# LeanDojo

Theorem Proving with Retrieval-Augmented Language Models



#### <sup>1.</sup> Introduction

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## Introduction

- An open-source Lean playground consisting of toolkits, data, models, and benchmarks
- ReProver: an LLM-based prover augmented with retrieval for selecting premises from a vast math library
- ITP in place of ATP



# Background

- Theorem Proving
  - Transitioned from classical ML provers to transformers and graph search techniques
- Premise Selection
  - retrieval-augmented models decide between retrieved and memorized premises.
- Data and Tools for Theorem Proving
  - Tools like CoqGym, PRISM, HOList, and LeanDojo enable data extraction and interaction with proof assistants
  - LeanDojo stands out by robustly interacting with Lean 4 and supporting premise extraction.
- Retrieval-Augmented Language Models
  - In contrast to other methods that use Github or stack overflow, retrieves theorems accessible to current file

# LeanDojo: Toolkit and Benchmark

- Two essential needs
  - Extracts training data from Lean and construct a benchmark
  - Interact with Lean programmatically
- Data Extraction: Lean source code lacks runtime information like intermediate proof states. LeanDojo addresses this by:
  - File Dependencies and ASTs
  - States and Tactics
  - Premise Recording
- LeanDojo Benchmark:
  - extracted from mathlib
  - largest math-focused theorem proving datasets. 98,734 theorems from 3,384 Lean files
- Interaction with Lean
  - initialize(theorem)
  - run\_tac(state, tactic)

#### **ReProver: Retrieval-Augmented Theorem Prover**

- Given the current proof state, it retrieves a handful of potentially useful premises and generates tactic candidates
- Retrieving from Accessible Premises: restrict to premises accessible to the current theorem
- Tactic Generation:
  - retrieved premises are concatenated with the state
  - Transformer to generate the tactic
- Trained on google/byt5-small

## **Results**

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Method	random			novel_premises		
	R@1	R@10	MRR	R@1	R@10	MRR
BM25	6.7	17.2	0.15	5.9	15.5	0.14
w/ all premises	1.9	11.9	0.08	2.1	12.4	0.08
Ours	13.5	38.4	0.31	9.1	27.6	0.24
w/ all premises	11.7	36.2	0.27	7.1	23.1	0.20
w/o in-file negatives	10.8	33.1	0.25	7.9	25.7	0.22



https://arxiv.org/pdf/2306.15626