The Epistemic and Practical Reasoner

an implementation of argument-based practical reasoning

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Outline

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Argument-based reasoning (1)

- a type of *defeasible reasoning*
  - synonyms: nonmonotonic / commonsense reasoning
  - can deal with inconsistent or incomplete belief bases
  - inferences are not certain, but can be made provided that there is no information to the contrary that defeats them

Argument-based reasoning (1)

- a type of *defeasible reasoning*
  - synonyms: nonmonotonic / commonsense reasoning
  - can deal with inconsistent or incomplete belief bases
  - inferences are not certain, but can be made provided that there is no information to the contrary that defeats them
- based on arguments that may contradict each other
  - e.g. conflicting conclusions (rebuttal)

$$\frac{\text{Tweety is a bird} \quad \text{birds can fly}}{\text{Tweety can fly}}$$

$$\frac{\text{Tweety is a penguin} \quad \text{penguins cannot fly}}{\text{Tweety cannot fly}}$$

Argument-based reasoning (2)

- difference between arguments and classical proofs
  - classical logic
    - about the truth of a proposition
    - single proof is sufficient
  - defeasible logic
    - about having more justification for a proposition than against it
    - interaction between multiple arguments

Argument-based reasoning (3)

Abstract argumentation framework (Dung)

- set of arguments with defeat relation
- abstract: internal structure of arguments and definition of defeat are not specified
- semantics define extensions with justified arguments
  - sceptical grounded semantics
  - credulous preferred semantics
- argument games determine the status of individual arguments according to certain semantics
  - G-game (sceptical)
  - P-game (credulous)

Argument-based reasoning (4)

Sceptical vs. credulous reasoning

- consider two arguments of equal strength:
  - Nixon is a pacifist, because Nixon is a Quaker and Quakers are pacifists
  - Nixon is not a pacifist, because Nixon is a Republican and Republicans are not pacifists
- they defeat each other
- neither conclusion is *sceptically justified*
- either conclusion is *credulously defensible*
- context determines which kind of reasoning is more rational

Practical reasoning

- reasoning about goals, desires and actions
- choose between different options to achieve a goal
  - one that also achieves another goal
  - or that at least does not prevent too many goals from being achieved...
- highly dependent on epistemic reasoning (reasoning about knowledge or beliefs)
- own set of properties and problems
- focus here on determining which desires can be defeasibly inferred from a belief base

Research question and method (1)

Three topics concerning argument-based practical reasoning are chosen to focus on:

- combination of epistemic and practical reasoning: e-p-semantics (Prakken)
- the practical syllogism (Bench-Capon and Prakken)
- accrual of arguments (Prakken, Bench-Capon and Prakken)

Research question and method (1)

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- accrual of arguments (Prakken, Bench-Capon and Prakken)

Research question:

- Are these theories correct and completely specified?
- If not, what changes and additions are needed to make them better or more complete?

Research question and method (2)

Two reasons for implementing a theory

- test for correctness and completeness of the theory
  - theory must be completely specified
  - examples can be verified
- prototype for applications
  - an intelligent agent reasoning about goals and actions

Outline

E-p-semantics (1)

Combining epistemic and practical reasoning

In certain contexts, reasoning about beliefs is sceptical while reasoning about action is credulous.

- practical example:
  - I want to take bus 42, because I want to be at the station and bus 42 will take me there
  - I want to cycle to the station, because I want to be at the station and cycling to it will take me there
- epistemic example:
  - bus 42 does not ride today, because a bus strike was announced in the papers yesterday
  - bus 42 does ride today, because I saw one passing this morning
- credulous practical reasoning and sceptical epistemic reasoning are *interleaved*

E-p-semantics (2)

Combining epistemic and practical reasoning

Formalisation

- distinction between epistemic and practical arguments
- new semantics: e-p-semantics
  - combination of grounded semantics for epistemic arguments and preferred semantics for practical arguments
- new argument game: GP-game
  - combination of G-game rules for epistemic arguments and P-game rules for practical arguments

The practical syllogism (1)

If action a causes state b, and I have the goal to be in state b, then it is rational for me to wish to do a.

- very natural way to reason about action
- abductive ('backwards') inference
- goes back as far as Aristotle
- need to consider negative side-effects of the action
  - a might also cause unwanted state b'
- need to consider alternatives for achieving the goal
  - state b might also be realised by action a'

The practical syllogism (2)

Formalisation

- modal operator D standing for desire
- two new inference rules
  - positive practical syllogism:
    a causes b, I want b, so I want a
  - negative practical syllogism:
    a prevents b, I want b, so I do not want a
- alternative defeat
  - a_1 causes b, I want b, so I want a_1
  - a_2 causes b, I want b, so I want a_2
  - not rational to want both, so they defeat each other

Accrual of arguments (1)

Accrual of arguments: 'add up' multiple arguments with the same conclusion.

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- an accrual might be stronger than its elements
  - A: I want to be fit, jogging will get me fit, so I want to go jogging
  - B: I want to loose weight, jogging will help me loose weight, so I want to go jogging
  - C: I do not want to be wet, it is raining, jogging in the rain will get me wet, so I do not want to go jogging
  - suppose C is stronger than either A or B, but A and B together are stronger than C

Accrual of arguments (2)

- an accrual might be weaker than its elements
  - A: I want to be fit, jogging will get me fit, so I want to go jogging
  - B: I do not want to be hot, it is hot outside, jogging in the heat will get me hot, so I do not want to go jogging
  - C: I do not want to be wet, it is raining, jogging in the rain will get me wet, so I do not want to go jogging
  - suppose A is weaker than either B or C, but B and C together are weaker than A

Accrual of arguments (3)

Three principles of accrual

- accruals can be stronger or weaker than their elements: strength cannot be calculated from the strengths of the elements
- only the largest possible accrual may be used
- flawed arguments may not accrue

Formalisation

- accrual inference rule
- rebuttal only between accrual arguments
- accrual undercut: an accrual undercutter A undercuts an accrual B if B's elements are a proper subset of A's elements

Accrual of arguments (4)

Difficulty: strength of accruals

- in first theory completely unspecified
- second theory: based on goals reached and prevented if the argument's final desire is carried out

Problems:

- applies only to practical arguments, not epistemic ones
- combination with degree of belief and rule strength
- set of prevented goals may be defined outside the argument
- ordering of sets of goals is only partial (there may be infinitely many goals)
- the ordering must be defined somewhere

Outline

The language

- propositional modal logic
- non-nested modality D standing for desire
- facts and rules
- two types: epistemic and practical
- strength between 0 and 1
- examples:

```
r1: canFly <- bird 0.8.
~canFly <- penguin 0.7.
~r1 <- penguin 0.9.
penguin.
bird <- penguin.
```

```
r1: beAtStation <- takeBus42.
r2: beAtStation <- cycleToStation.
DbeAtStation.
~r1 <- busStrike.
busStrike.
~busStrike.
```

The structure of arguments

- trees of chained defeasible inferences
- one conclusion, zero or more subarguments
- two types: epistemic and practical
- no circular arguments
- example:

$$\dfrac{\dfrac{\dfrac{}{\text{penguin}}\,\text{FF} \quad \dfrac{}{\text{bird <- penguin}}\,\text{FR}}{\text{bird}}\,\text{RA} \quad \dfrac{}{\text{canFly <- bird}}\,\text{FR}}{\text{canFly}}\,\text{RA}$$

Inference schemes (1)

Inferences are instantiations of inference schemes.

- from fact
- from rule
- rule application

$$\frac{\tilde{}\text{canFly} \leftarrow \text{penguin} \quad \text{penguin}}{\tilde{}\text{canFly}}\ \text{RA}$$

- DKD

$$\frac{\text{Daction}}{\tilde{}\text{D}\tilde{}\text{action}}\ \text{DKD}$$

Inference schemes (2)

- positive practical syllogism

$$\frac{\text{state} \leftarrow \text{action, circumstance} \quad \text{Dstate} \quad \text{circumstance}}{\text{Daction}} \ \text{PPS}$$

- negative practical syllogism

$$\frac{\tilde{}\text{state} \leftarrow \text{action, circumstance} \quad \text{Dstate} \quad \text{circumstance}}{\tilde{}\text{Daction}} \ \text{NPS}$$

- accrual

$$\frac{a \quad a}{a} \ \text{ACCR}$$

- accrual undercutter

Strength of arguments

Simple arguments:

- weakest link
- last link

Accrual arguments:

- all equal
- strongest link
- number of promoted desires

Conflicts between arguments

Three types of conflict:

- rebuttal
- alternative
- accrual undercut

Argument A defeats argument B if

- A rebuts B and A is at least as strong as B; or
- A accrual-undercuts B; or
- A is an alternative to B and A is at least as strong as B; or
- A defeats a subargument of B

Argument games (1)

Interaction between arguments for and against a certain proposition.

Argument games (2)

A bit simplified

Move:

- identifier
- player: PRO or CON
- argument
- target

Game (general):

- sequence of moves
- PRO moves first: the main argument
- PRO and CON move in turn
- a move's argument defeats the target's argument
- a player wins if the other has no legal moves left
- if PRO wins, the main argument is justified

Argument games (3)

A bit simplified

G-game (sceptical):

- PRO may not repeat any arguments

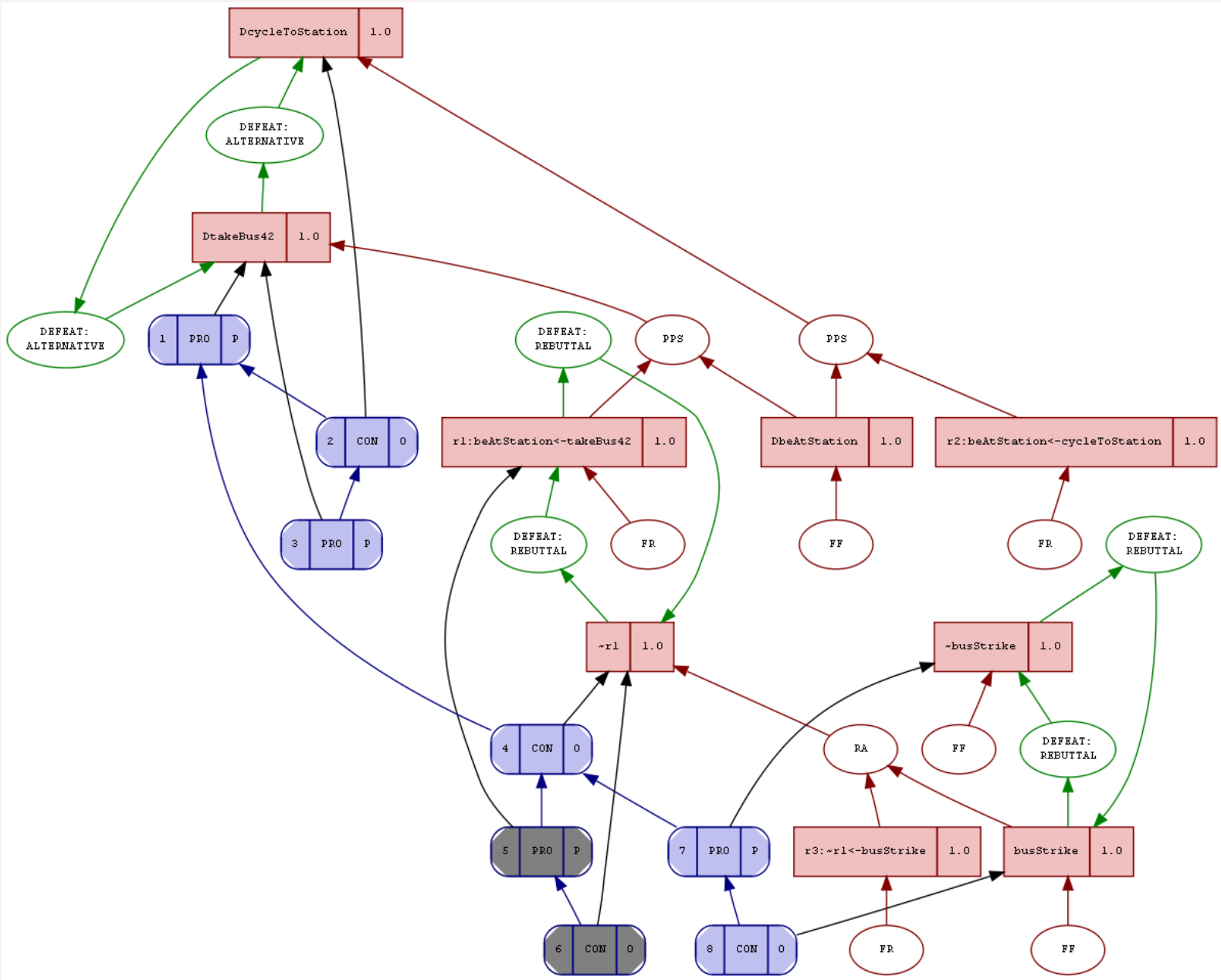
P-game (credulous):

- PRO may not repeat CON's arguments
- CON may not repeat his own arguments

GP-game (sceptical epistemic and credulous practical):

- combination of G-game rules for epistemic arguments and P-game rules for practical arguments

Argument games (4) - Example GP-game



Outline

The Epistemic and Practical Reasoner

Overview

- written in Java 6
- graphical user interface
- input: belief base, query and parameters
- arguments and an argument game are generated
- output: log, xml and graph

Demonstration

Outline

Results

Recall the research question:

- Are the implemented theories correct and completely specified?
- If not, what changes and additions are needed to make them better or more complete?

Results

Answer:

- e-p-semantics
  - fully specified
  - only minor errors in examples
- practical syllogism
  - inference schemes PPS and NPS fully specified
  - alternative defeat only defined for use with accrual
  - alternative definition was created straightforwardly
- accrual of arguments
  - inference schemes accrual and accrual undercutter fully specified
  - accrual can be made more efficient by adding a restriction
  - major problem: accrual strength
  - games can become very long

Further work

- accrual strength
  - radical change in the way strength is currently modelled
- more elaborate notion of undercut
- extension to first-order predicate logic
- other approaches to argument-based practical reasoning

More information

Interested?
The Epistemic and Practical Reasoner and my thesis can be found on www.wietskevisser.nl/research/epr