Markov Logic Networks for Natural Language Question Answering

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Task: Answering Elementary Science Questions (i.e. Non-Factoid QA)

Example Question:

Question: Living things depend on energy from

(A) the Sun (B) the Moon (C) soil (D) water

As T/F: Living things depend on energy from the Sun.

Knowledge Base:

Sentences parsed with AI2's FOL parser from Clark (2014) into IF-THEN rules:

Example:

Growing thicker fur in the winter helps some animals to stay warm

$$
\begin{aligned}
&isa(g, \text{grow}), isa(a, \text{some\_animals}), isa(f, \text{thicker\_fur}), \\
&isa(w, \text{the\_winter}), agent(g, a), object(g, f), in(g, w) \\
&\Rightarrow \exists s, r : isa(s, \text{stays}), isa(r, \text{warm}), \\
&\quad enables(g, s), agent(s, a), object(s, r) \qquad (1)
\end{aligned}
$$

Questions Parsed:

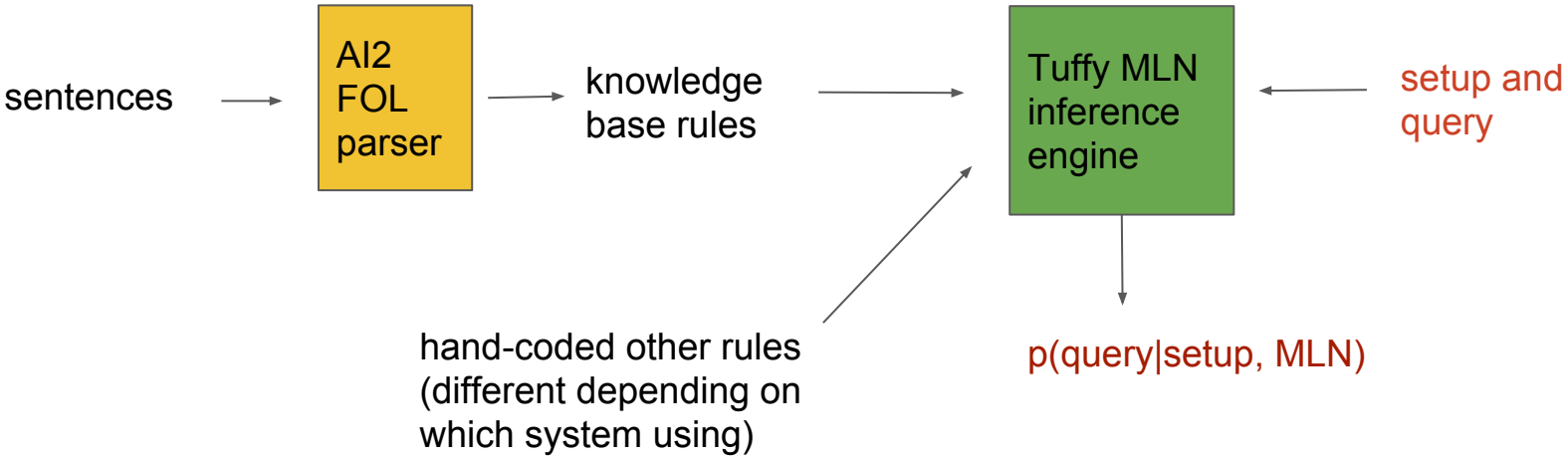
Questions are parsed similarly:

Question (as T/F):

A fox grows thick fur as the season changes. This helps the fox to keep warm

$$
\begin{aligned}
setup :& isa(F, \text{fox}), isa(G, \text{grows}), isa(T, \text{thick\_fur}), \\
& agent(G, F), object(G, T) \\
query :& isa(K, \text{keep\_warm}), enables(G, K), agent(K, F)
\end{aligned}
$$

Main Architecture (as I understand it...)



1st Set-up: FOL-MLN

$$isa(g, \text{grow}), isa(a, \text{some\_animals}), isa(f, \text{thicker\_fur}),$$
$$isa(w, \text{the\_winter}), agent(g, a), object(g, f), in(g, w)$$
$$\Rightarrow \exists s, r : isa(s, \text{stays}), isa(r, \text{warm}),$$
$$enables(g, s), agent(s, a), object(s, r) \quad (1)$$

Rules in:

- KB rules
- semantic rules (cause(x,y) → effect (y,x), etc)
- lexical alignment “rules” (from external algorithm)

$$query : isa(K, \text{keep\_warm}), enables(G, K), agent(K, F)$$

GOAL: train MLN and find probability of answer choice, (a separate grounding??): i.e.

result(query) = true

Big Issue: Too many groundings

2nd Set-up: ER-MLN

$$isa(G, \text{grow}), isa(A, \text{some\_animals}), isa(F, \text{thicker\_fur}),$$
$$isa(W, \text{the\_winter}), agent(G, A), object(G, F), in(G, W)$$
$$\Rightarrow isa(S, \text{stays}), isa(R, \text{warm}),$$
$$enables(G, S), agent(S, A), object(S, R)$$

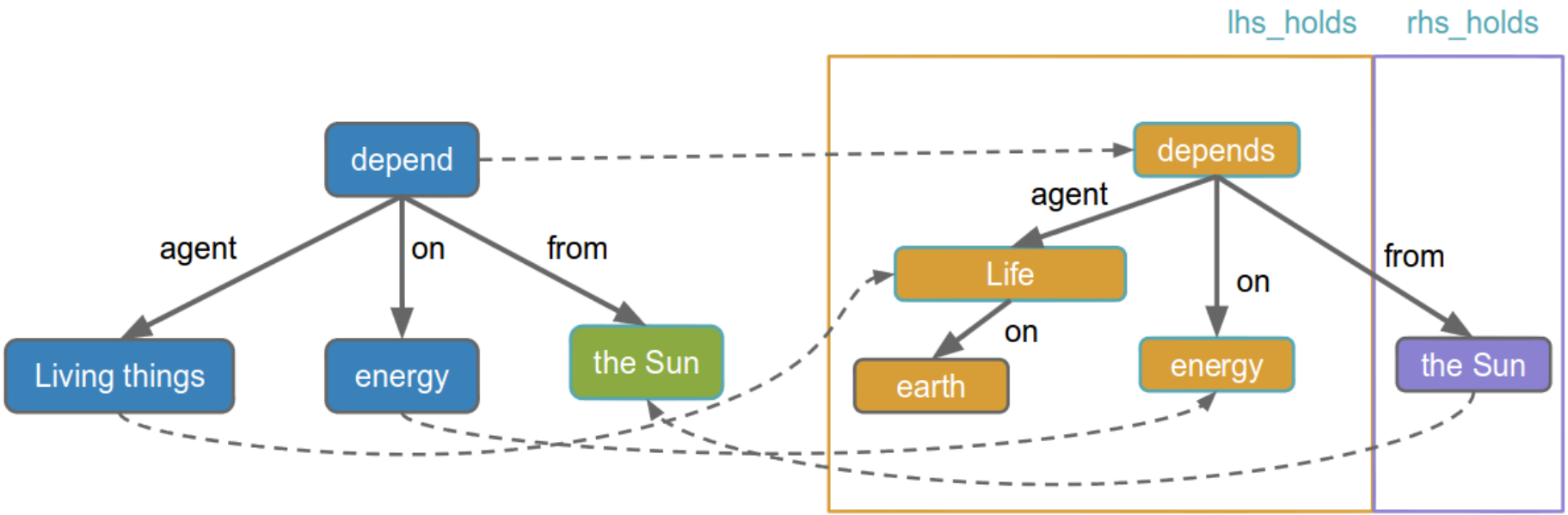
Rules in:

- KB rules - **NOW with no variables**
- semantic rules (cause(x,y) → effect (y,x), etc)
- lexical alignment “rules” (from external algorithm)
- **NEW -- Equivalence/Resolution rules:** sameAs() predicate which interacts with others with hand-coded rules (p.4)
- **NEW -- Partial Match rules:** J, K, L, … → R you also have J→R, K→R, L→R, ...

GOAL: train MLN and find probability of answer choice, (a separate grounding??): i.e. result(query) = true

Big Issue: Brittle to syntactic differences (but better than FOL-MLN) and problems with words like “bat” (i.e. baseball vs. animal)

New idea - use MLN to do Alignment of graphical structure:



3rd Set-up: PRALINE

$$holds(Grow), holds(Animals), holds(Fur),$$
$$holds(Winter) \Rightarrow holds(Stays), holds(Warm)$$

"Rules" in: (very different, I think…)

- **NEW**: want - Nodes (words?) and edges (alignments between nodes) of G , frame as rules:
  - Node(nodeid), edge(nodeid, nodeid, label), setup(nodeid), query(nodeid), inLHS(nodeid), inRHS(nodeid)....
- **NEW: Graph alignment rules** -- codes up the lexical alignment… ~ transitivity, etc.
- **NEW: Inference rules:** -- to get new rules...
- (??old rules??)

$$holds(x), aligns(x, y) \Rightarrow holds(y)$$

GOAL: ??? like: P(holds(Stays),holds(Warm) | holds(Fox),holds(Grows),holds(Fur), M)

Success!