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:

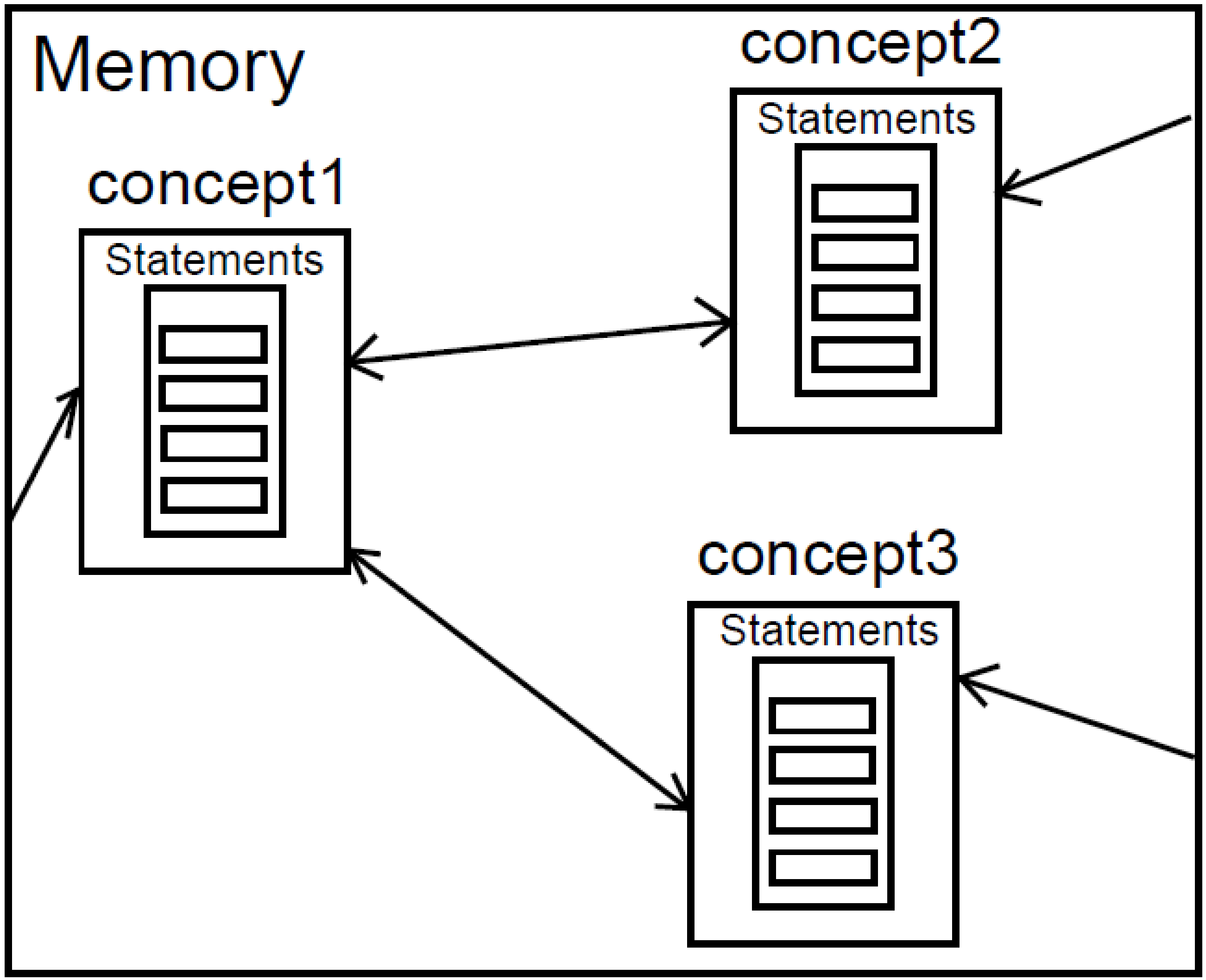
- Memory
- Control
- Logic

Memory

Containing concepts:

- Named by terms
- Semantically linked
- Containing task statements

Memory


Memory
concept2
Statements
concept1
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:

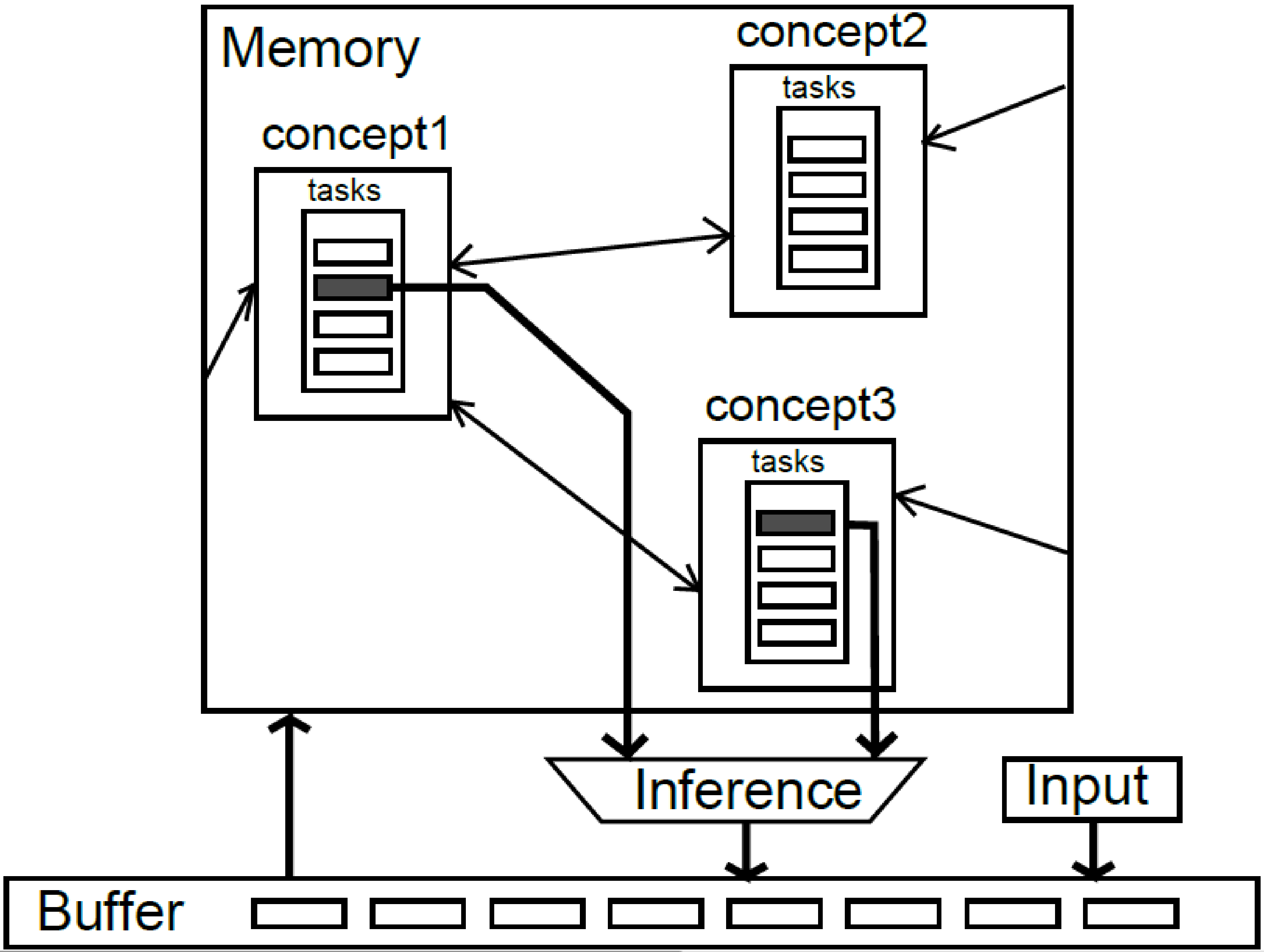
- Represent a certain pattern in experience
- Keeping track of the evidence about the pattern it represents. (Revision)
- Allow remembering relevant preconditions, execute operation goals (Decision)
- Interact with task/event buffer (Temporal Reasoning, „Top-down Attention“)

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 priorized in the right context.

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

Big Picture


Memory
concept1
tasks
concept2
tasks
concept3
tasks
Inference
Input
Buffer

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

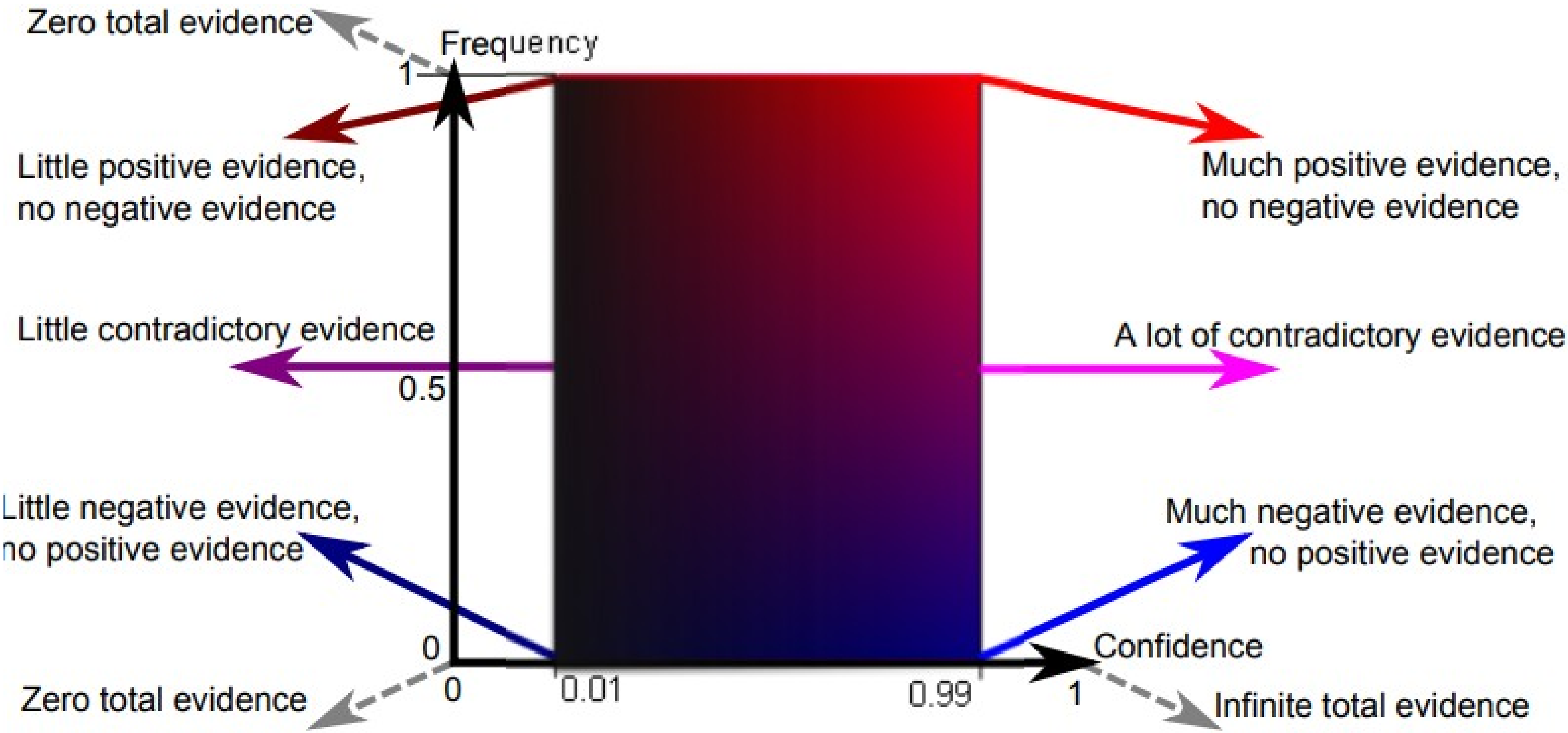
From evidence to truth value

Positive evidence w_+

Negative evidence w_-

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

Truth Value


Zero total evidence
Frequency
1
Little positive evidence,
no negative evidence
Much positive evidence,
no negative evidence
Little contradictory evidence
A lot of contradictory evidence
0.5
Little negative evidence,
no positive evidence
Much negative evidence,
no positive evidence
0
Confidence
Zero total evidence
0
0.01
0.99
1
Infinite total evidence

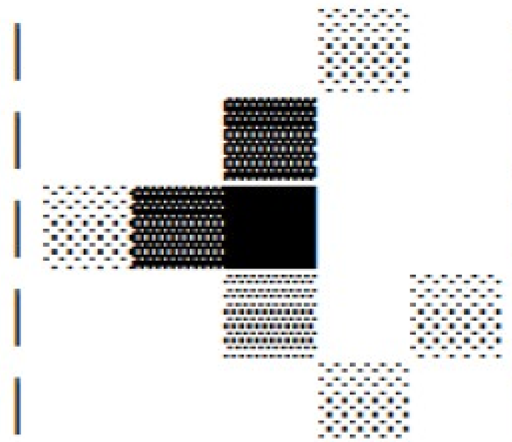
Observing temporal patterns

Example, Sequences:

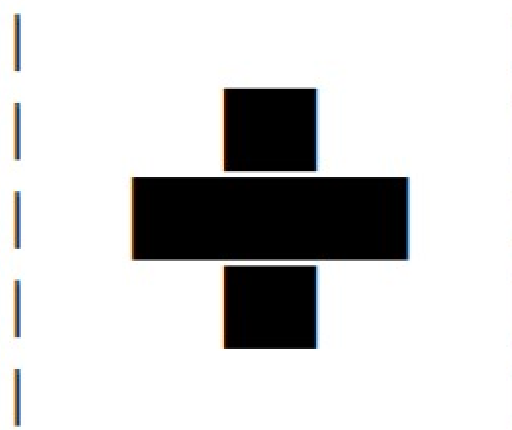
A, B events, derive compound event:
(A,B)

Example

given observation



to what extent was



observed?

Predictive hypothesis generation

Example, Temporal Induction:

A, B events, derive hypothesis:

A => B

Anticipation

Given A => B is believed, and given A is observed:
predict B

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

allows A => B to get revised.

Example

Conditioning based on observed event sequence

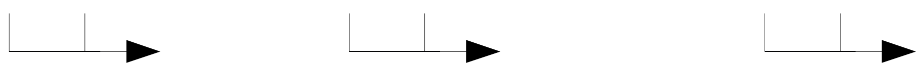
a,b,c,a,a,a,b,c,b,b,b,a,b,c

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

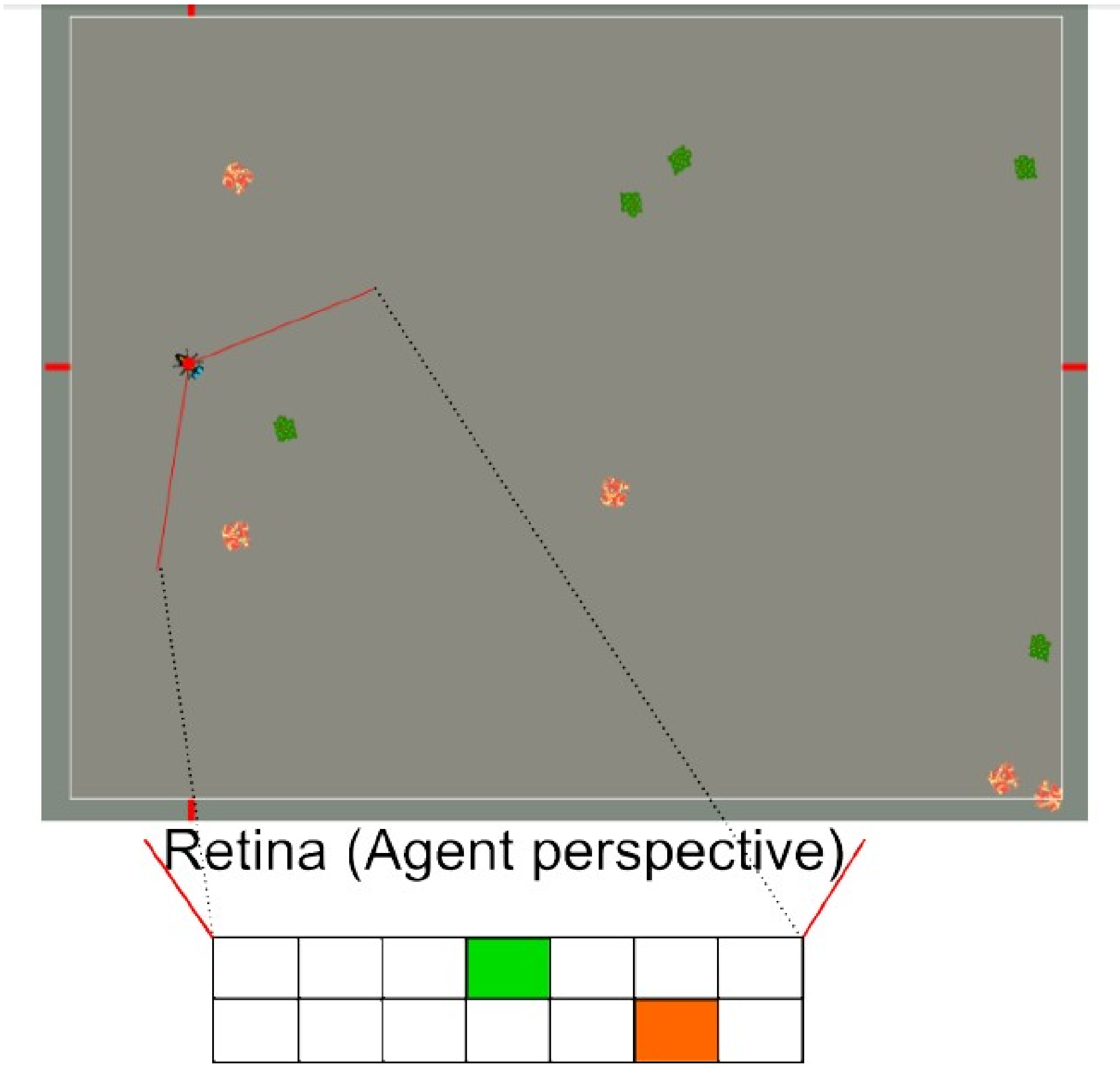
Input as events of the form:

$\{pixel_i\} \rightarrow$ [on] %degree%

Operations:

$(*,\{SELF\}) \rightarrow$ ^left

Microworld



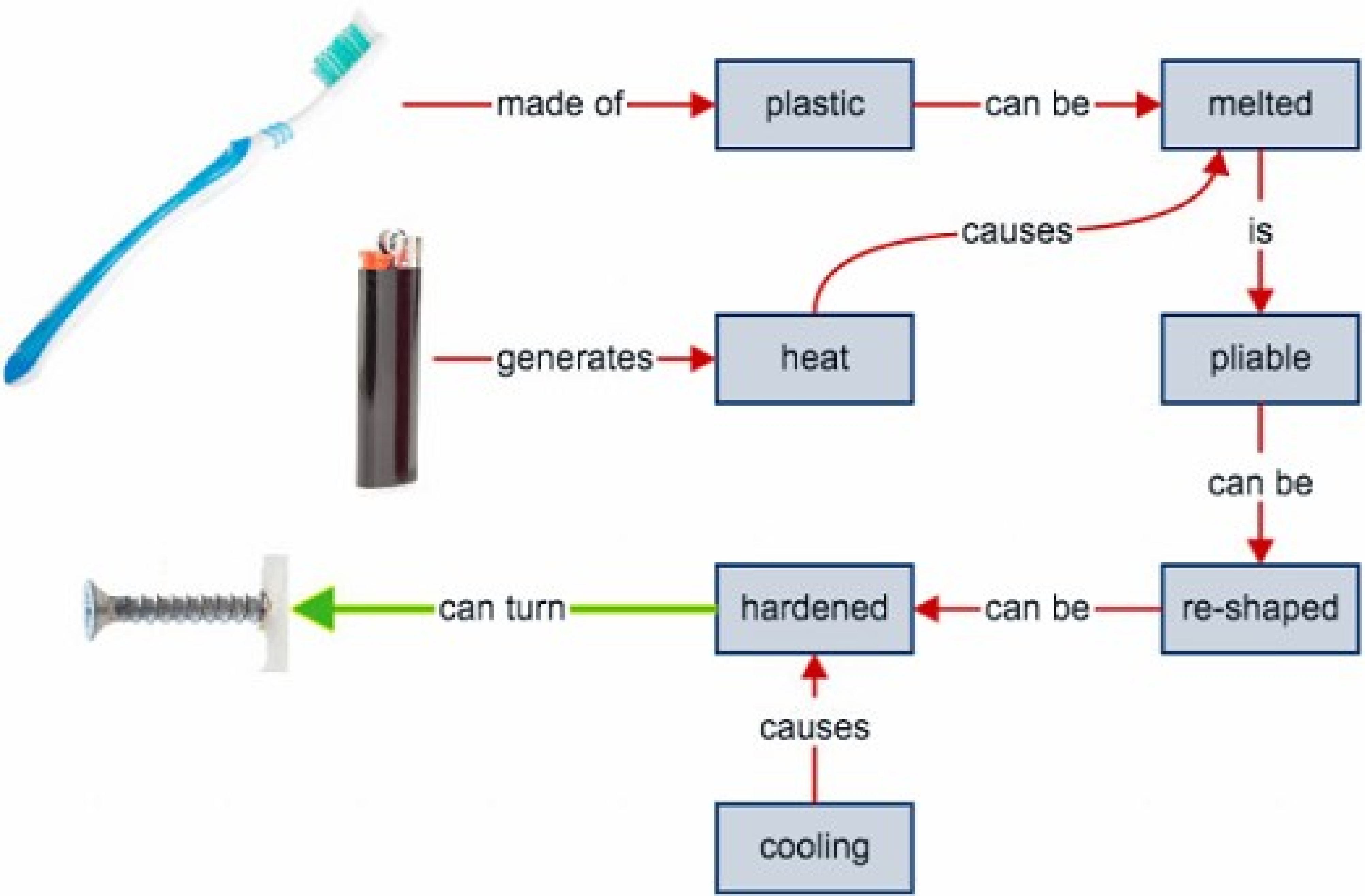
Stick „jump&run“

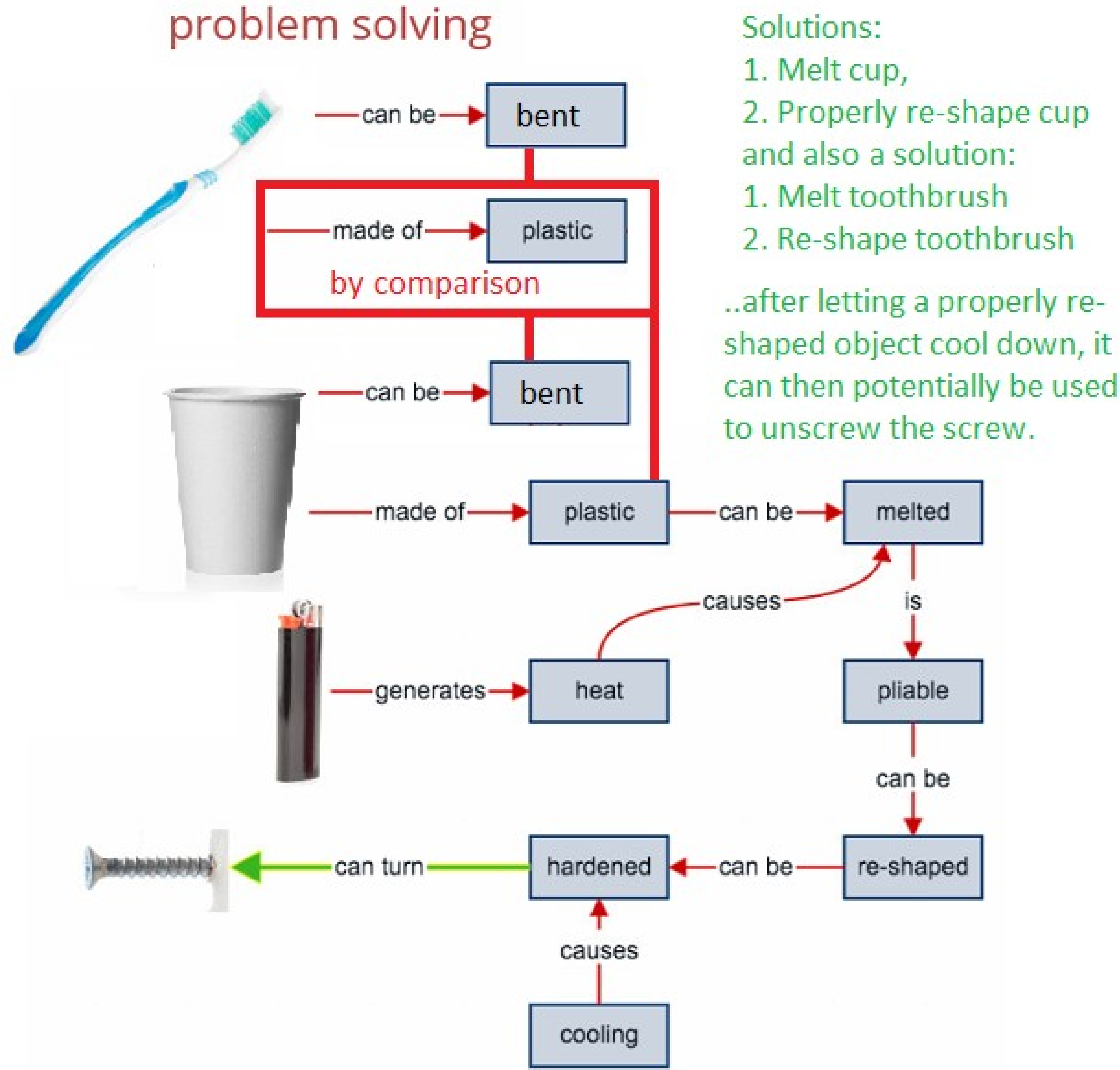
Goal: Move to the right side
Issue: Obstacles are in the way
Solution: Jump over it

Improvisation through analogy

- „Toothbrush" decision making example

problem solving




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.
can be
bent
made of
plastic
by comparison
can be
bent
made of
plastic
can be
melted
causes
is
generates
heat
pliable
can be
can turn
hardened
can be
re-shaped
causes
cooling

Thank you!