Rational OpenCog Controlled Agent

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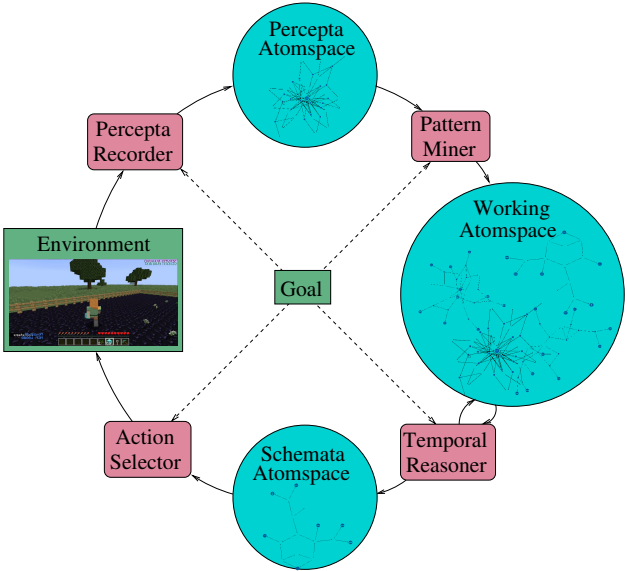
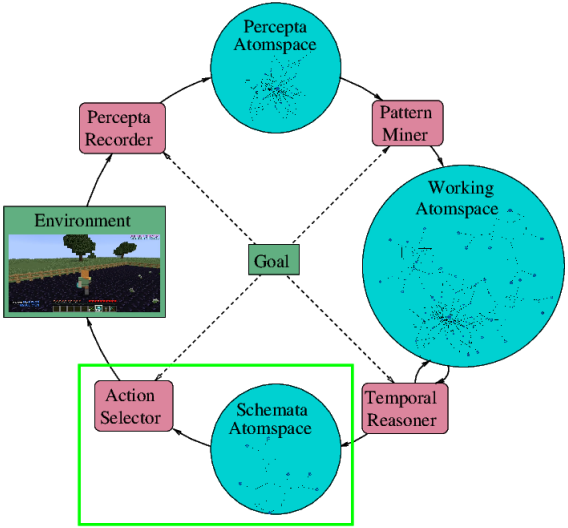
Artificial General Intelligence 2023 (AGI-23)

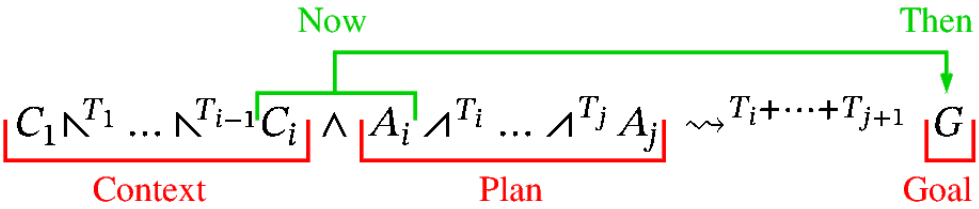

Percepta
Atomspace
Pattern
Miner
Working
Atomspace
Temporal
Reasoner
Schemata
Atomspace
Action
Selector
Environment
Goal
Percepta
Recorder

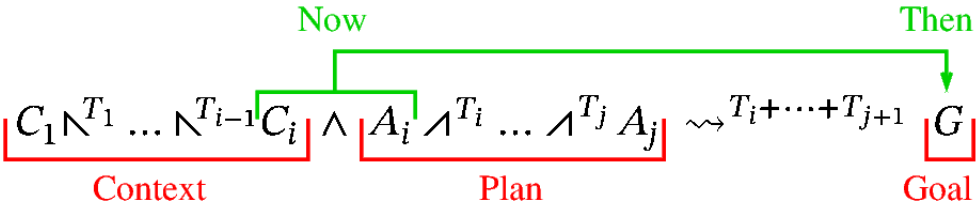


Cognitive Schematic

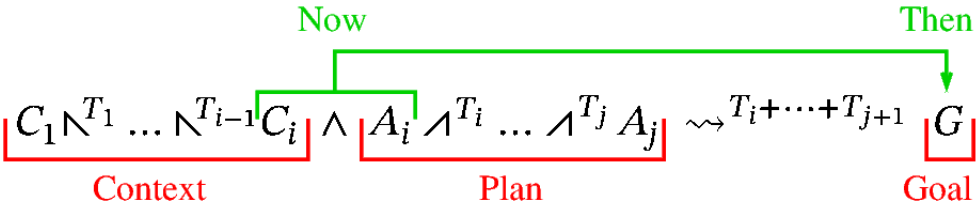
- Context $\wedge$ Action $\rightsquigarrow^{T}$ Goal

$$C_1 \barwedge^{T_1} \ldots \barwedge^{T_{i-1}} C_i \;\wedge\; A_i \barwedge^{T_i} \ldots \barwedge^{T_j} A_j \;\rightsquigarrow^{T_i + \cdots + T_{j+1}}\; G$$

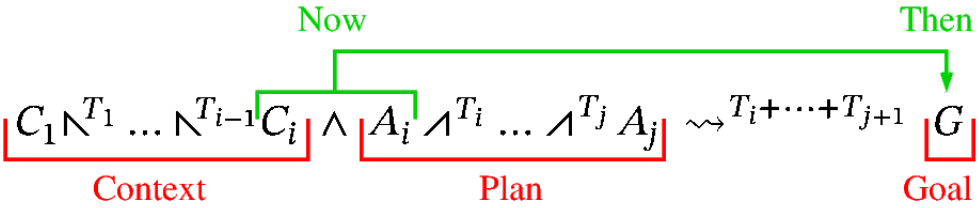

Now
Then
$C_1 \wedge^{T_1} \ldots \wedge^{T_{i-1}} C_i \wedge A_i \nearrow^{T_i} \ldots \nearrow^{T_j} A_j \rightsquigarrow^{T_i+\cdots+T_{j+1}} G$
Context
Plan
Goal



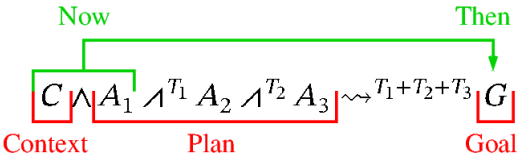
$$\left[C_1 \wedge^{T_1} \ldots \wedge^{T_{i-1}} C_i\right](t) \quad = \quad \textit{True} \mid \textit{False}$$



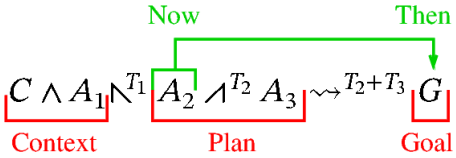
$$\left[C_1 \wedge^{T_1} \ldots \wedge^{T_{i-1}} C_i\right](t) \quad = \quad \textit{True} \mid \textit{False}$$
$$\mapsto \quad \mathcal{D}ist(Bool)$$



$$\begin{aligned} \left[C_1 \wedge^{T_1} \ldots \wedge^{T_{i-1}} C_i\right](t) &= \mathit{True} \mid \mathit{False} \\ &\mapsto \mathcal{D}ist(Bool) \\ &\mapsto \mathcal{D}ist(\mathcal{D}ist(Bool)) \end{aligned}$$


Now
Then
$C \wedge A_1 \curlywedge^{T_1} A_2 \curlywedge^{T_2} A_3 \rightsquigarrow^{T_1+T_2+T_3} G$
Context
Plan
Goal

$$C \wedge A_1 \nearrow^{T_1} A_2 \nearrow^{T_2} A_3 \rightsquigarrow^{T_1+T_2+T_3} G$$



$$C \wedge A_1 \nearrow^{T_1} A_2 \nearrow^{T_2} A_3 \rightsquigarrow^{T_1+T_2+T_3} G$$

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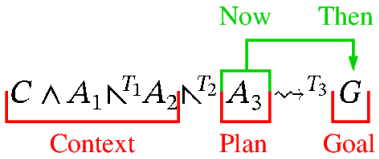

Example: Collect Diamonds

Actions

- get(key)
- go(house)
- collect(diamond)

Percepts

- outside(house)
- inside(house)
- hold(key)
- next(door)
- reward(1)
- reward(0)

Example: Collect Diamonds

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$\text{outside(house)} \wedge \text{get(key)} \nearrow^1 \text{go(house)} \nearrow^1 \text{collect(diamond)} \rightsquigarrow^3 \text{reward(1)}$

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$\text{hold(key)} \wedge \text{go(house)} \nearrow^1 \text{collect(diamond)} \rightsquigarrow^2 \text{reward(1)}$

Example: Collect Diamonds

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$\text{hold(key)} \wedge \text{go(house)} \nearrow^1 \text{collect(diamond)} \rightsquigarrow^2 \text{reward(1)}$

$\text{inside(house)} \wedge \text{collect(diamond)} \rightsquigarrow^1 \text{reward(1)}$

Example: Collect Diamonds

$\text{outside(house)} \wedge \text{get(key)} \nearrow^1 \text{go(house)} \nearrow^1 \text{collect(diamond)} \rightsquigarrow^3 \text{reward(1)}$

$\text{hold(key)} \wedge \text{go(house)} \nearrow^1 \text{collect(diamond)} \rightsquigarrow^2 \text{reward(1)}$

$\text{inside(house)} \wedge \text{collect(diamond)} \rightsquigarrow^1 \text{reward(1)}$

The Paradox of Choice

Many applicable schemata

$$\begin{aligned} C_1 \wedge A_1 &\rightsquigarrow^{T_1} G &&\stackrel{\text{m}}{=} && TV_1 \\ &\vdots \\ C_{9999} \wedge A_{9999} &\rightsquigarrow^{T_{9999}} G &&\stackrel{\text{m}}{=} && TV_{9999} \end{aligned}$$

The Paradox of Choice

Many applicable schemata

$$\begin{aligned} C_1 \wedge A_1 &\rightsquigarrow^{T_1} G &&\stackrel{\text{m}}{=} && TV_1 \\ &\vdots \\ C_{9999} \wedge A_{9999} &\rightsquigarrow^{T_{9999}} G &&\stackrel{\text{m}}{=} && TV_{9999} \end{aligned}$$

Some contradicting each other

$$\begin{aligned} C_1 \wedge A &\rightsquigarrow^{T_1} G &&\stackrel{\text{m}}{=} && <0.9\ 0.5> \\ C_2 \wedge A &\rightsquigarrow^{T_1} G &&\stackrel{\text{m}}{=} && <0.1\ 0.5> \end{aligned}$$

The Paradox of Choice

Many applicable schemata

$$\begin{aligned} C_1 \wedge A_1 &\rightsquigarrow^{T_1} G &&\stackrel{\text{m}}{=} TV_1 \\ &\vdots \\ C_{9999} \wedge A_{9999} &\rightsquigarrow^{T_{9999}} G &&\stackrel{\text{m}}{=} TV_{9999} \end{aligned}$$

Some contradicting each other

$$\begin{aligned} C_1 \wedge A &\rightsquigarrow^{T_1} G \stackrel{\text{m}}{=} <0.9\ 0.5> \\ C_2 \wedge A &\rightsquigarrow^{T_1} G \stackrel{\text{m}}{=} <0.1\ 0.5> \end{aligned}$$

With different risk/reward profiles

$$\begin{aligned} C_1 \wedge A_1 &\rightsquigarrow^{T_1} G \stackrel{\text{m}}{=} <0.9\ 0.1> \\ C_2 \wedge A_2 &\rightsquigarrow^{T_2} G \stackrel{\text{m}}{=} <0.6\ 0.9> \end{aligned}$$

Balancing exploitation and exploration

Solomonoff-ish Induction

+

Thompson Sampling

Balancing exploitation and exploration

Solomonoff-ish Induction ↘

\+

Thompson Sampling ↙

Second Order Mixture

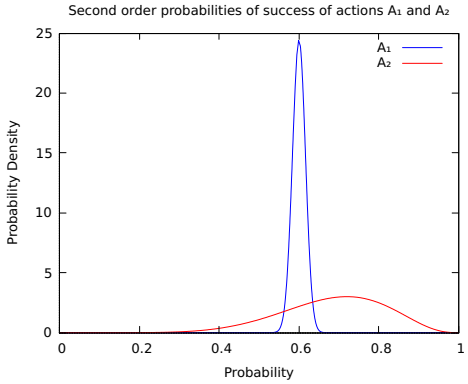
Balancing exploitation and exploration

Solomonoff-ish Induction ↘

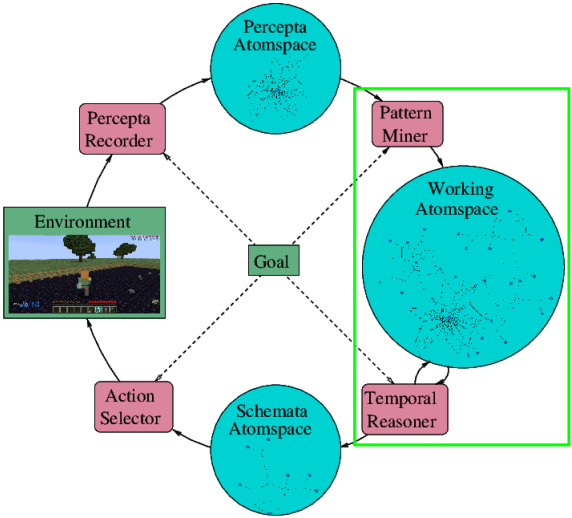
\+

Thompson Sampling ↙

Second Order Mixture



Learning Schemata



Pattern Mining
+
Temporal Reasoning

Pattern Mining Schemata

Time	*Event*
⋮	⋮
10	*reward(0)*
10	*outside(house)*
10	*hold(key)*
10	*go(house)*
11	*inside(house)*
11	*go(diamond)*
11	*reward(0)*
12	*reward(1)*
⋮	⋮

$$\begin{array}{c} \vdots \\ \vdots \\ \vdots \\ hold(key) \wedge go(house) \rightsquigarrow^{1} inside(house) \stackrel{m}{=} <0.833, 0.007> \\ \vdots \\ \vdots \\ \vdots \end{array}$$

Reasoning Schemata

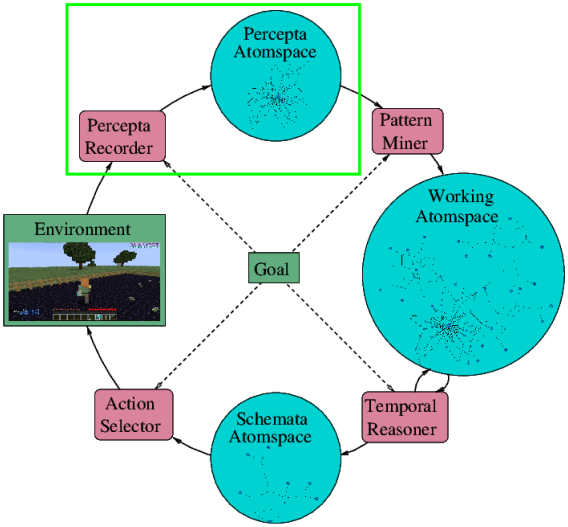
$$\dfrac{\dfrac{\textit{outside(house)} \wedge \textit{go(key)} \rightsquigarrow^1 \textit{outside(house)} \qquad \textit{outside(house)} \wedge \textit{go(key)} \rightsquigarrow^1 \textit{hold(key)}}{\textit{outside(house)} \wedge \textit{go(key)} \rightsquigarrow^1 \textit{outside(house)} \wedge \textit{hold(key)}}\,(\text{CC}) \qquad \textit{outside(house)} \wedge \textit{hold(key)} \wedge \textit{go(house)} \rightsquigarrow^1 \textit{inside(house)}}{\textit{outside(house)} \wedge \textit{go(key)} \nearrow^1 \textit{go(house)} \rightsquigarrow^2 \textit{inside(house)}}\,(\text{PD})$$

Reasoning Schemata

$$\dfrac{\dfrac{\dfrac{outside(house) \wedge go(key) \rightsquigarrow^1 outside(house) \quad outside(house) \wedge go(key) \rightsquigarrow^1 hold(key)}{outside(house) \wedge go(key) \rightsquigarrow^1 outside(house) \wedge hold(key)}\,(\text{CC}) \quad outside(house) \wedge hold(key) \wedge go(house) \rightsquigarrow^1 inside(house)}{outside(house) \wedge go(key) \nearrow^1 go(house) \rightsquigarrow^2 inside(house)}\,(\text{PD})$$

$$\vdots$$

$$outside(house) \wedge go(key) \nearrow^1 go(house) \nearrow^1 go(diamond) \rightsquigarrow^3 reward(1) \triangleq <0.833, 0.005>$$



Timestamped Recorded Events:

Time	*Event*	*Evaluation*
⋮	⋮	⋮
10	*reward(0)*	*reward(0)(10) = True*
10	*outside(house)*	*outside(house)(10) = True*
10	*hold(key)*	*hold(key)(10) = True*
10	*go(house)*	*go(house)(10) = True*
11	*inside(house)*	*inside(house)(11) = True*
11	*go(diamond)*	*go(diamond)(11) = True*
11	*reward(0)*	*reward(0)(11) = True*
12	*reward(1)*	*reward(1)(12) = True*
⋮	⋮	⋮

Future Work

- Attention Allocation
- Concept creation and schematization
- Plan in the inner world