Argumentation and Temporal Persistence

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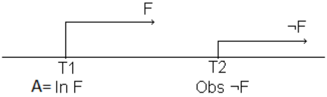
Outline

Motivation

- Understand Temporal Persistence via Argumentation
  - Study this in the specific content of Language $\mathcal{E}$
  - Our analysis is applicable more widely
- Link to Frame Problem and Qualification Problem
- Builds on earlier work: Language $\mathcal{E}$[2] and Argumentation[1]
- Motivation
  - Not all domains are consistent
- Extension: Introduce new arguments for
  1. backwards persistence
  2. persistence from observations



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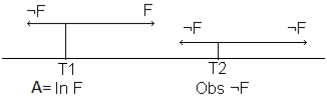

Outline

Language $\mathcal{E}$

- Action Language
- Propositions:
  - c-propositions (A initiates/terminates F when C)
  - h-propositions (A happens at T)
  - t-propositions (L holds at T)
- Models are truth assignments to Fluents that satisfy:
  - Persistence: Truth Values of Fluents remains the same in time intervals where no relevant action occurs
  - A fluent F changes its truth value only via occurrence of an initiation or a termination point

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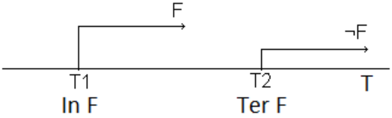
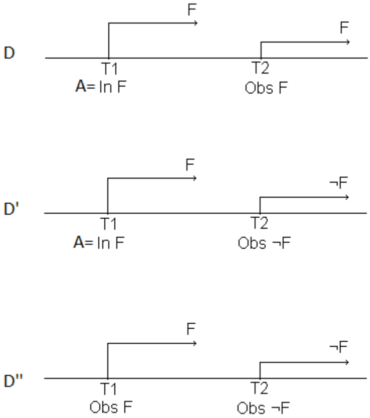
- Priorities
  - $PG[F, T; T1] < NG[F, T; T2]$, for all $T1 < T2$
  - ...

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T1
A= In F
T2
Obs F
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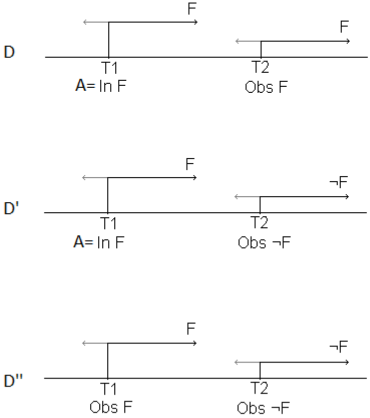
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Argumentation Basics

- Argumentation Framework $< Arg, A >$
  - Arg is a set of Arguments
  - A is an Attacking Relation on Arg
- Admissibility: Set of Arguments such that:
  - Non self attacking
  - Attacks all its attacks
- Models: Maximal admissible sets

Outline

Argumentation Program $(B(D), A, <)$

- $B(D) \rightarrow$ background theory
- $A \rightarrow$ argument rules
    - Persistence
    - Local Generation Arguments
    - Local Observation Arguments:
    - Assumption at 0
- $< \rightarrow$ priority relation

For all time points t_1, t_2 and t such that $t_1 < t < t_2$,

$HoldsAt(f, t_2) \leftarrow HoldsAt(f, t)$ $\quad PFP[f, t_2; t]$

$HoldsAt(f, t_1) \leftarrow HoldsAt(f, t)$ $\quad PBP[f, t_1; t]$

$\neg HoldsAt(f, t_2) \leftarrow \neg HoldsAt(f, t)$ $\quad NFP[f, t_2; t]$

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$$
\begin{array}{ll}
HoldsAt(f, t+1) \leftarrow Initiation(f, t) & PG_F[f, t] \\
\neg HoldsAt(f, t) \leftarrow Initiation(f, t) & PG_B[f, t] \\
\neg HoldsAt(f, t+1) \leftarrow Termination(f, t) & NG_F[f, t] \\
HoldsAt(f, t) \leftarrow Termination(f, t) & NG_B[f, t]
\end{array}
$$

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$$HoldsAt(f,t) \leftarrow Observation(f,t) \qquad PO[f,t]$$

$$\neg HoldsAt(f,t) \leftarrow Observation(\neg f,t) \qquad NO[f,t]$$

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$HoldsAt(f, 0)$ $\quad PA[f, 0]$

$\neg HoldsAt(f, 0)$ $\quad NA[f, 0]$

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If $t_1 < t_2$
$PFP[f, t^*; t_1] < NFP[f, t^*; t_2]$, $NFP[f, t^*; t_1] < PFP[f, t^*; t_2]$,
$PBP[f, t^*; t_2] < NBP[f, t^*; t_1]$, $NBP[f, t^*; t_2] < PBP[f, t^*; t_1]$,
$NFP[f, t_2; t_1] < PO[f, t_2]$, $PFP[f, t_2; t_1] < NO[f, t_2]$,
$NBP[f, t_1; t_2] < PO[f, t_1]$ and $PBP[f, t_1; t_2] < NO[f, t_1]$.

Argumentation Program $(B(D), A, <)$

- $B(D) \rightarrow$ background theory
- $A \rightarrow$ argument rules
  - Persistence
  - Local Generation Arguments
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- $<\rightarrow$ priority relation

At 0
$PA[f, 0] < NO[f, 0]$ and $NA[f, 0] < PO[f, 0]$

Argumentation Program $(B(D), A, <)$

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At t
$PG_B[f,t] < PO[f,t]$ and $NG_B[f,t] < NO[f,t]$

Argumentation Program $(B(D), A, <)$

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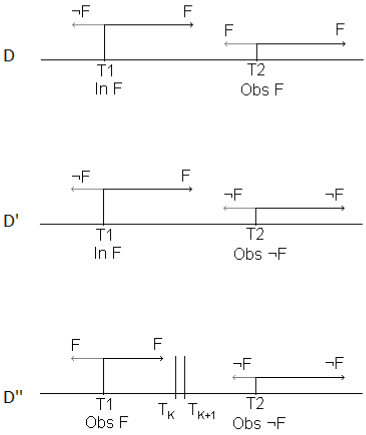
At $t+1$
$PG_F[f,t] < NO[f,t+1]$ and $NG_F[f,t] < PO[f,t+1]$

Note that there are no priorities between conflicting forward and backward persistence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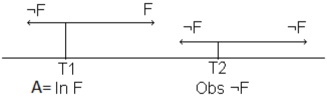
Qualification Problem[3]

- Domains have meaning even when we observe an unexpected failure of an action
- No conclusion between T_1 and T_2
  - Arguments for F and $\neg F$



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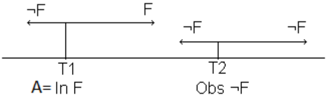

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Results

- Recover and also extend Language $\mathcal{E}$
- The extended semantics can be explained by Language $\mathcal{E}$
- Fully recover Language $\mathcal{E}$

Forward persistence arguments = backwards persistence arguments

Theorem

Let D be a language $\mathcal{E}$ domain description and a countable number of h-propositions. Then:

- *For every language $\mathcal{E}$ model, M, of D there exists an admissible extension, E, of the corresponding argumentation program $\Delta \equiv (B(D), A, <)$ such that E corresponds to M, i.e. $E \models$ holds-at(f, T) if and only if $M(f, T) = true$ and $E \models \neg$holds-at(f, T) if and only if $M(f, T) = false$.*
- *There exists a complete admissible extension D of the corresponding argumentation program $\Delta \equiv (B(D), A, <)$.*

Results

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Add a generation point

Theorem

Let D be a domain description. For every maximally admissible extension E there exist a domain D' obtained from D by adding new events such that there exist a language $\mathcal{E}$ model, M, of D' that corresponds to E (i.e. $E \models holds\text{-}at(f, t)$ if and only if $M \models holds\text{-}at(f, t)$).

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Assign higher priority to conflicting forward persistence arguments over backwards persistence arguments

Theorem

Add the following priorities rules when $t_1 < t_2$:
$PFP[f, t; t_1] > NBP[f, t; t_2]$ *and* $NFP[f, t; t_1] > PBP[f, t; t_2]$.
Then, every maximally admissible extension E, for any domain D corresponds to a model M of the language $\mathcal{E}$, of D.

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Conclusion

- The extension of Language $\mathcal{E}$ enable us to:
  - recover and also extend Language $\mathcal{E}$
  - give a semantic meaning to domains that cannot be interpreted in Language $\mathcal{E}$
- Closer to original Event Calculus
- The formalization does not depend on Language $\mathcal{E}$
- Based on "Natural" Properties
- Advance Qualification Problem

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Thanks for listening!!!

Questions ?

Antonis C. Kakas, Rob Miller, and Francesca Toni, *An argumentation framework of reasoning about actions and change*, LPNMR, 1999, pp. 78–91.

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