STAR: A System of Argumentation for Story Comprehension and Beyond

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STAR: STory comprehension through ARgumentation

- Motivation
  - Is **argumentation** useful for some aspects of automated narrative comprehension?
  - How can theories of narrative comprehension and story understanding from **psychology** help in the design of such systems?
  - The need for a tool to use in **empirical studies**.

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  - ◇ The need for a tool to use in **empirical studies**.

- Theoretical Basis of *STAR*
  - ◇ Argumentation-based semantics/computation: operates on a **narrative**, a set of **association rules**, and a **priority relation** among rules.
  - ◇ Inbuilt general notions of **persistence** and **causality** inspired by reasoning about actions research.
  - ◇ Builds and adapts a **comprehension model** as parts of the story/narrative are sequentially input.

Story Input in STAR

We have run *STAR* on small stories consisting of one or two paragraphs and 5 to 10 or so sentences.

> *"Ann rang the doorbell. ...., ..., ..., ..., ..."*

STAR enables the input of stories to be staggered, and dispersed with **questions** which give an insight into the **comprehension model** that *STAR* builds and modifies as the story progresses.

Doorbell Story, Scene 1

> *"Ann rang the doorbell."*

Questions:

- Does Ann have the door keys?
- Is Ann a visitor or a resident?

Doorbell Story, Scenes 1 and 2

> *"Ann rang the doorbell. Mary, who was in the flat watching TV, got up from her chair and walked to the door. She was afraid."*

Question:

- Why did Mary walk to the door? (To open the door? To find out who was there?)

Doorbell Story, Scenes 1, 2 and 3

"Ann rang the doorbell. Mary, who was in the flat watching TV, got up from her chair and walked to the door. She was afraid. Mary looked through the keyhole. She saw Ann, her flatmate, at the door."

Questions:

- Does Ann have the door keys?
- Is Ann a visitor or a resident?
- Why did Mary walk to the door?
- Why did Ann ring the doorbell?

Doorbell Story, Scenes 1, 2, 3 and 4

"Ann rang the doorbell. Mary, who was in the flat watching TV, got up from her chair and walked to the door. She was afraid. Mary looked through the key-hole. She saw Ann, her flatmate, at the door. Mary opened the door and asked Ann why she did not use her keys to come in the flat."

Questions:

- Why did Ann ring the doorbell?

Doorbell Story, Scenes 1, 2, 3, 4 and 5

"Ann rang the doorbell. Mary, who was in the flat watching TV, got up from her chair and walked to the door. She was afraid. Mary looked through the key-hole. She saw Ann, her flatmate, at the door. Mary opened the door and asked Ann why she did not use her keys to come in the flat. Ann replied that she was upset that Mary did not agree to come with her to the shops."

Question:

- Why did Ann ring the doorbell?

Doorbell Story, Scenes 1, 2, 3, 4, 5 and 6

"Ann rang the doorbell. Mary, who was in the flat watching TV, got up from her chair and walked to the door. She was afraid. Mary looked through the key-hole. She saw Ann, her flatmate, at the door. Mary opened the door and asked Ann why she did not use her keys to come in the flat. Ann replied that she was upset that Mary did not agree to come with her to the shops. She wanted to get her up from her chair in front of the TV."

Question:

- Why did Ann ring the doorbell?

STAR Sessions and Narratives

- *STAR*'s session statements allow a story to be subdivided, and therefore interrupted to ask questions and examine the current state of the comprehension model:

```
session(s(0),[],all).
session(s(1),[q(1),q(2)],all).
session(s(2),[q(3)],all).
etc.
```

- The story itself is represented by a series of time-stamped observations:

```
s(0) ::  person(ann) at always.
.....
s(1) ::  ring(ann,doorbell) at 2.
s(2) ::  in_flat(mary) at 3.
s(2) ::  watch(mary,tv) at 3.
etc.
```

Questions in STAR

- In the syntax of *STAR*, the first two questions relating to the doorbell story are:

```
q(1) ??  has(ann,doorkeys) at 1.

q(2) ??  is_a(ann,visitor) at 1;
         is_a(ann,resident) at 1.
```

- Questions can be reused in different sessions to check for changes in the comprehension model.
- For each answer choice to a question, the system returns one of **accepted** (this choice holds in the comprehension model), **rejected** (its negation holds), or **possible** (neither hold).

The Second Doorbell Session

```
session(s(2),[q(3)],all).

s(2) ::  in_flat(mary) at 3.
s(2) ::  watch(mary,tv) at 3.
s(2) ::  getup(mary,chair) at 3.
s(2) ::  walk_to(mary,door) at 4.
s(2) ::  afraid(mary) at 4.

q(3) ??  wants(mary,see_who_at(door)) at 4;
         wants(mary,open(door)) at 4.
```

- Note: unlike in humans, *STAR* questions do not affect the comprehension model.

Background World Knowledge

- As well as a narrative and questions, a *STAR* domain file includes **world knowledge** appropriate for a story or group of stories on a theme.
- World knowledge consists of:
  - A **fluent declaration** (listing concepts that persist over time).
  - **Association rules** between concepts.
  - **Priority statements** between pairs of association rules.

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- Association rules can be **property rules**, **causal rules** or **preclusion rules**. There is also an inbuilt **intertia rule** for fluents.
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- *STAR* includes **inbuilt priorities**, e.g. causal rules are stronger than inertia rules, which are stronger than property rules.
- The argumentation-based framework ensures that all associations are **defaults**.

Fluent Declaration for the Doorbell Story

```
fluents([
                in_flat(_),
                watch(_,_),
                afraid(_),
                flatmate(_,_),
                upset_with(_,_),
                has(_,_),
                is_a(_,_),
                expect(_,_),
                wants(_,_),
                knows(_,_),
                agree(_,_),
                refused(_,_)
]).
```

Some Property Association Rules

- "Those with door keys do not normally ring the doorbell."

```
p(11) ::  has(Person,doorkeys) implies
            -ring(Person,doorbell).
```

- "Visitors do not normally have doorkeys, but residents do."

```
p(12) ::  is_a(Person,visitor) implies
            -has(Person,doorkeys).

p(13) ::  is_a(Person,resident) implies
            has(Person,doorkeys).
```

Some Causal Association Rules and a Priority

- "If the doorbell rings and a person is not expecting visitors this normally makes the person afraid."

```
c(31) ::  rings(doorbell),
          -expect(Person,visitors) causes
          afraid(Person).
```

- "If it is a flatmate at the door then normally this stops fear."

```
c(36) ::  see_at(Person,Other,door),
          flatmate(Person,Other) causes
          -afraid(Person).

c(36) >> c(31).
```

STAR Output After Doorbell Session 2

```
>>> Comprehension model:
s(0) :  person(ann) at always
.....
s(2) :  afraid(mary) at 4

0:  in_flat(mary) -expect(mary,visitors) -flatmate(mary,ann)
    -has(ann,doorkeys) -is_a(ann,resident) watch(mary,tv) ...
1:  in_flat(mary) -expect(mary,visitors) -flatmate(mary,ann)
    -has(ann,doorkeys) -is_a(ann,resident) watch(mary,tv) ...
2:  in_flat(mary) -expect(mary,visitors) -flatmate(mary,ann)
    -has(ann,doorkeys) -is_a(ann,resident) watch(mary,tv) ...
3:  afraid(mary) < in_flat(mary)> -expect(mary,visitors) ...
    < watch(mary,tv)> ...
4:  < afraid(mary)> in_flat(mary) -expect(mary,visitors) ...
    < walk_to(mary,door)> wants(mary,find_out_who_at(door))
    -wants(mary,open(door)) -watch(mary,tv)...

>>> Answering question q(3):
+ accepted choice:  ,[wants(mary,find_out_who_at(door))at 4]
- rejected choice:  ,[wants(mary,open(door))at 4]
```

Demo of doorbell.pl

STAR Default Reasoning: Some "Tweety" Stories

"Tweety is a bird. Tweety is a penguin."

"Tweety can fly. Tweety is a penguin."

"Tweety can't fly. Tweety is a penguin."

World Knowledge:

- Normally birds can fly, penguins can't fly, and penguins are birds.

Questions:

- Is Tweety a penguin? Is Tweety a bird? Can Tweety fly?

STAR "Penguin" Domain File

```
session(s(1),[q(1)], all).
session(s(2),[q(1)], all).

fluents([bird,penguin,canfly]).

% s(1) ::  bird at 3.
s(1) ::  canfly at 3.
% s(1) ::  -canfly at 3.
s(2) ::  penguin at 6.

p(1) ::  bird implies canfly.
p(2) ::  penguin implies -canfly.
p(3) ::  penguin implies bird.

p(2) >> p(1).

q(1) ??  penguin at 9; bird at 9; canfly at 9.
```

Demo of penguins.pl

STAR "Penguin" Session 1 Output

```
>>> Comprehension model:

s(1) :  canfly at 3

0:  canfly -penguin
1:  canfly -penguin
2:  canfly -penguin
3:  < canfly> -penguin
4:  canfly -penguin
5:  canfly -penguin
6:  canfly -penguin
7:  canfly -penguin
8:  canfly -penguin
9:  canfly -penguin

>>> Answering question q(1):
- rejected choice:  ,[penguin at 9]
?  possible choice:  ,[bird at 9]
+ accepted choice:  ,[canfly at 9]
```

STAR "Penguin" Session 2 Output

```
>>> Comprehension model:

s(1) :  canfly at 3
s(2) :  penguin at 6

0:  bird canfly penguin
1:  bird canfly penguin
2:  bird canfly penguin
3:  bird < canfly> penguin
4:  bird canfly penguin
5:  bird canfly penguin
6:  bird canfly < penguin>
7:  bird canfly penguin
8:  bird canfly penguin
9:  bird canfly penguin

>>> Answering question q(1):
+ accepted choice:  ,[penguin at 9]
+ accepted choice:  ,[bird at 9]
+ accepted choice:  ,[canfly at 9]
```

Empirical Studies with STAR

- We need tools such as *STAR* to answer questions about story undersanding (and commonsense reasoning in general) that are ultimately empirical.

- Main aims of our experiments are to explore:
  - The **nature of representation**: what are "natural representations" of world knowledge?
  - The **effective use of knowledge**: how is world knowledge effectively retrieved and/or specialised for the (comprehension) task in hand?
  - **Coherence in comprehension**: how can the psychological notion of coherence be exploited to increase the effectiveness of computation?

Some Psychological Experiments

- What knowledge do humans appeal to when comprehending a story? To what extent is it logical/argumentative? How deep/shallow is chaining of rules during comprehension?
- Initial experiment:
  - ◇ Readers answered comprehension questions with "think aloud" justifications.
  - ◇ Reader data pooled together, analysed and compiled into *STAR* world knowledge.
  - ◇ *STAR*'s comprehension model answered questions according to the majority human view.

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  - ◇ *STAR*'s comprehension model answered questions according to the majority human view.
- More recent experiment:
  - ◇ More systematic using a larger pool of 60 readers.
  - ◇ Four different stories on the same "life at home" theme.
  - ◇ Readers asked to report world knowledge used in structured natural language version of association rules.

Experiments for Automated W.K. Acquisition

- We will experiment by crawling the Web for pages containing words found in a small corpus of short stories.
- What representation facilitates best the acquisition process?
- What are the pros and cons of learning directly in the language of the *STAR* system?
- Is the gathered knowledge general / specific enough to be used for comprehending actual stories?
- What types of knowledge cannot be extracted automatically due to lack of (reliable) training data?
- Is the *distributional hypothesis*, that "a word is characterized by the company it keeps" (Firth 1957), sufficient to justify that the learned knowledge is commonsensical?

Summary

- *STAR* is (primarily) a tool to experiment with automated story comprehension.
- It facilitates reasoning about action, causation and change, and reasoning with default association rules.
- It facilitates empirical studies in the realm of commonsense reasoning.
- It is based on argumentation for defeasible non-monotonic reasoning using:
  - skeptical grounded extensions
  - Argumentation Logic (to accommodate limited contrapositive reasoning)
- Please try out *STAR*:
  - Runs with standard SWI Prolog.
  - Download package, tutorial and examples at `cognition.ouc.ac.cy/narrative/`.