

Program Synthesis for Robot Learning from Demonstrations (LfD)

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<https://github.com/ut-amrl/Prolex>

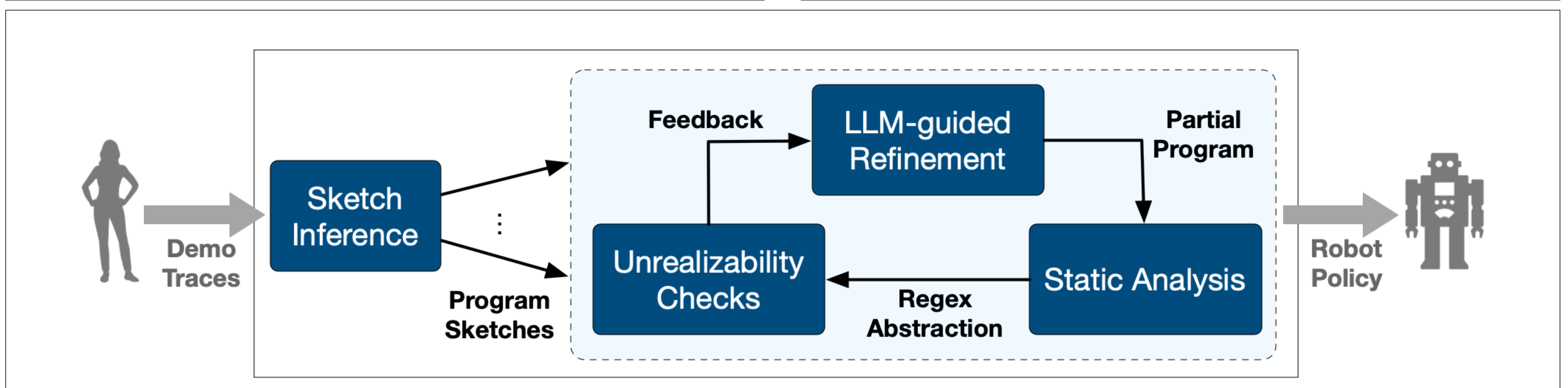


Overview and Key Challenges

- *Background:* robotic policies suffer from large data overhead, low generalizability, and low interpretability
- *Key Idea:* synthesize programmatic policies which are interpretable and amenable to formal verification
- *Challenges:* (1) long horizon tasks necessitating repetition (nested loops) and decision making (conditional blocks) (2) large environments to reason over (object types, properties, relationships), and (3) few demonstrations per task

Scientific Impact

- A new programmatic LfD algorithm that targets long-horizon robot tasks
- Requires synthesizing programs with complex control flow structures, including nested loops with multiple conditionals
- Applications to programs involving grounded objects
- Published Paper:
 - [POPL '24] Noah Patton, Kia Rahmani, Meghana Missula, Joydeep Biswas, and Isil Dillig. 2024. Programming-by-Demonstration for Long-Horizon Robot Tasks. Proc. ACM Program. Lang. 8, POPL, Article 18 (January 2024).



Solution

Sketch Inference

Treating each statement in the demonstration as a character in a string, the RegEx Learner:

1. First, learn a set of RegExs over these characters that generate the given string
2. Then, prune away RegExs that would not be executable (e.g. disjunction)
3. Translate RegExs into program sketches: conditionals to if, and Kleene stars to loops

LLM-Guided Refinement

- Using a Large Language Model, and the program as context, we can reorder our completion search
- For example, a program involving beds and sheets is more likely to involve pillows as well, rather than coffee cups

Pruning

Partial programs are over-approximated as RegEx by:

1. Partial evaluation of the partial program
 2. Determining loop iterations
 3. Determining condition values
- If the user demonstrations are not accepted by the over approximate RegEx we can prune

Broader Impact on Society

- Step towards robust, interpretable, and verifiable robotic deployments
- LfD paradigm enables non-expert end-users to generate robotic policies

Broader Impact on Education Outreach

- Arko Banerjee, undergraduate student with PI Dillig and Co-PI Biswas
- Meghana Missula, Masters student with PI Dillig and Co-PI Biswas

Broader Impact on Participation

- Deployed and utilized open-source tools
- Involving undergraduate, masters, and PhD researcher outreach

Award ID#: 2319471

