



Proof Truth

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Goals

- We explore the ability of Deep Learning (DL) models to handle logic.
- This can enable DL models to solve complex, multi-step problems that require reasoning through different scenarios.
- Stakeholders: AI researchers, AI and tech companies, regulators and policymakers, and, ultimately, consumers of technology.

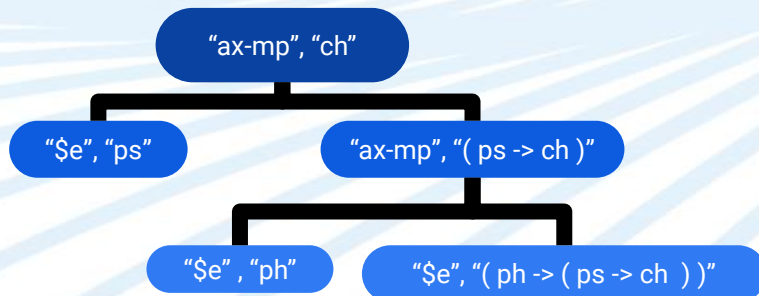
Dataset

- Metamath is a simple meta logic system.
- set.mm - main proof dataset containing **42494 proofs**.
- We **wrote an API** to interact with the command-line **metamath** program and extract the proofs from set.mm in the format we wanted.
- We processed the resulting dataset into a **dataset of (directed) graphs**, where each node corresponds to a proof step and edges related the nodes whenever there is a hierarchical relationship between the proof steps.

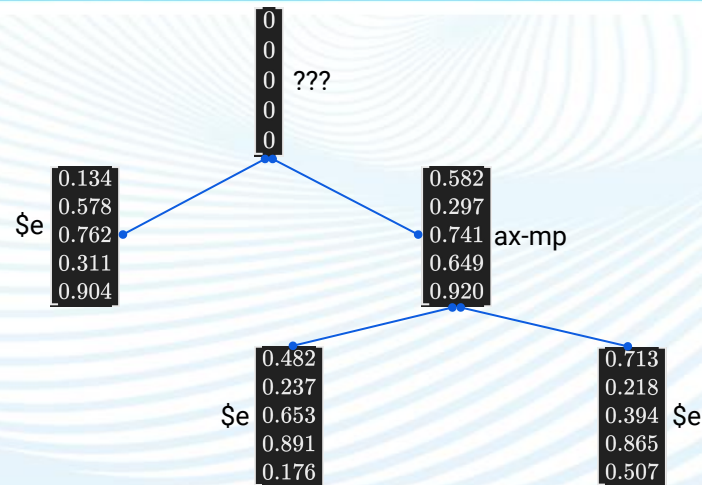
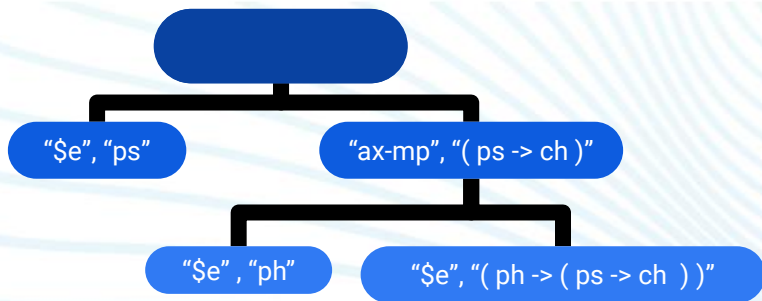
A proof for “double modus ponens” inference in metamath.

```
MM> show proof mp2 /lemmon
3 mp2.2      $e |- ps
8 mp2.1      $e |- ph
9 mp2.3      $e |- ( ph -> ( ps -> ch ) )
10 8,9 ax-mp  $a |- ( ps -> ch )
11 3,10 ax-mp $a |- ch
MM> █
```

API using pexpect library



Label Prediction with GIN



Over 2000 classes (two seen here are \$e and ax-mp)

Top 5 accuracy is 69.6%

Statement Prediction

- Our architecture was a long short-term memory (LSTM) RNN with a single hidden layer.
- We used random walks and skip-grams to generate “text”.
- The model generated a single character at a time.
- The model was successfully able to generate logically correct statements but struggled with permuting symbolic variables.

E.g. Based on the assumptions:

- $a \rightarrow (b \rightarrow c)$
- $c \rightarrow b$

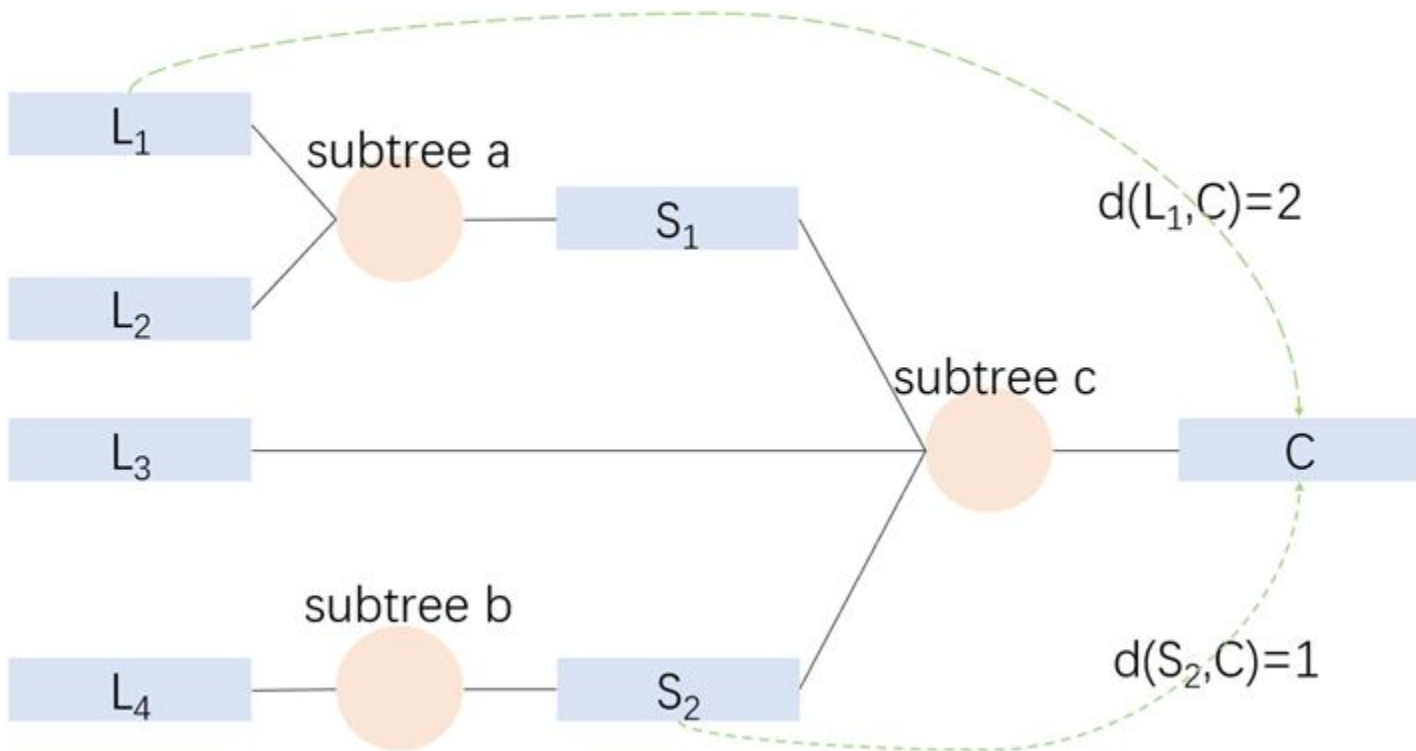
The model predicted:

$a \rightarrow (c \rightarrow b)$

Instead of:

$a \rightarrow (b \leftrightarrow c)$

Vectorized Proof tree



Cross-Attention Model

