Incorporating Planning and Reasoning into a Self-Motivated, Communicative Agent

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Outline

1. Motivation and Proposal
2. Architecture
3. Results
4. Conclusion
Planning, Reasoning, and Self-Motivation

How do we integrate them?

Planning and Reasoning

“fulfillment of user goals”

Self-Motivation

“Utility-optimizing mappings”
Our Proposal: Motivated Explorer (ME)

- Should I drink the juice or walk to Grove?

- Knowledge-based reasoning about actions and future states

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ME: A Self-Motivated, Communicative Agent
Our Proposal: Motivated Explorer (ME)

Should I drink the juice or walk to Grove?

- Knowledge-based reasoning about actions and future states
- Motivated by consideration of the long-range utility of choices
Explicit self-knowledge:

- amenable to self-observation and use
Explicit self-knowledge:

- amenable to self-observation and use
- conveyable by the agent
Explicit self-knowledge:

- amenable to self-observation and use
- conveyable by the agent
- open to inferences with world knowledge
ME’s Explicit Self-Awareness

KB

- a5 is a book.
- I own a5.
- Guru likes a5.
- a5 is readable.

- Facts about itself, the current situation, and the world
- General knowledge in the form of Horn-like clauses
- Introspective:
  - Applicable operators and achievable goals
ME’s Explicit Self-Awareness

- Facts about itself, the current situation, and the world
- General knowledge in the form of Horn-like clauses
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  - Applicable operators and achievable goals
  - Propositional attitudes

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ME: A Self-Motivated, Communicative Agent
ME’s Explicit Self-Awareness

- Facts about itself, the current situation, and the world
- General knowledge in the form of Horn-like clauses
- Introspective:
  - Applicable operators and achievable goals
  - Propositional attitudes
  - Actions and exogenous events so far

KB:
- a5 is a book.
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Driven by “desire” to maximize total utility, using own metrics of rewards and penalties
ME’s Thoughtful Self-Motivation

- Driven by “desire” to maximize total utility, using own metrics of rewards and penalties
- Grounded in reasoned lookahead and evaluation
1. Search forward from a given state.
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2. Propagate back expected rewards and costs of applicable actions and resulting states.
1. Search forward from a given state.
2. Propagate back expected rewards and costs of applicable actions and resulting states.
3. Execute the first action of the seemingly best plan.
Architecture: ME’s Lookahead in Planning and Execution

1. Search forward from a given state.
2. Propagate back expected rewards and costs of applicable actions and resulting states.
3. Execute the first action of the seemingly best plan.
4. Update knowledge.

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ME: A Self-Motivated, Communicative Agent
ME’s incomplete knowledge of the world
ME’s incomplete knowledge of the world

Exogenous events (rain and fire)
Example: A fire may start and disrupt ME’s travel.
ME’s incomplete knowledge of the world

Exogenous events (rain and fire)
Example: A fire may start and disrupt ME’s travel.

Multi-step actions
ME’s incomplete knowledge of the world

Exogenous events (rain and fire)
Example: A fire may start and disrupt ME’s travel.

Multi-step actions

The “actual” version of ME’s chosen action is executed, updating ME’s knowledge and the world.
Example: Model Version of the Sleep Operator

(setq sleep (make-op
:name 'sleep
:pars '(?f ?h)
:preconds '((is_at ME home) (is_tired_to_degree ME ?f)
(>= ?f 0.5) (> ?f ?h) (not (there_is_a_fire))
(is_hungry_to_degree ME ?h))
:effects '((is_tired_to_degree ME 0)
(not (is_tired_to_degree ME ?f))
(is_hungry_to_degree ME (+ ?h 2)))
:time-required '(* 4 ?f)
:value '(* 2 ?f)
))
Example: Actual Version of the Sleep Operator

(setq sleep (make-op
:name 'sleep.actual
:pars '(?f ?h)
:startconds '(((is_at ME home) (is_tired_to_degree ME ?f)
  (> ?f 0.5) (> ?f ?h) (is_hungry_to_degree ME ?h))
:stopconds '(((there_is_a_fire) (is_tired_to_degree ME 0))
:deletes '(((is_tired_to_degree ME ?#1)
  (is_hungry_to_degree ME ?#2))
:adds '(((is_tired_to_degree ME (- ?f (* 0.5 (elapsed_time?))))
    (is_hungry_to_degree ME (+ ?h (* 0.5 elapsed_time?)))))
))

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ME: A Self-Motivated, Communicative Agent
- guru knows whether pizza is edible.
- ME is thirsty and hungry, knows juice is potable and at home.
- Exogenous events: fire and rain
- Operators: walk, sleep, eat, drink, ask other agents whether something is true, answer the user’s yes/no and wh- questions
Results of Goal-Directed Behavior

Ablation of Opportunistic Behavior

- ME’s sole goal: eating pizza
- Actions: asking guru to acquire food knowledge, traveling to reach guru and pizza, and eating pizza
- Total utility of 66.5, after 18 steps

Output:

(RAIN 0), ((WALK HOME GROVE PATH1) 0),
((WALK HOME GROVE PATH1) 1), (FIRE 2),
((ASK+WHETHER GURU (EDIBLE PIZZA) GROVE)
3), (RAIN 5), ((WALK GROVE HOME PATH1) 5),
(FIRE 8), (RAIN 9), ((WALK GROVE HOME PATH1) 9),
((WALK HOME PLAZA PATH2) 12),
((WALK HOME PLAZA PATH2) 14), (FIRE 15),
((EAT PIZZA PLAZA) 17).
Results of Opportunistic Behavior

Opportunistic Behavior

- Total utility of 80.5, after 18 steps
- Direct result of seizing initial opportunity to drink *juice*

Output:

(RAIN 0), ((DRINK 4 JUICE HOME) 0), (FIRE 2),
(RAIN 5), ((WALK HOME GROVE PATH1) 5),
((WALK HOME GROVE PATH1) 0) 6), (FIRE 7),
((ASK+WHETHER GURU (EDIBLE PIZZA) GROVE) 8), (RAIN 9), ((WALK GROVE HOME PATH1) 10),
(RAIN 11), ((WALK GROVE HOME PATH1) 11),
(RAIN 13), ((WALK HOME PLAZA PATH2) 13),
((WALK HOME PLAZA PATH2) 15), (RAIN 16),
((EAT PIZZA PLAZA) 17).
>> (listen!)
You're welcome to ask ME a question.

(ask-yn user (can_talk guru)) (ask-wh user (is_animate ?y))

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STEP TAKEN: (ANSWER_USER_YNQ (CAN_TALK GURU))

(GURU CAN TALK)
For question (CAN_TALK GURU), according to ME's current knowledge base, ME offers the answer above.

STEP TAKEN: (ANSWER_USER_WHQ (IS_ANIMATE ?Y))

(ME IS ANIMATE)
(GURU IS ANIMATE)
For question (IS_ANIMATE ?Y), other than the above positive instance(s) that ME knows of, ME assumes nothing else as the answer.
 Explicitly self-aware and self-motivated ME
Summary

- Explicitly self-aware and self-motivated ME
- Deliberate self-motivation
Explicitly self-aware and self-motivated ME
Deliberate self-motivation
Integration of behavioral and planning-based agents
Explicitly self-aware and self-motivated *ME*

Deliberate self-motivation

Integration of behavioral and planning-based agents

Towards a conversation agent with knowledge-and suggestion-driven dialogue behavior