Context-Sensitive Description Logics in a Dynamic Setting

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RoSI - TU Dresden
Role-based Software Infrastructures for continuous-context-sensitive Systems
Overview

Context-Sensitive DL in a Dynamic Setting
Description Logics of Context
Dynamic Setting

Contribution to RoSI
Context-Sensitive DL in a Dynamic Setting
Description Logics

• a **family** of formal knowledge representation languages
• decidable (most of them)
• feasible (most of the cases)

Syntax :

• $N_C, N_R, N_I$: concept, role, and individual names respectively
• a **TBox** $\mathcal{T}$: describes the hierarchy, relation between concepts
• a **ABox** $\mathcal{A}$: represents the data
• a **RBox** $\mathcal{R}$: describes the role properties and hierarchy
### Concept Expression

\[ C ::= N_c \mid (C \cap C) \mid (C \cup C) \mid \neg C \mid T \mid \perp \]

\[ \exists r.C \mid \forall r.C \mid \geq nr.C \mid \leq nr.C \mid \exists r.Self \mid \{a\} \]

### General Concept Inclusion (GCI) - TBox

\[ C \sqsubseteq D. \]

\[ C \equiv D \text{ stands for } C \sqsubseteq D \text{ and } D \sqsubseteq C. \]

### Individual Assertions - ABox

\[ C(a), \ r(a, b), \ a \approx b, \text{ or } a \not\approx b \]

### Role Inclusion - RBox

\[ s_1 \circ \ldots \circ s_n \sqsubseteq r \]
Figure 1: CROM - ConDL

Two-dimensional context DLs $\mathcal{L}_m[\mathcal{L}_o]$ [2]

### Axiom Examples

<table>
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<tr>
<th>$\top \sqsubseteq [\exists \text{worksFor} . {\text{Siemens}} \sqsubseteq \exists \text{hasAccessRights} . {\text{Siemens}}]$</th>
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Other considerations (e.g. rigid concepts and roles)
CROM to ConDL

DL - $\text{SHOIQ}[[\text{SHOIQ}]]$ [3]

Verifying consistency of CROM models

- encode the CROM model to ConDL
- JConHT: a $\text{SHOIQ}[[\text{SHOIQ}]]$ reasoner
- $2\text{EXPTIME}$-hard
Dynamic Setting

Possible approach:

- situation calculus
- temporal logics
- non-monotonic logics
Dynamic Setting

Possible approach:

- situation calculus
- temporal logics
- non-monotonic logics

How many layers do we need?

- $\mathcal{L}_m[\mathcal{L}_o] \ vs$
- $\mathcal{L}_{m-1}[\mathcal{L}_m[\mathcal{L}_o]]$
Dynamic Setting

Possible approach:
- situation calculus
- temporal logics
- non-monotonic logics

How many layers do we need?
- $\mathcal{L}_m[\mathcal{L}_o]$ vs $\mathcal{L}_{m-1}[\mathcal{L}_m[\mathcal{L}_o]]$

Should we go deeper...?

https://suwalls.com/digital-art/recursive-painting-9137
A Step Back

What are the questions we want to answer?

Figure 2: Knowledge Base System Schema
Situation Calculus

Used to describe a dynamic domain.
Situation Calculus

Used to describe a dynamic domain.

- actions that can be performed in the world
- fluents that describe the state of the world
- situations

FOL
Situation Calculus

Used to describe a dynamic domain.

\[
\begin{align*}
\text{FOL} &= \{ \\
& \quad \text{• actions that can be performed in the world} \\
& \quad \text{• fluents that describe the state of the world} \\
& \quad \text{• situations} \\
\}\end{align*}
\]

A situation is:

- *init*, the initial situation, or
- *do*(\(A, S\)), the situation resulting from doing action \(A\) in situation \(S\), if it is possible to do action \(A\) in situation \(S\).

Generally: undecidable

Situation calculus extended with DLs: undecided [1]
Some examples (of LTL):

- $p \rightarrow q U r$: $p$ implies $q$ until $r$
- $\bigcirc p \rightarrow \bigcirc \bigcirc r$: if $p$ holds at next step, $r$ holds at two next steps

“Standard” temporal logics: decidable.
Contribution to RoSI
Real World Case - Chemical Reaction

Context-dependent:
- temperature
- catalyst
- surface area
- etc.

Some reactions are irreversible.

Some interesting questions:

- which combination of contexts that leads to unintended conclusion
- can we make sure a data is safe after an individual change the role?

The formal model is static
The formal model is static(?)
The formal model is static(?)

Thus, we need a dynamic language for CROM (e.g. event-based)
Questions?
Questions?
Idea?
Calvanese, Diego and De Giacomo, Giuseppe and Soutchanski, Mikhail
*On the undecidability of the situation calculus extended with description logic ontologies.*

Böhme, Stephan and Lippmann, Marcel
*Decidable description logics of context with rigid roles.*

Böhme, Stephan and Kühn, Thomas
*Reasoning on Context-Dependent Domain Models.*
Rudolph, Sebastian and Schweizer, Lukas and Tirtarasa, Satyadharma
Wolpertinger: A Fixed-Domain Reasoner
ISWC 2017 : Demo Track

Sarah Alice Gaggl, Sebastian Rudolph, and Lukas Schweizer.
Fixed-domain reasoning for description logics.