Praxicon
A Semantic Memory for Robots

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Humanoid Robots

Requirements

- Recognize objects
- Recognize actions
- Generate actions
- Generalize
Long-term memory
(Tulving, 1972)

- **Episodic memory** stores experiences, events, situations, etc.
- **Semantic memory** stores the accumulated general world knowledge, and has generalisation and reasoning abilities (Quillian, 1968).
- **Procedural memory** is related to single action and action sequence learning.
- Robots already have episodic and procedural memory

Robots need a semantic memory.

Knowledge graphs
Existing semantic networks

- WordNet, ConceptNet,…
- In some resources, language representations are linked to images (e.g. imaginet, babelnet).

These resources are **disembodied**. They are tied to language idiosyncrasies and lack inherent structure that unifies language-perception-action.

We need an **embodied semantic network** that links language with perception and action to deal with unexpected situations.
Findings in neuroscience

Background

• Mirror neurons
The same neurons that fire when performing an action also fire when we observe someone else performing the same action. (Risolati, 1992)

• Visuomotor neurons
The same neurons that fire when performing an action with a specific object also fire when we observe the object itself.

• Broca’s area
the neural locus of language, action perception and production common syntactic mechanisms in language and action.

The minimalist grammar of action

• First generative grammar of action

• Based on basic findings in experimental research on the human brain's biological basis

• Action-centric, embodied representation in Semantic Networks.

The minimalist grammar of action

Action constituents

• **Tool complement**: the effector of the movement.

• **Object complement**: object affected by a tool-use action.

• **Goal**: final purpose of an action sequence.

If any of the three changes, the action changes:

• *Different goal*: grasp apple with hand to [displace, eat].

• *Different affected object*: grasp [apple, banana] with hand to eat.

• *Different tool*: grasp apple with [hand, tongs] to eat.
The minimalist grammar of action

Example

Production Rules

4 $A'' \rightarrow g A'$
3 $A' \rightarrow (m) A'$
2 $A' \rightarrow A' (o_c)$
1 $A' \rightarrow A \, t_c$
The Praxicon
A semantic memory for humanoid robots

- Action/sensorimotor-centric Semantic Network (Using the minimalist grammar of action).
- Multirepresentational.
- Referential (language is grounded).
- Recursive. Recursive Conceptual structures
- Driven by findings in neuroscience in every knowledge representation decision.
The Praxicon
Components & principles

- **Concepts**: Nodes - multi-representational
- **Relations**: Edges - labeled, bidirectional
- One concept may be related with many concepts, but with only one type of relation.
- Finite set of relations.
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<th>Types of relations</th>
<th>The finite set of allowed relations</th>
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Entity concept

Example
Action concept

Example
Recursive conceptual structure

Example

- $RS \rightarrow C \ RP \mid \ RP \ C$
- $RP \rightarrow C \ R \mid \ R \ C$
- $R \rightarrow C_{1_{RTx}} \ C_{2_{RTx}}$

EXAMPLE:

R: fan **hasCondition** closed
RP: R **hasShape** oblong
RS: RP **tool-action** push_withFan_ball

or in language terms:

R: closed fan
RP: closed fan is oblong
RS: push the ball with the closed fan

(action enabled by the oblong shape of the closed fan)
Praxicon population

How to generate the Praxicon graph

• Populate from perception and action. This requires mechanisms to acquire knowledge from experiences the robot has while interacting with the world and storing them in the Praxicon.

• Using existing resources, for instance a language resource like Wordnet or a motoric or visual dataset. Using specific transformation mechanisms, that alter these resources or import them in a way that conform to the specifics of Praxicon.

• Behavioural experimental data, like the Cognitive Lithic tools corpus.
Poeticon research related to Praxicon

Cognitive experiments


More than 120 participants, more than 90 hours of spontaneous speech...
Application
Make a sandwich
Thank you!