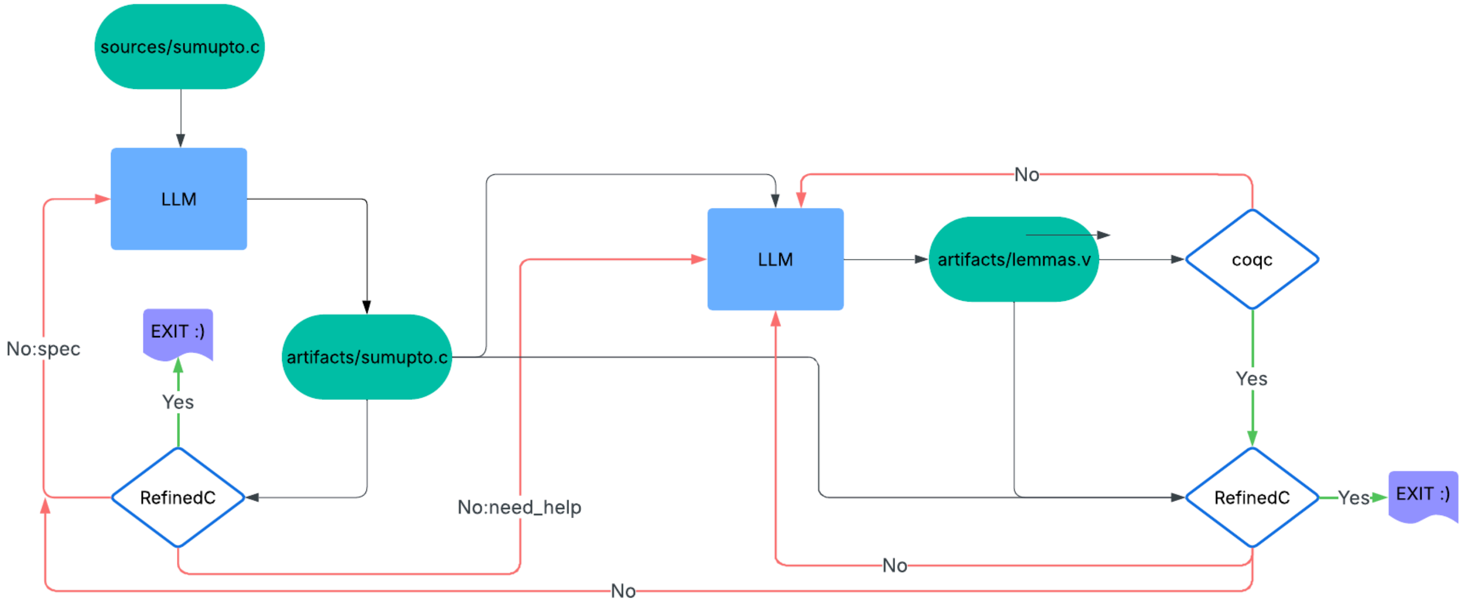
- I'm excited for using FVAPPS solutions to make finetune datasets

RefinedC Copilot

Automating C verification (*in progress*)



RefinedC Copilot: A Scaffold



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- Maybe we can make that cheaper with automation?

It's a live hypothesis, the project isn't super far along yet.

III. Should you work on GSAI

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- Comparing/contrasting with competing agendas

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- Can you **poke holes** in the worldview?
- Comparing/contrasting with competing agendas
- Estimate $p(\text{success})$, $p(\text{success} \mid x \text{ investment})$, etc.

Personal fit (skills, interests, what is fun)

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- Formal verification
- Programming language theory (including probabilistic semantics, information theory)
- ML/LLM stuff is mostly from a black box perspective. Lots of scaffolds.

IV. Hear more at gsai.substack.com

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