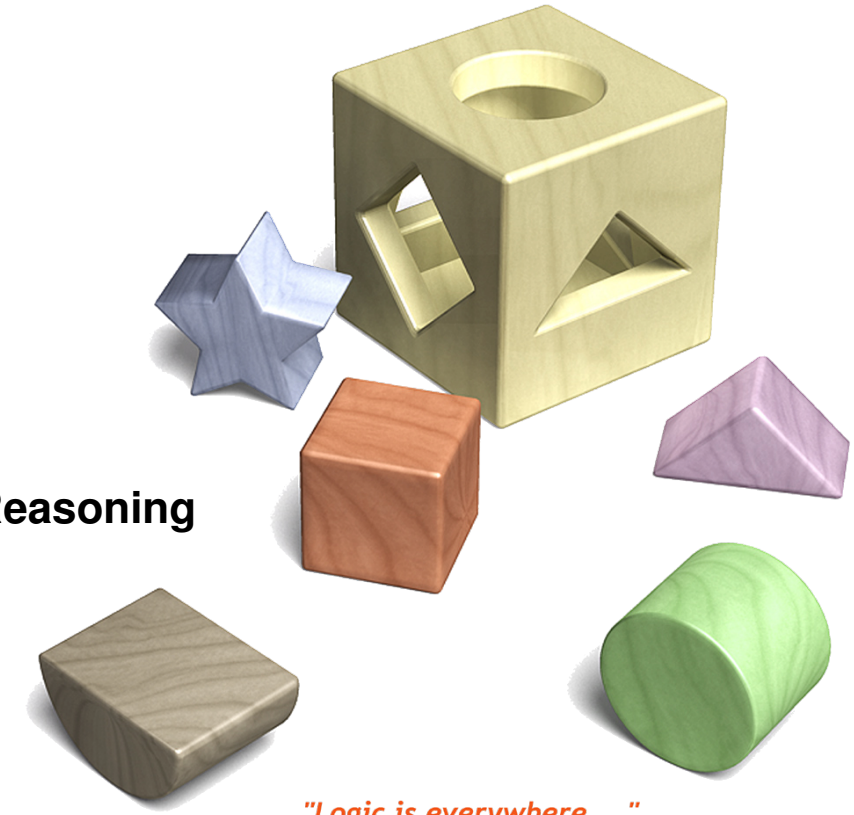
On Commonsense Domains within the Winograd Schema Challenge

Aneta Koleva

International Center for Computational Logic
Technische Universität Dresden
Germany

- Winograd Schema Challenge
- Previous Approaches
- Knowledge Types Identification and Reasoning
- Categorization of Winograd Schemas
- Conclusion



"Logic is everywhere ..."

Motivation

- **Winograd Schema Challenge (Levesque et. al, 2012)**

  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.**

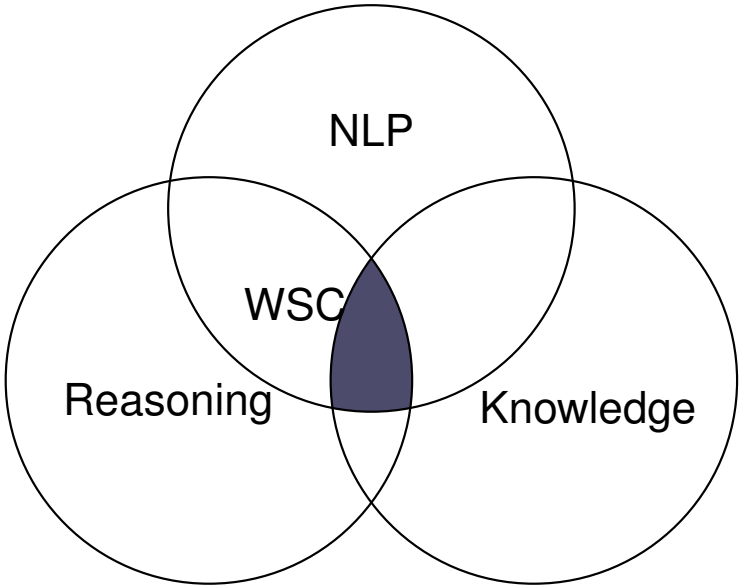
Motivation

- **Winograd Schema Challenge (Levesque et. al, 2012)**

  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.**



Winograd Schema Challenge

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.**

Winograd Schema Challenge

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.**

- **Winograd Schema:**
  - **Sentence containing two nouns, one ambiguous pronoun and a special word**
  - **Question asking about the referent of the pronoun**
  - **Two possible answers corresponding to the noun phrases in the sentence**

Winograd Schema Challenge

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.**

- **Winograd Schema:**
  - **Sentence containing two nouns, one ambiguous pronoun and a special word**
  - **Question asking about the referent of the pronoun**
  - **Two possible answers corresponding to the noun phrases in the sentence**
- **Characteristics:**
  - **Easy to answer for an adult English speaker**
  - **Always contains special word**
  - **Google proof**

Competition

- Competition in 2016 at IJCAI-16
  - Two time-constraint rounds - 210 min. each
    - Pronoun Disambiguation Problems (PDPs) - 60
    - Parts of Winograd Schemas - 150
  - Four competitors
  - Best result: 58% correctly resolved PDPs
  - There was no second round
- Current state-of-the-art (Radford et. al, 2019) achieves 70.7% accuracy on the WSs dataset

Previous Approaches

- Machine learning and deep learning
  - Supervised ranking SVM
  - Supervised classification Task
  - Knowledge enhanced embeddings
  - Google's language models
  - Open AI language model
- Knowledge-based
  - Knowledge graphs with Relevance Theory
  - Semantic parsing and knowledge hunting
  - Parsing query results and assigning scores
  - Knowledge types identification

A Simple Method for Commonsense Reasoning (Trinh and Le, 2018)

- **Language models** trained on unlabeled data

A Simple Method for Commonsense Reasoning (Trinh and Le, 2018)

- **Language models trained on unlabeled data**
  - **Recurrent Neural Networks**
  - **Trained on large datasets and on a dataset customized for WSC**

A Simple Method for Commonsense Reasoning (Trinh and Le, 2018)

- Language models trained on unlabeled data
  - Recurrent Neural Networks
  - Trained on large datasets and on a dataset customized for WSC
- Substitution ambiguous pronoun
  - The trophy doesn't fit in the suitcase because the trophy is too big
  - The trophy doesn't fit in the suitcase because the suitcase is too big

A Simple Method for Commonsense Reasoning (Trinh and Le, 2018)

- Language models trained on unlabeled data
  - Recurrent Neural Networks
  - Trained on large datasets and on a dataset customized for WSC
- Substitution ambiguous pronoun
  - The trophy doesn't fit in the suitcase because the trophy is too big
  - The trophy doesn't fit in the suitcase because the suitcase is too big
- Language models assign probabilities to both sentences

A Simple Method for Commonsense Reasoning (Trinh and Le, 2018)

- Language models trained on unlabeled data
  - Recurrent Neural Networks
  - Trained on large datasets and on a dataset customized for WSC
- Substitution ambiguous pronoun
  - The trophy doesn't fit in the suitcase because the trophy is too big
  - The trophy doesn't fit in the suitcase because the suitcase is too big
- Language models assign probabilities to both sentences
- Evaluation and results
  - PDPs 70% accuracy
  - WSC 63.7% accuracy

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

- Identified 12 knowledge types which cover the entire WSC dataset
- Developed a logical reasoning algorithm
- Evaluated on 100 problems from WSC and achieved 100% accuracy

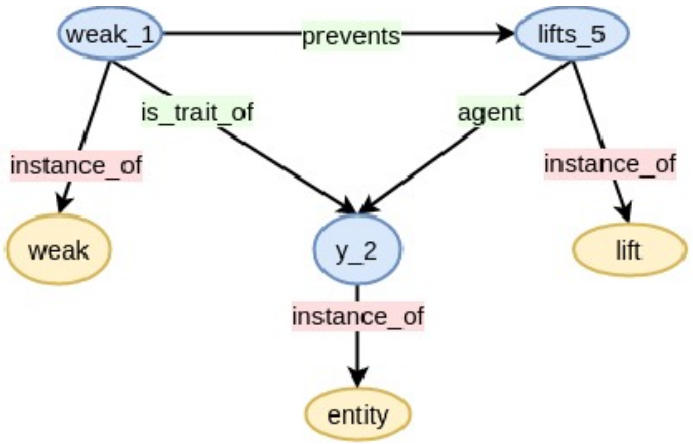
[1] kparser.org

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

- Identified 12 knowledge types which cover the entire WSC dataset
- Developed a logical reasoning algorithm
- Evaluated on 100 problems from WSC and achieved 100% accuracy
- Solver
  1. Semantic graph[1] of the input sentence and question
  2. Semantic graph representation of background knowledge
  3. Graph merging
  4. Project question graph on the merged graph
  5. Answer - the node from the merged graph which is from the same domain as the unknown node from the question graph

[1] kparser.org

- **Representation of the knowledge "*weak y prevents y lifts*"**



Methodology

Categorization of Winograd Schemas

- **Motivation**
  - **Current state-of-the-art has a poor performance**
  - **Background knowledge is crucial for predicting the correct answer**

Categorization of Winograd Schemas

- **Motivation**
  - **Current state-of-the-art has a poor performance**
  - **Background knowledge is crucial for predicting the correct answer**
  - **Idea**
    1. **Analyze the input Winograd Schema and identify the domain**
    2. **Search for knowledge specific to this domain**
    3. **Apply reasoning procedure**

Identified Categories

Category	Example
1. Physical	**S:** John couldn't see the stage with Billy in front of him because he is so **[short/tall]**. **Q:** Who is so [short/tall]?
2. Emotions	**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]?

Annotation of Winograd Schemas

- **Strong agreement between the annotators**
  Cohen's kappa score 0.66
- **Annotation Results**

Category	Annotator 1	Annotator 2
Physical	36	39
Emotions	7	9
Interactions	44	24
Comparison	19	26
Causal	16	18
Multiple knowledge	28	34

Graph Representation for Physical Category

1. **The man couldn't lift his son because he was so weak.**
2. **The trophy doesn't fit into the brown suitcase because it's too small.**

Reasoning

- **Knowledge required for both examples is about physical features**
- **Similar reasoning rules for categorizing the traits**
  1. **weak(X) :- lift(X,Y), not lift(modifier, could).**
  2. **small(Y) :- fit(X,Y), not fit(modifier, could).**

Reasoning

- Knowledge required for both examples is about physical features
- Similar reasoning rules for categorizing the traits
  1. weak(X) :- lift(X,Y), not lift(modifier, could).
  2. small(Y) :- fit(X,Y), not fit(modifier, could).
- Reasoning Algorithm
- Change of background knowledge
  - has_k(weak,prevents,lift).

Contributions

- Overview of different approaches towards WSC
- None achieves close to 90% accuracy
- We analyzed the entire WSC corpus and identified 6 categories
- We identified a mistake in the Reasoning Algorithm and proposed a correction

Future Work

- **Better Reasoning Algorithm**
- **Knowledge Graphs (RDF) representation**