Cohen & Levesque : language

- Language:
  - Operators:
    - HAPPENS □ : action □ happens *next*
    - DONE □ : action □ has *just* happened
    - AGT i a : agent i is the *only* agent of action a
    - BEL i □ : formula □ follows from i's beliefs
    - GOAL i □ : formula □ follows from i's goals
    - a ≤ b : action a is an initial subsequence of b

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Cohen & Levesque : language(2)

- Formulas and actions

□ ::= p (□ Pred) | ¬ □ | □$_1$ □ □$_2$ | ... | □x □ |
HAPPENS □ | DONE □ | AGT i a |
BEL i □ | GOAL i □ | a ≤ b

□ ::= a (□ A) | □? | □$_1$; □$_2$ | □$_1$ + □$_2$ | □$^□$

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Cohen & Levesque: models

- Semantics
  - Model: <□, P, E, Agt, T, B, G, □>, where
    - □ is a set (universe of discourse)
    - P is a set of agents
    - E is a set of primitive event types
    - Agt □ [E□ P] specifies the agent of an event
    - T□[Z□ E]: a set of possible worlds (event seqs)
    - B □ T□P□Z□T is the belief accessibility relation
    - G □ T□P□Z□T is the goal accessibility relation
    - □ interprets predicate symbols

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Cohen & Levesque: satisfaction

- Satisfaction: [v(a) □ E*]
  - M, □, v, n ⊨ AGT i a □ Agt[v(a)] = {v(i)}
  - M, □, v, n ⊨ HAPPENS □ □ exists m≥n such that M, □, v, n [[□]] m
  - M, □, v, n ⊨ DONE □ □ exists m≤n such that M, □, v, m [[□]] n
  - M, □, v, n ⊨ BEL i □ □ for all □* with <□,n>B[v(i)]□*: M, □*, v, n ⊨ □
  - M, □, v, n ⊨ GOAL i □ □ for all □* with <□,n>G[v(i)]□*: M, □*, v, n ⊨ □

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Cohen & Levesque: models(2)

- Constraints on the model:
  - *Consistency*: relation B is euclidean, transitive and serial; relation G is serial
  - *Realism*: G □ B: worlds consistent with what the agent has chosen are not ruled out by his beliefs
- Agt: E* □ 2^P defined by:

  Agt[$e_1 \ldots e_n$] = {Agt(e_i) | 1≤i≤n}

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Cohen & Levesque: BEL/GOAL

- Validities:
  - ⊨(BEL i □ □ BEL i (□ □ □)) □ BEL i □
  - ⊨ BEL i □ □ BEL i (BEL i □))
  - ⊨ ¬BEL i □ □ BEL i ¬(BEL i □))
  - ⊨ BEL i □ □ ¬BEL i ¬ □
  - ⊨(GOAL i □ □ GOAL i (□ □ □)) □ GOAL i □
  - ⊨ GOAL i □ □ ¬GOAL i ¬ □
- Necessitation:
  - If ⊨□ then ⊨ BEL i □ and ⊨ GOAL i □

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Cohen & Levesque: A-GOALS

- Achievement goals

A-GOAL i □ = GOAL i (LATER □) □
BEL i ¬ □

[LATER □ = ¬□ □ □□]
[□□ = □a (HAPPENS a; □?)]

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No persistence/deferral forever

- Assumption:

⊨ □¬(GOAL i (LATER □))

Agents eventually drop all achievement goals!

[LATER □ = ¬□ □ □□]
[□□ = □a (HAPPENS a; □?)]

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Cohen & Levesque

- Realism

⊨ BEL i □ □ GOAL i □

- Expected consequences

⊨ GOAL i □ □ BEL i (□ □ □) □
GOAL i □

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Cohen & Levesque : P-GOALS

- Persistent goals

P-GOAL i □ =
GOAL i (LATER □) □
BEL i ¬□ □
[BEFORE(BEL i □ BEL i ¬□)
¬GOAL i (LATER □)]

[BEFORE □ □ =
□c(HAPPENS c;□ ?) □ □a (a≤c) □ HAPPENS a;□?]

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Cohen & Levesque: logic of P-GOALS

- ⊨ P-GOAL i ¬ □ □ ¬P-GOAL i □
- *⊨ P-GOAL i □ □ □(BEL i □ BEL i ¬□)
- *⊨ [P-GOAL j □ □ COMPETENT j □ □
  ¬BEFORE(BEL j ¬ □)¬GOAL j (LATER □)]
  □ □□

[COMPETENT i □ = BEL i □ □ KNOW i □]
[KNOW i □ = □ □ BEL i □]
*: using the no deferral assumption!

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Cohen & Levesque: INTEND$_1$

- INTEND$_1$ i □ =
  P-GOAL i [DONE i
  (BEL i (HAPPENS □))?; □]

NB Wrong definition:
- INTEND$_1$ i □ = P-GOAL i □b (HAPPENS i b; (DONE i □)?)

[HAPPENS i a = HAPPENS a □ AGT i a]
[DONE i a = DONE a □ AGT i a]

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Cohen & Levesque: $INTEND_1$

- $INTEND_1$ i □ =
  P-GOAL i [DONE i
  (BEL i (HAPPENS □))?; □]

NB Wrong definition:

- $INTEND_1$ i □ = P-GOAL i □b (HAPPENS i b; (DONE i □)?)

[HAPPENS i a = HAPPENS a □ AGT i a]
[DONE i a = DONE a □ AGT i a]

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Cohen & Levesque: $INTEND_2$

- $INTEND_2$ i □ =
  P-GOAL i □a (DONE i
  [BEL i □b HAPPENS i b; □?) □
  ¬GOAL i ¬HAPPENS i a; □?]?; a; □?)

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Cohen & Levesque: $INTEND_2$

- $INTEND_2$ i □ =
  P-GOAL i □a (DONE i
  [BEL i □b HAPPENS i b; □?) □
  ¬GOAL i ¬HAPPENS i a; □?]?; a; □?)

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Cohen & Levesque: Bratman revisited

- Screen of admissibility
  ⊨ $INTEND_1$ i □ □ (BEL i [DONE i □
  □ ¬DONE i □]) □ ¬$INTEND_1$ i □;□
- 'Tracking' success
  ⊨ (DONE i [$INTEND_1$ i □ □
  BEL i (HAPPENS i □)]?; □) □
  BEL i (¬DONE i □) □
  ¬BEL i (¬DONE i □) □
  $INTEND_1$ i □

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Cohen & Levesque

- Dropping futile intentions
  ⊨ j≠i □ BEL i □□a(DONE j ¬□?;a;□?)
  □
  ¬$INTEND_2$ i □
  ¬BEL i [□a(DONE j ¬□?;a;□?) □
  ¬ □a(DONE i ¬□?;a;□?]

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