Temporal Reasoning with OpenCog

Nil Geisweiller

SingularityNET & OpenCog Foundations

Why Temporal Reasoning?

1. Lag between cause and effect
2. Meta-reasoning: Think about think about think about think about ...

PLN Recall

P, Q, ...: $Atom^n \to \{True, False\}$

```
And <TV>
  P                    ≡         𝒫(P, Q) ≈ TV.strength
  Q
```

$$\text{And <TV>}\begin{array}{l} P \\ Q \end{array} \equiv \mathcal{P}(P, Q) \approx TV.strength$$

```
Not <TV>
  P                    ≡         𝒫(P) ≈ 1−TV.strength
```

$$\text{Not <TV>}\ P \equiv \mathcal{P}(P) \approx 1 - TV.strength$$

```
Implication <TV>
  P                    ≡         𝒫(Q|P) ≈ TV.strength
  Q
```

$$\text{Implication <TV>}\begin{array}{l} P \\ Q \end{array} \equiv \mathcal{P}(Q|P) \approx TV.strength$$

PLN rules: Implication Direct Evaluation

```
Evaluation
   P
   Ei
...
Evaluation
   Q
   Ei
|-
Implication <TV>
   P
   Q
```

$$TV.strength = \frac{\sum_x f_\wedge(P(x).strength, Q(x).strength)}{\sum_x P(x).strength}$$

PLN rules: Deduction

```
Implication
  P
  Q
Implication
  Q
  R
|-
Implication <TV>
  P
  R
```

$$TV.strength = \mathcal{P}(R|Q,P) \times \mathcal{P}(Q|P) + \mathcal{P}(R|\neg Q,P) \times \mathcal{P}(\neg Q|P)$$

Temporal Predicate

$$P : Atom^n \times T \to \{True, False\}$$

$$P : \_\,^-\_\,^-\_$$

$$Q : \sqcup \sqcap \sqcap \sqcup \sqcup\sqcup$$

SequentialAnd

```
BackSequentialAnd <TV>                    And <TV>
   L                                         Lag
   P                              ≡             L
   Q                                           P
                                             Q


ForeSequentialAnd <TV>                    And <TV>
   L                                         P
   P                              ≡         Lead
   Q                                           L
                                             Q
```

PredictiveImplication

```
BackPredictiveImplication <TV>              Implication <TV>
   L                                           Lag
   P                              ≡               L
   Q                                             P
                                              Q


ForePredictiveImplication <TV>              Implication <TV>
   L                                           P
   P                              ≡            Lead
   Q                                             L
                                                 Q
```

PredictiveImplication

```
BackPredictiveImplication <TV>
    L
    P
    Q
```
$\equiv$
```
Implication <TV>
    Lag
        L
        P
    Q
```

```
ForePredictiveImplication <TV>
    L
    P
    Q
```
$\equiv$
```
Implication <TV>
    P
    ForeSequentialAnd
        L
        P
        Q
```