

Emotions as Heuristics in Multi-Agent Systems

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Outline

- 1 Problem Statement
- 2 Emotions in Multi-Agent Systems
 - Agent Autonomy
 - Agent Cooperation and Coordination
 - Human-Agent Interaction
- 3 Methodology
 - Example
 - Current and Future Research

Problem Statement

Issues in Multi-Agent Systems

- 1 Nondeterminism in decision making
- 2 Restriction in cooperation protocols
- 3 Believability in human-computer interaction

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Agent Autonomy

- Nondeterminism in decision making
 - ▶ Excessive deliberation
 - ▶ Lack of preference
- Emotions as heuristics

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Agent Cooperation and Coordination

- Achieving global objectives
 - ▶ Restrictive cooperation protocols
 - ▶ Nondeterminism
- Emotions as heuristics
 - ▶ Anticipatory actions

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Human-Agent Interaction

- Hybrid multi-agent systems
 - ▶ Efficacious interfaces
- Emotions as heuristics
 - ▶ Believability

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Example

Formal Specification

$$I(\pi, \kappa) \wedge \mathit{Com}(\pi) \wedge \alpha \preceq \pi \wedge \mathbf{B}([\alpha]\kappa') \rightarrow \\ [\alpha](\mathbf{B}\neg\kappa' \wedge \mathit{Com}(\pi \setminus \alpha) \rightarrow \mathbf{sad}(\pi \setminus \alpha, \kappa))$$

- π is a plan
- κ is a goal (a conjunction of literals)
- κ' is a subgoal of κ (i.e. $\kappa \rightarrow \kappa'$ holds)

Example II

Transition Rule

$$\frac{\langle \sigma, \gamma, \Pi, E \rangle \models \text{PossIntend}(\alpha; \pi', \kappa) \ \& \ (\alpha; \pi', \kappa) \in \Pi \ \& \ \text{PostCond}(\alpha) \models \kappa' \ \& \ \tau(\sigma, \alpha) = \sigma'}{\langle \sigma, \gamma, \Pi, E \rangle \rightarrow \langle \sigma', \gamma, \Pi', E' \rangle}$$

where

$$\Pi' = (\Pi \setminus \{(\alpha; \pi', \kappa)\}) \cup \{(\pi', \kappa)\}$$

$$E' = \begin{cases} E \cup \{\mathbf{sad}(\pi, \kappa)\} & \text{if } \sigma' \neq \kappa' \\ E & \text{otherwise} \end{cases}$$

Example III

Specification of Effect

$$I(\pi, \kappa) \wedge \mathbf{Com}(\pi) \wedge \mathbf{sad}(\pi, \kappa) \rightarrow$$

$$[\mathbf{deliberate}] (\neg I(\pi, \kappa) \vee \neg \mathbf{Com}(\pi) \vee$$

$$\mathbf{Com}(\text{if } \mathbf{Can}(\pi, \kappa) \text{ then } \pi \text{ else } \mathbf{replan}(\pi', \kappa); \pi'))$$

Additional Deliberation Step

if $\mathbf{sad}(\pi, \kappa) \in E$ & $\langle \sigma, \gamma, \Pi, E \rangle \not\equiv \mathbf{Can}(\pi, \kappa)$
 then $\{\mathbf{replan}(\pi', \kappa); \mathbf{execute}(\pi')\}$
 else $\mathbf{execute}(\pi)$

Example III

Specification of Effect

$$I(\pi, \kappa) \wedge Com(\pi) \wedge \mathbf{sad}(\pi, \kappa) \rightarrow$$

$$[deliberate](\neg I(\pi, \kappa) \vee \neg Com(\pi) \vee$$

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Current and Future Research

- 3APL as starting point
- New layered architecture
 - 1 Reactive processes
 - 2 **Deliberation**
 - 3 Reflection / social reasoning
- Secondary emotions in deliberation

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