OpenNARS:

Autonomous Learning and Decision-Making

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Properties of the Non-Axiomatic Reasoning System (NARS)

Designed to work with insufficient knowledge and resources, featuring:

- Real-time operation
- Being open to unexpected tasks
- Learning from experience
- Dealing with uncertainty

=> High degree of autonomy
NARS Overview

Inference Engine:

- Memory
- Control
- Logic
Memory

Containing concepts:

- Named by terms
- Semantically linked
- Containing task statements
Memory

Memory

concept1

Statements

concept2

Statements

concept3

Statements
Control

Probabilistic premise selection:

- Favoring high priority items

In each step:
  1. Select concept C, and task T from it
  2. Select a belief B from neighbour concept D
  3. Apply inference using T and B as premises
  4. Feed results back into correct concepts
Concept

Some concept roles:

- Represent a certain pattern in experience

- Keeping track of the evidence about the pattern it represents. (Revision)

- Allow remembering relevant preconditions, execute operation goals (Decision)

- Interact with task/event buffer (Temporal Reasoning, „Top-down Attention“)
Memory&Control:
Desired Properties

- Allow often appearing patterns to stabilize:
  - Perception viewpoint: making them easier to be re-observed
  - Cognition viewpoint: Allow useful knowledge to „survive“ and to be highly prioritized in the right context.

- Allow mental flexibility: Concepts being composed and decomposed by the reasoning process.
Logic: Desired Properties

- Allow sufficient expressiveness for the encodings the system will need to form
- Ability for deductive, inductive and abductive reasoning
- Allow to deal with uncertainty
Non-Axiomatic Logic

- Evidence-based Truth Value

Featuring:
- Deduction
- Induction (Learning-related)
- Abduction
From evidence to truth value

Positive evidence $w_+$
Negative evidence $w_-$

- Frequency: $w_+ / (w_+ + w_-)$
- Confidence $(w_+ + w_-) / ( (w_+ + w_-) + k )$
Truth Value

- Zero total evidence
- Little positive evidence, no negative evidence
- Little contradictory evidence
- A lot of contradictory evidence
- Little negative evidence, no positive evidence
- Much negative evidence, no positive evidence
- Much positive evidence, no negative evidence
- Infinite total evidence

Frequency

Confidence
Observing temporal patterns

Example, Sequences:
A, B events, derive compound event:
(A,B)
Example

given observation

to what extent was

observed?
Predictive hypothesis generation

Example, Temporal Induction:
A, B events, derive hypothesis:
A => B
Anticipation

Given $A \implies B$ is believed, and given $A$ is observed: predict $B$

Predicted event $B$ wasn't observed?
Generate negative evidence for $B$

allows $A \implies B$ to get revised.
Example

Conditioning based on observed event sequence
a,b,c,a,a,a,b,c,b,b,b,a,b,c

how => c ?
Example

Conditioning based on observed event sequence

a, b, c, a, a, a, b, c, b, b, b, a, b, c

how => c ?

a => c ?
b => c?
(a, b) => c?
Procedural knowledge

Conditioning to acquire procedural knowledge:

(a, b) => c

(precondition, operation) => goal
Microworld

2D environment, featuring:

- Agent in bird-view perspective
- Goal to capture green objects
- Goal to avoid red objects
Microworld

Perception:
• Pixel-based 1D-retina from agent perspective

Actions:
• Rotate left, rotate right, move forward
Input Representation

Input as events of the form:
\[
\{\text{pixel}_i\} \rightarrow \text{[on]} \ %\text{degree}\%
\]

Operations:
\[
(\ast,\{\text{SELF}\}) \rightarrow ^\text{left}
\]
Microworld
Stick „jump&run“

Goal: Move to the right side
Issue: Obstacles are in the way
Solution: Jump over it
Improvisation through analogy

• „Toothbrush“ decision making example
Problem solving

- The toothbrush is made of plastic.
- Placing the toothbrush in a melted state causes it to be pliable.
- Placing in a hardened state allows it to be re-shaped.
- The melting process generates heat.
- The hardened state can be achieved by cooling.

Screw: Can be turned to achieve a hardened state, which can then be re-shaped.
problem solving

Solutions:
1. Melt cup,
2. Properly re-shape cup
   and also a solution:
1. Melt toothbrush
2. Re-shape toothbrush

..after letting a properly re-shaped object cool down, it can then potentially be used to unscrew the screw.
Thank you!