TECHNISCHE UNIVERSITÄT DRESDEN

On Commonsense Domains within the Winograd Schema Challenge

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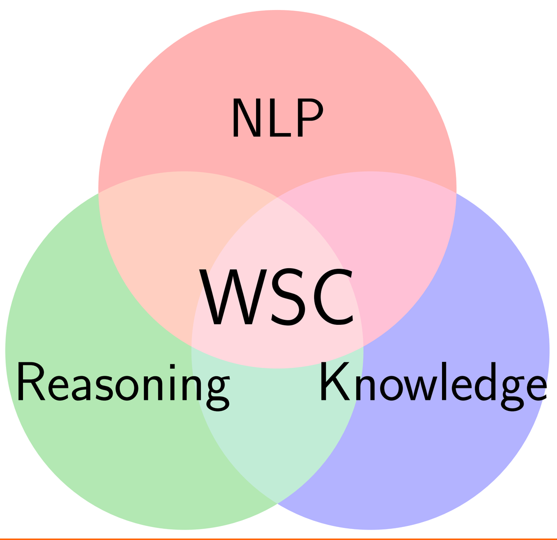
Commonsense Reasoning in Computers

Levesque (2011) proposes a new test for assessing computer intelligence that requires the use of commonsense reasoning.

S: The trophy does not fit into the brown suitcase because it is too [small/large].
Q: What is too [small/large]?
A: The suitcase/the trophy.

Add (least necessary) background knowledge and apply to reasoning algorithm.



Winograd Schema Challenge (WSC)

- Structure of a Winograd Schema:

Sentence containing two nouns	trophy, suitcase
One ambiguous pronoun	it
A special word	small/large
Question about the referent of the pronoun	What is too [small/large]
Two possible answers	The suitcase/the trophy

- Characteristics:
  - Easy to answer for an adult English speaker.
  - Always contains special word.
  - *Google-proof* - statistical methods over large text corpora should not be able to resolve a WS.

Machine-Learning vs Knowledge-Based Approaches

Technique	PDPs Size Correct	WSC Size Correct	WSC* Size Correct	Remarks
Supervised ranking SVM model [6]	NA	NA	282 - 30% 205 - 73%	-provided additional dataset set -no evaluation on WSC dataset
Classification task with NN [3]	NA	282 - 100% 157 - 56%	282 - 30% 177 - 63%	-first to use substitution of the pronoun with the antecedents
Knowledge Enhanced Embeddings (KEE) [4]	60-100% 40 - 66.7%	NA	NA	-best results in the 2016 WSC competition
Google's language models [10]	60-100% 42 - 70%	273 - 100% 173 - 63.7%	NA	-no reasoning involved in the discovery of the correct answer -state-of-the-art for PDPs
OpenAI language models [5]	NA	273 - 100% 193 - 70.70%	NA	-current state-of-the-art for WSC -requires a lot of data for training -results are not reproducible
Graphs with Relevance theory [8]	NA	4 - 2.6% 4 - 100%	NA	-manual construction of graphs -first representation of WS as dependency graph
2 identified categories [9]	NA	71 -25% 49 - 69%	NA	-first attempt of identifying commonsense knowledge types -developed the KParser
Semantic relations categories [1]	NA	100 - 34% 100 - 100%	138 - 14% 111 - 80%	-provided Reasoning Algorithm -identified 12 commonsense types which capture the entire WSC
Knowledge hunting framework [2]	NA	273 - 100% 119 - 43.5%	NA	-refined query generation -developed an algorithm for scoring the retrieved sentences

*Additional dataset with 943 WS provided in [7] .

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Knowledge Types Identification and Reasoning (Sharma and Baral, 2018)

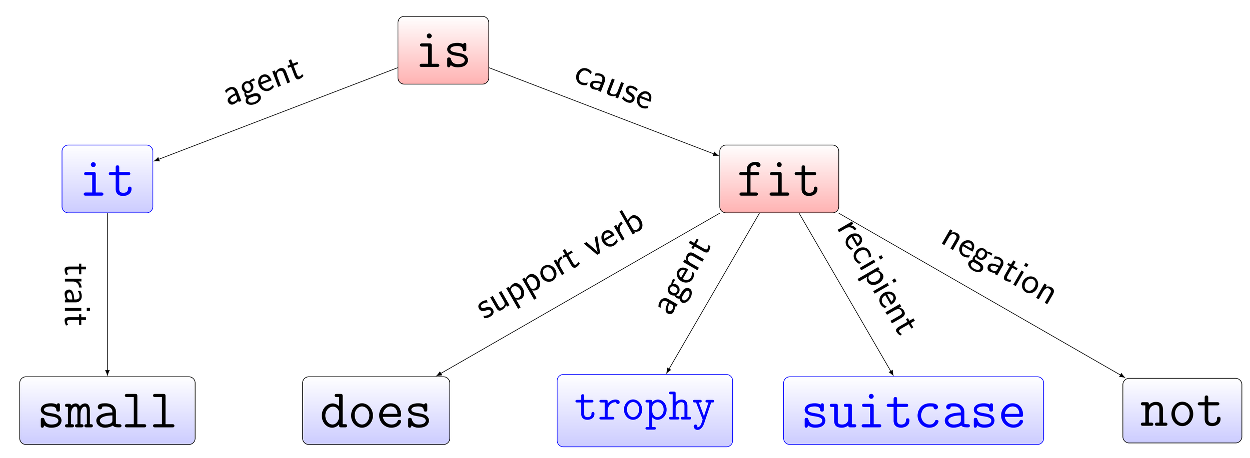
- Identified 12 knowledge types which cover entire WSC dataset.
- Categorization based on the structure of the Winograd sentence.
- 10 knowledge types based on interaction between entities and actions.
- Provided a logical reasoning algorithm in ASP.
- Evaluated on 100 problems from WSC and achieved 100% accuracy.

Extracted knowledge: “small y prevents y fits”.
Knowledge type: “Property prevents Action”.

```
1 %entity y has a trait small
2 has_k(small,is_trait_of,y).
3 %having trait small prevents the entity to fit another entity
4 has_k(small,prevents,fits).
5 %entity y is the recipient of the action fit
6 has_k(fits,recipient,y).
```

- Rule 4 has no effect in the reasoning procedure!

The trophy doesn't fit into the brown suitcase because it's too small.



Reasoning Algorithm

Change of the formalization of the background knowledge such that it contributes to the reasoning procedure.

```
1 %entity y is small if we know it could not fit another entity
2 has_k(small,is_trait_of,y) :- has_k(fit, recipient, y),
3                                not has_k(fit,modifier,could).
4 %entity y should fit another entity
5 has_k(fit,recipient,y).
```

- Rule 1 has effect in the reasoning procedure!
- Extend this relation to other problems within one domain (e.g. Physical).
- In rule 5, switching **recipient** with **agent** leads to no answer!

Categorization of Winograd Schemas

- Inductively analyzed the WSC dataset and identified 6 categories.
- Categorization based on the content of the Winograd sentence.
- Two annotators annotated the entire WSC corpus with these categories.
- Calculated Cohen's kappa - measure for inter-rater agreement $\kappa = 0.66$

Category	Example
1. Physical	**S:** The man couldn't lift his son because he is so [weak/heavy]. **Q:** Who is so [weak/heavy]?
2. Emotional	**S:** Frank felt [vindicated/crushed] when his longtime rival Bill revealed that he was the winner of the competition. **Q:** Who was the winner of the competition?
3. Interactions	**S:** Joan made sure to thank Susan for all the help she had [given/received]. **Q:** Who had [given/received] help?
4. Comparison	**S:** Joe's uncle can still beat him at tennis, even though he is 30 years [older/younger]. **Q:** Who is [older/younger]?
5. Causal	**S:** Pete envies Martin [because/although] he is very successful. **Q:** Who is very successful?
6. Multiple knowledge	**S:** Sam and Amy are passionately in love, but Amy's parents are unhappy about it, because they are [snobs/fifteen]. **Q:** Who are [snobs/fifteen]?

Conclusions and Outlook

- Most knowledge-based approaches, so far, have concentrated on the semantic structure of the WS sentence.
- None have specified domain specific categories, i.e., the information about the relation between entities and their properties within a certain domain.
- How to identify the most necessary and the least possible knowledge for solving a WS?
- An approach, where knowledge is provided only 'by demand' might be more efficient and adequate.