HOL4PRS: Proof Recommendation System for HOL4 Theorem Prover

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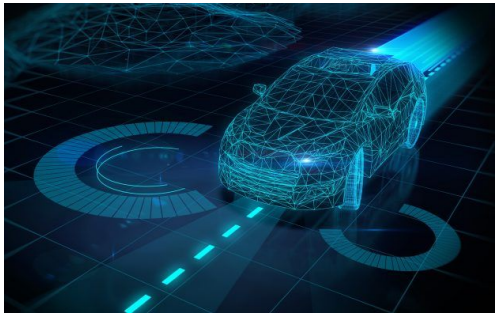
Why formal verification is so important?

- Ensuring the correct functionality of complex software systems or critical hardware components is crucial.

Aerospace

Healthcare



Automotive

Formal Verification

- Formal verification verifies a system's behavior under all conditions.
- Interactive Theorem Provers (ITPs) help apply mathematical logic to verify these behaviours.

PVS

Challenges of ITPs

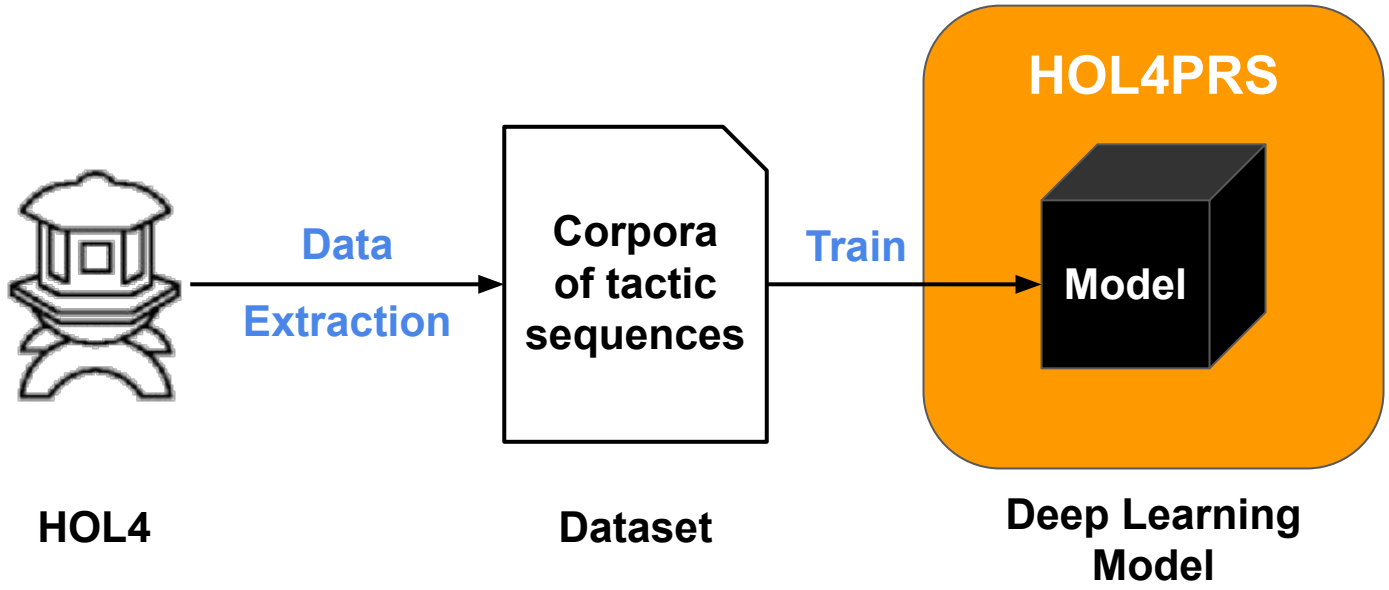
Challenging and labor-intensive !

Smart copilot that guides us through theorem proving.

Related Works

Related Work	Approach	Prover	Success Rate
Gauthier et al., 2020	Machine Learning (k-NN)	HOL4	66.4%
Blaauwbroek et al., 2020	Machine Learning	Coq	23.4%
Luan et al., 2021	Deep Learning (LSTM)	Coq	87%
Yeh et al., 2023	Deep Learning (T5)	PVS	70%

HOL4PRS: Proof Recommendation System for HOL4 Theorem Prover

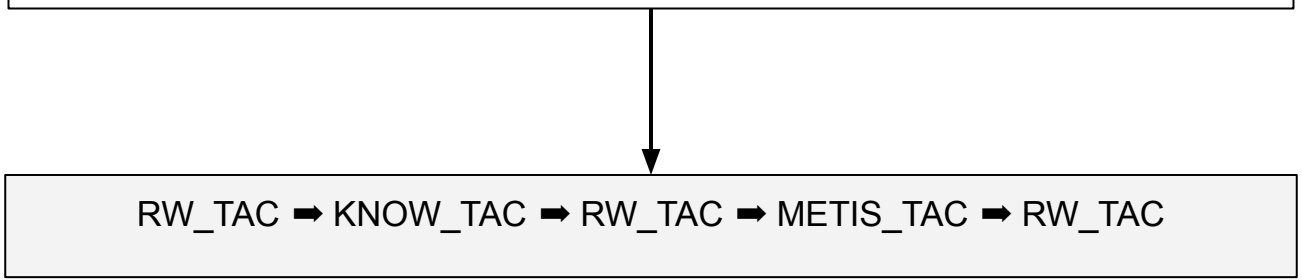


Data Extraction

.*sml* File

```
val rule_18 = store_thm("rule_18",
  ``!X Y. D_AND X Y = D_OR (P_AND X Y)(P_AND Y X)``,

RW_TAC std_ss[D_AND_def, P_AND_def, D_OR_def]
THEN KNOW_TAC(``  !s.( max (X s) (Y s)) =
    (
         min (if X s <= Y s then Y s else PosInf)
           (if Y s <= X s then X s else PosInf))``)
    THEN1 (RW_TAC std_ss[extreal_max_def, extreal_min_def] THEN
METIS_TAC[extreal_lt_def, extreal_le_def, lt_le, le_lt, le_trans,
lt_trans, lt_infty, le_infty])
THEN RW_TAC std_ss[] ) ;
```



Tactic Sequence

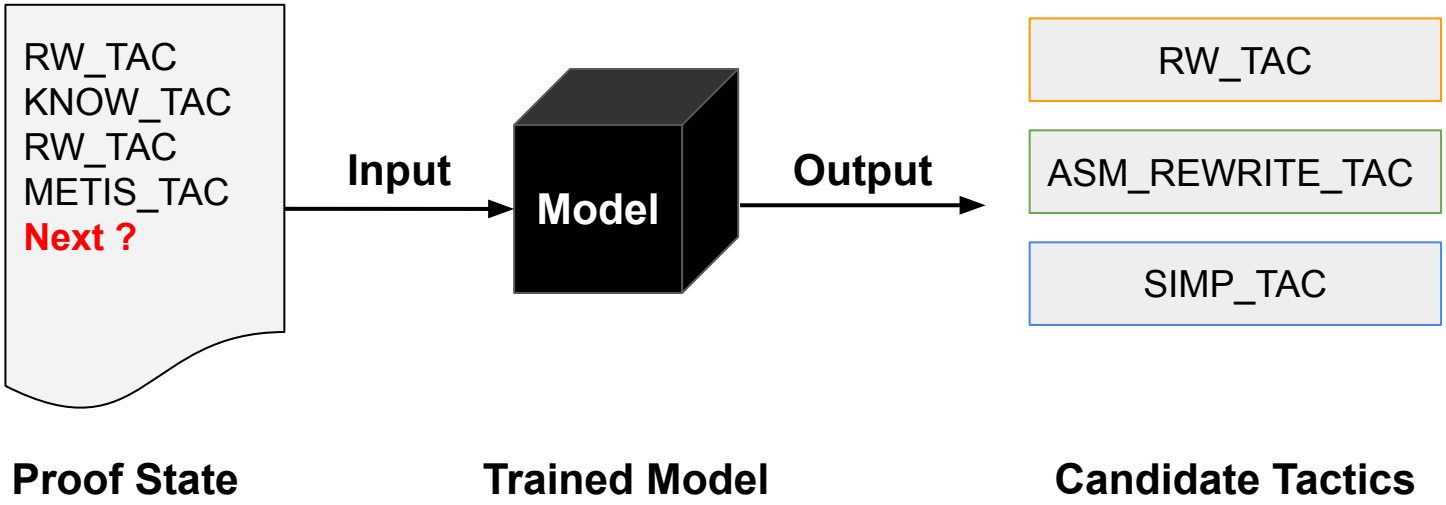
Datasets

Proof: A sequence of n tactics used to prove a theorem.

Proof States: All possible tactic sequences recorded from a proof.

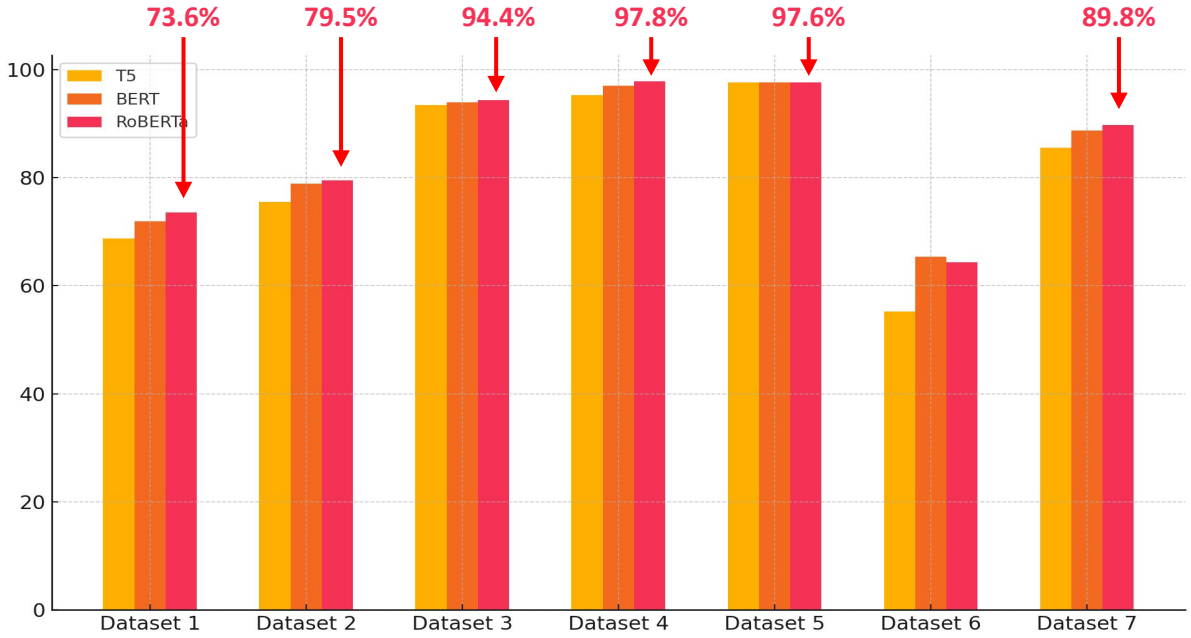
	Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5	Dataset 6	Dataset 7
Proofs	1,873	2,475	153	295	61	279	5,136
Proof States	43,167	57,602	2,973	7,371	1,784	3,259	116,156

Train Model


RW_TAC
KNOW_TAC
RW_TAC
METIS_TAC
Next ?
Input
Model
Output
RW_TAC
ASM_REWRITE_TAC
SIMP_TAC
Proof State
Trained Model
Candidate Tactics

Experimental Results

7-Correctness Rate: Probability that the correct tactic is among the top 7 recommendations.



HOL4PRS deploys RoBERTA for Top-7 recommendations

Future Work

- Integrate more contextual information with the input to improve the accuracy and relevance of proof step recommendations.

- Autonomously generate complete proofs without human intervention.

Demo