Context in Cognitive Robotics

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Context in Cognitive Robotics

Definition

Roughly, context is a collection of related ideas, assumptions and other knowledge used for reasoning.

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Benefits

Essential for human language and classification, and in KRR:

- Parsimony in representation and reasoning
- Flexibility in representation and entailment
- Representation of inconsistent, incomplete knowledge

(McCarthy, 1989; Akman and Surav, 1996)

Context Formalisms

Goal

Reifiy context, so it can be reasoned about.

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Declare proposition p holds ("is true") in a context c:

$$c' : \quad ist(c, p)$$

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An alternative, short-hand notation:

$$c : \quad p$$

(Guha, 1995)

Context Formalisms

Divide-and-conquer

- Knowledge base partitioning
- Structuring of global representation
- Common logical language, semantics
- Common inference mechanism

(Bouquet et al., 2003)

Context Formalisms

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Compose-and-conquer

- Collection of local theories
- Combines partial, approximate representations
- Differing language, semantics
- Differing inference mechanism

(Bouquet et al., 2003)

Cognitive Robotics

Objectives

Enable common-sense reasoning for cognitive systems:

- Localise reasoning over large knowledge bases
- Represent incomplete/inconsistent knowledge/belief
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Approach

Use reified contexts with:

- Fine-grained modelling of the world
- Combines partial, approximate representations
- Common knowledge base
- Common language and semantics

Planning using Contexts

A RoboCup @Home-like domain:

$$
\begin{aligned}
lounge &: \quad Connects(kitchen) \\
kitchen &: \quad Connects(lounge) \\
cup_1 &: \quad Blue \\
cup_1 &: \quad Location(kitchen) \\
cup_2 &: \quad Red \\
cup_2 &: \quad Location(lounge) \\
robot &: \quad Location(lounge) \\
robot &: \quad \neg Holding(x)
\end{aligned}
$$

Planning using Contexts

Situation calculus precondition and effect axioms:

$$
\begin{aligned}
move: \quad & Poss(Move(l), s) \equiv \\
& \quad ist(for\_sit(s), Location(m)) \wedge ist(m, Connects(l)) \\
move: \quad & ist(for\_sit(do(a, s)), Location(l)) \equiv a = Move(l) \\
& \quad \vee (a \neq Move(l) \wedge ist(for\_sit(s), Location(l)))
\end{aligned}
$$

Planning using Contexts

Declaring a context for planning:

$$
\begin{aligned}
plan: &\quad for\_sit(S_0) = robot \\
plan: &\quad ist(move, p) \rightarrow p \\
plan: &\quad ist(\Sigma_{sit\_calc}, p) \rightarrow p
\end{aligned}
$$

Planning using Contexts

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\end{aligned}
$$

Deriving a plan for moving to the kitchen and back:

$$
\begin{aligned}
plan: \quad & ist(for\_sit(do(Move(kitchen), S_0)), \\
& \quad Location(kitchen)) \\
plan: \quad & ist(for\_sit(do(Move(lounge), do(Move(kitchen), S_0))), \\
& \quad Location(lounge))
\end{aligned}
$$

Perception using Contexts

A perceptual context might look like:

$$\begin{aligned} perception : \quad & Perceive(x) \land Location(l) \land \\ & ist(c, x) \land ist(c, Location(l)) \rightarrow Seen(c) \end{aligned}$$

Reasoning about a scene:

$$\begin{aligned} scene : \quad & ist(robot, p) \rightarrow p \\ scene : \quad & ist(perception, p) \rightarrow p \\ scene : \quad & Perceive(Red) \end{aligned}$$

Where next?

- Define syntax, semantics for relations to contexts
- Examine use of relations between contexts:
    - Limiting reasoning domain
    - Emergent preconditions
    - Frame axioms
    - Progression
    - Dynamic inference
    - Defeasible reasoning

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