Uncertain Spatiotemporal Logic for AGI

PLN and the OpenCog Framework

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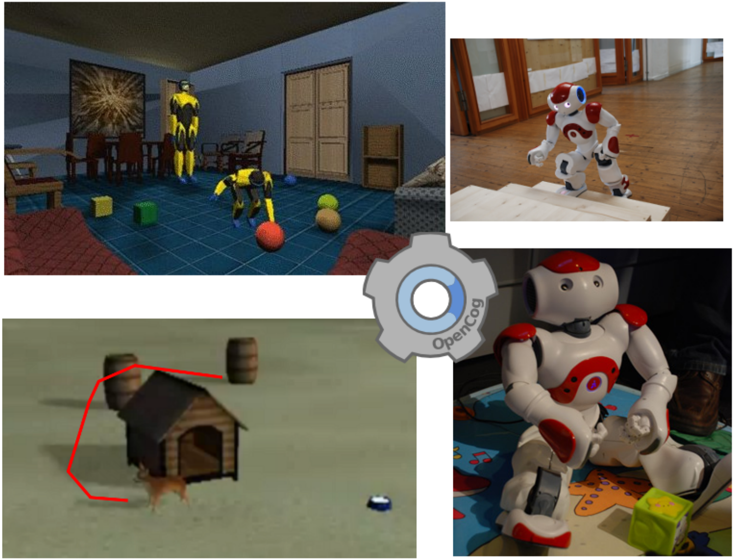
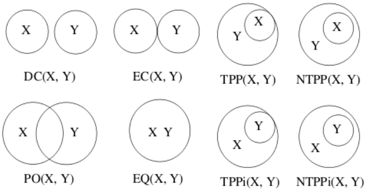
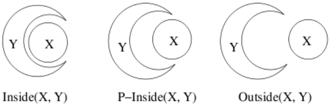
AGI-10

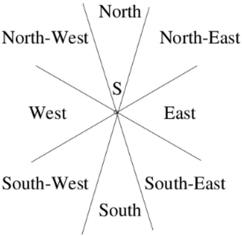
Motivation: Spatiotemporal reasoning within OpenCog

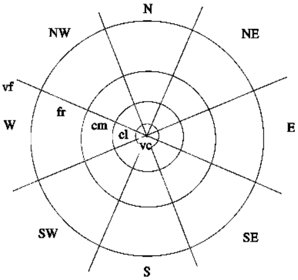


Existing Spatiotemporal Calculi: Space

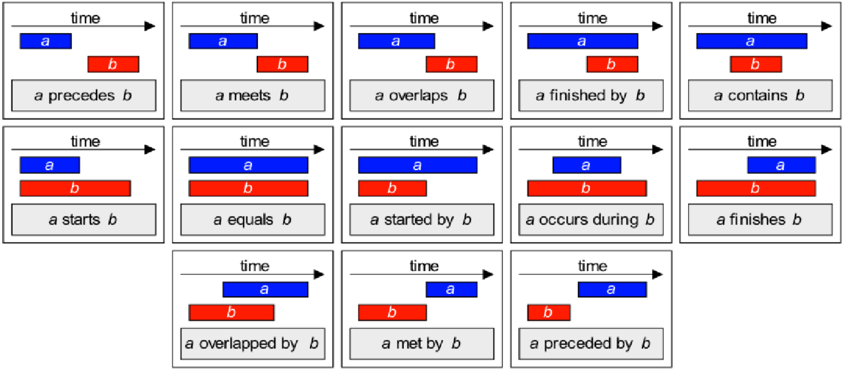




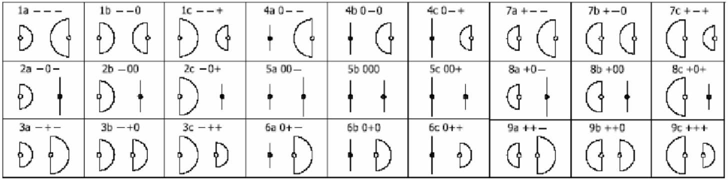


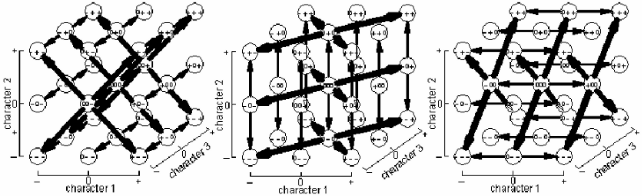


Existing Spatiotemporal Calculi: Time

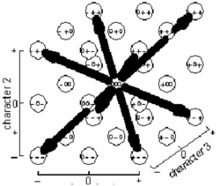


Existing Spatiotemporal Calculi: Motion



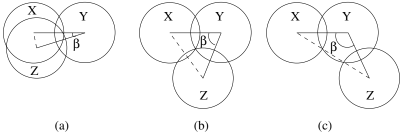


(a)



Uncertainty in Spatiotemporal Calculi

- There exist fuzzy extensions, but too much uncertainties



= Total uncertainty [0,1]

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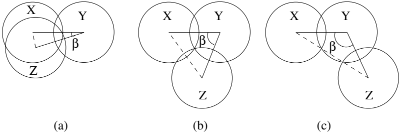
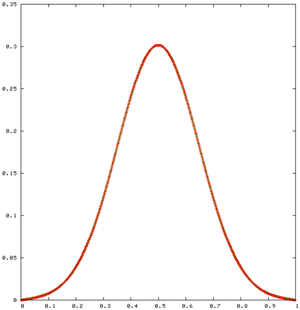


= Total uncertainty [0,1]

- However with fuzzy-probabilistic extension (similar to YKY's PZ-logic but with PLN TruthValue)



The math... in 10s

$$\mu_F = \underbrace{\int_0^1 \ldots \int_0^1}_{n} F(x_1, \ldots, x_n)\mu_1(x_1)\ldots\mu_n(x_n)dx_1 \ldots dx_n$$

Example of PLN rule for `PartOf` transitivity

$$\boxed{\begin{array}{l}
\texttt{ForAllLink}\ \$\texttt{X}\ \$\texttt{Y}\ \$\texttt{Z} \\
\quad \texttt{ImplicationLink_HOF} \\
\quad\quad \texttt{ANDLink} \\
\quad\quad\quad \texttt{PartOf}(\$\texttt{X}, \$\texttt{Y})\ \langle \texttt{tv}_1 \rangle \\
\quad\quad\quad \texttt{PartOf}(\$\texttt{Y}, \$\texttt{Z})\ \langle \texttt{tv}_2 \rangle \\
\quad\quad \texttt{ANDLink} \\
\quad\quad\quad \texttt{tv}_3 = \mu_F(\texttt{tv}_1, \texttt{tv}_2) \\
\quad\quad\quad \texttt{PartOf}(\$\texttt{X}, \$\texttt{Z})\ \langle \texttt{tv}_3 \rangle
\end{array}}$$

Example: fetching the toy inside the upper cupboard

Axioms

1. The toy is near the bag and inside the cupboard. The pillow is near and below the cupboard

$$\texttt{Near}(\texttt{toy},\texttt{bag})\ \langle\texttt{tv}_1\rangle$$
$$\texttt{Inside}(\texttt{toy},\texttt{cupboard})\ \langle\texttt{tv}_2\rangle$$
$$\texttt{Below}(\texttt{pillow},\texttt{cupboard})\ \langle\texttt{tv}_3\rangle$$
$$\texttt{Near}(\texttt{pillow},\texttt{cupboard})\ \langle\texttt{tv}_4\rangle$$

2. The toy is near the bad inside the cupboard, how much the toy is near the edge of the cupboard?

```
ImplicationLink_HOF
    ANDLink
        Near(toy, bag) ⟨tv_1⟩
        Inside(toy, cupboard) ⟨tv_2⟩
    ANDLink
        tv_3 = μ_F1(tv_1, tv_2)
        Near(toy, cupboard_edge) ⟨tv_3⟩
```

3. If I climb on the pillow, then shortly after I'll be on the pillow

```
PredictiveImplicationLink
    Climb_on(pillow)
    Over(self, pillow)
```

4. If I am on the pillow near the edge of the cupboard how near am I from the toy?

```
ImplicationLink_HOF
    ANDLink
        Below(pillow, cupboard) ⟨tv_1⟩
        Near(pillow, cupboard) ⟨tv_2⟩
        Over(self, pillow) ⟨tv_3⟩
        Near(toy, cupboard_edge) ⟨tv_4⟩
    ANDLink
        tv_5 = μ_F2(tv_1, tv_2, tv_3, tv_4)
        Near(self, toy) ⟨tv_5⟩
```

Example: fetching the toy inside the upper cupboard

Target Theorem

How near I am from the toy if I climb on the pillow

```
PredictiveImplicationLink
    Climb_on(pillow)
    Near(self, toy) ⟨?⟩
```

Inference

1. Axiom 2 with axiom 1

   $\texttt{Near(toy, cupboard\_edge)}\ \langle tv_6 \rangle$

2. Step 1 with axiom 1 and 3

   ```
   PredictiveImplicationLink
       Climb_on(pillow)
       ANDLink
           Below(pillow, cupboard) ⟨tv3⟩
           Near(pillow, cupboard) ⟨tv4⟩
           Over(self, pillow) ⟨tv7⟩
           Near(toy, cupboard_edge) ⟨tv6⟩
   ```

3. Step 2 with axiom 4, target theorem: How near I am from the toy if I climb on the pillow

   ```
   PredictiveImplicationLink
       Climb_on(pillow)
       Near(self, toy) ⟨tv9⟩
   ```

Conclusion

- Fuzzy-probabilistic seems more accurate
- No need to be overkill either, adjustable precision
- Perfectly adequate for OpenCog's reasoning engine PLN
  - Uncertain Reasoning
  - Learning or improving rules

Still need to implement and experiment...