

Corpus-Based Q&A with Neural Module Networks

Runpeng Liu '17, Liang Zhou '18

{rliu42, zhoul}@mit.edu

Massachusetts Institute of Technology

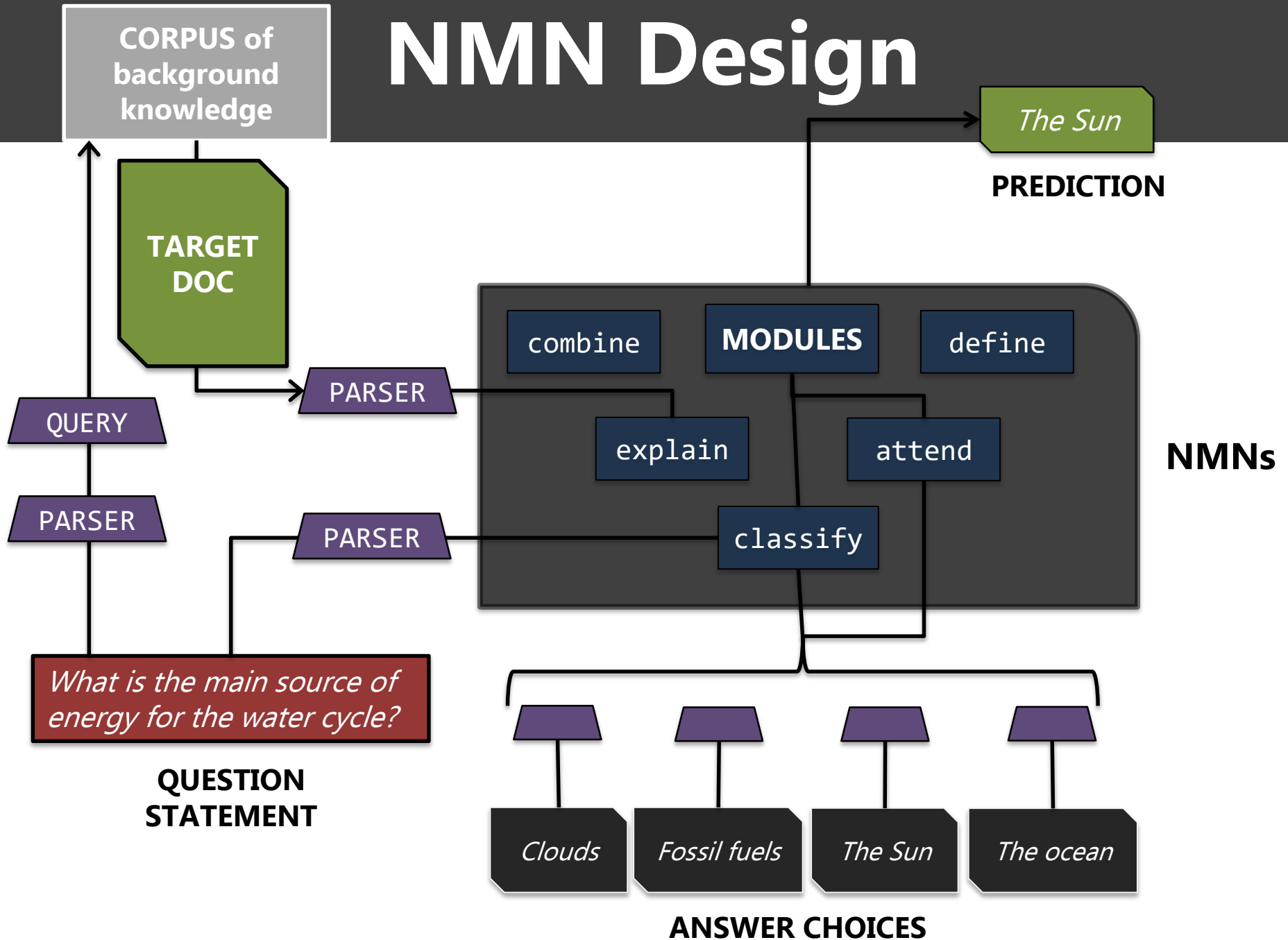
6.864 Natural Language Processing



Problem Statement

- **Goal:** to consistently understand and answer technical multiple-choice questions as accurately as possible.
 - **Proposed approach:** train neural module networks (NMNs) that specialize in a different reasoning tasks. Influenced by recent developments in computer vision.
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- **Dataset:** collection of 8th grade science exam questions + answers
 - 2500 multiple-choice questions, 4 answer choices each
 - **Corpus / Knowledge base:** Middle school-level science textbooks spanning different sub-fields
 - Physics, Chemistry, Biology, Earth Science, etc.

NMN Design



Vector Space Model (VSM)

- Implementation based on document frequency-inverse corpus frequency (TF-IDF)
- Searches for only the most RELEVANT
 - Concatenate question with each answer choice
 - Tokenize and stem
 - Query corpus and assign relevancy scores
 - Pick highest one

VSM Example

What is the main source of energy for the water cycle?

tokenization
+ stemming

[main, source,
energy, water, cycle]

concatenation

Clouds

*Fossil
fuels*

*The
ocean*

The Sun

[cloud]

[fossil,
fuel]

[sun]

[ocean]

CORPORA INDEX

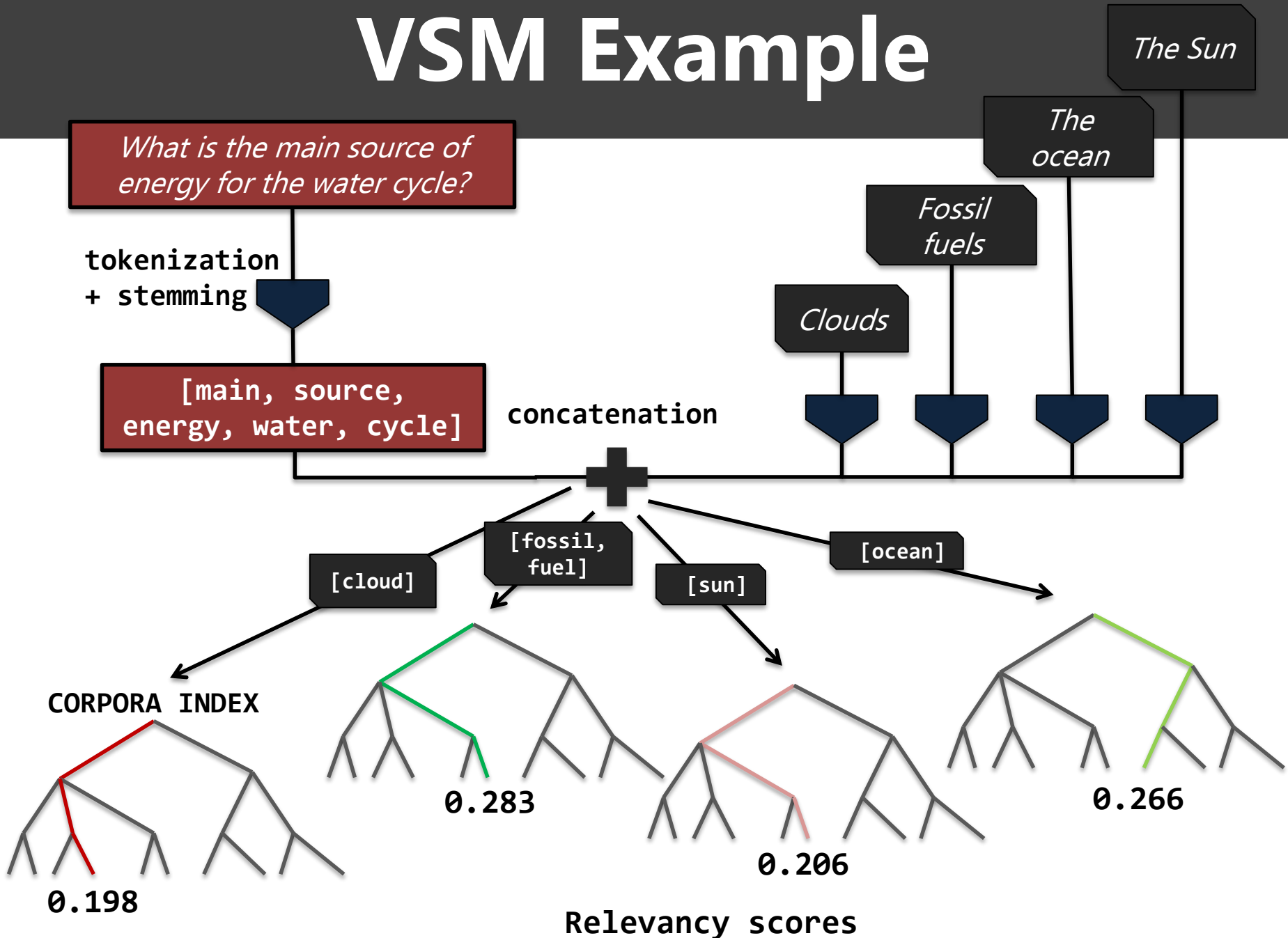
0.198

0.283

0.206

0.266

Relevancy scores



Sample Modules & Triggers

ATTEND

"Which describes..."

"Which is a..."

DEFINE

"Which of these..."

"What is ..."

"Give an example..."

EXPLAIN

"... because ..."

"why/how does..."

"which best explains..."

INVERT

*"all of the following
EXCEPT..."*

*"which of these is
least likely..."*

ATTEND: *Answer x Query \rightarrow [(Document, Relevancy)]*

DEFINE: *Document x Query \rightarrow [(Attention, Relevancy)]*

EXPLAIN: *Attention x Query \rightarrow [(Document, Attention)]*

INVERT: *Document x Relevancy \rightarrow Relevancy*

COMBINE: *Attention x Attention \rightarrow Attention*

CLASSIFY: *Document x Attention \rightarrow [(Answer, Relevancy)]*

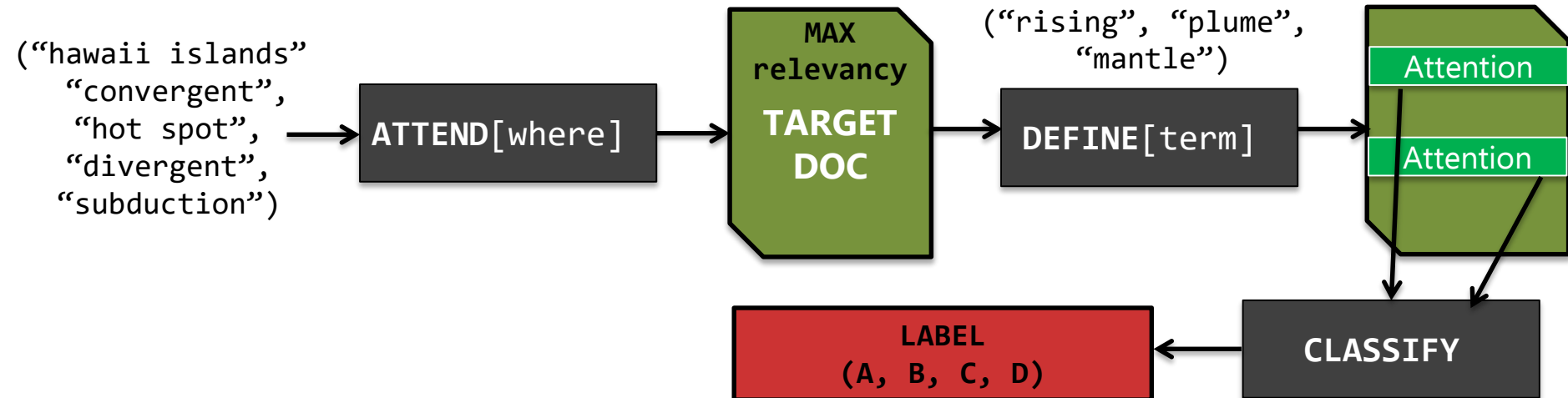
Module Composability

Q: What is the term given to the rising plume of mantle that is located below the Hawaii Islands?



A. convergent
C. divergent

B. hot spot
D. subduction



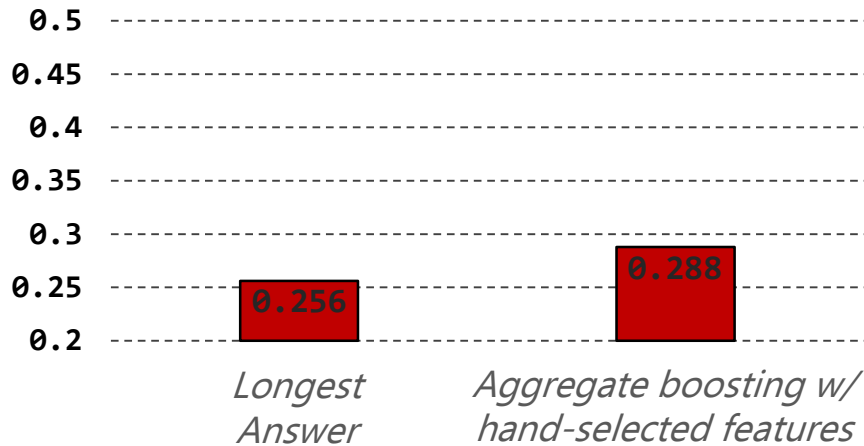
Q: Which statement best describes natural variations in the amount of ozone found in the stratosphere of Earth's atmosphere?



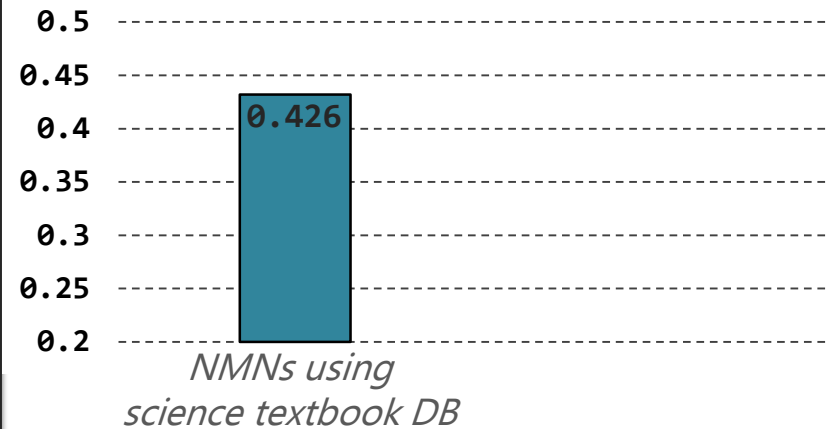
```
CLASSIFY[describe](  
  EXPLAIN("variation",  
    ATTEND("ozone",  
      ATTEND("stratosphere", ...)  
    )  
  )  
) --> LABEL (A, B, C, D)
```

Benchmarks & Results

Toy ML Approach

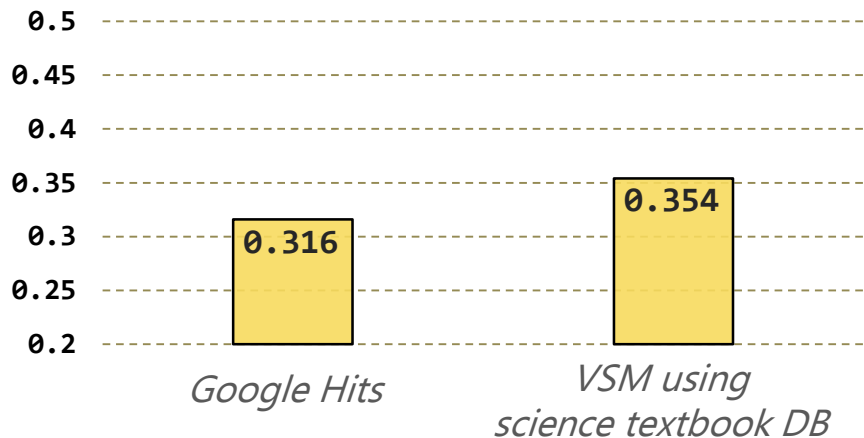


Neural Module Networks



How do we do better???

Relevancy Search / Vector Space Model



MIT Undergrads

72.6%

Conclusions & Limitations

- ***Pure ML approaches** based on aggregation of weak classifiers are unlikely to succeed*
- ***Relevancy searches** perform substantially better than chance. But: fall short on higher-level reasoning tasks*
- *Constructing **specialized knowledge base** considerably improves performance relative to popular search engines*
- ***NMNs** improve upon predictive power of relevancy searches, but still hard to optimize for complex questions requiring multi-layer composability*