Evaluation of multi-agent ethical planning tasks

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Multi-agent Planning Task

$$\Pi = (\Theta, T, u) \tag{1}$$

- $\Theta = (\pi_A, \pi_B, ..., \pi_n)$: The planning tasks of individual agents (with variable and initialization restrictions to ensure consistency).
- T: a scheduling function which determines which agent may act at a given timestep.
- u: a vector of moral utility functions (one for each agent).

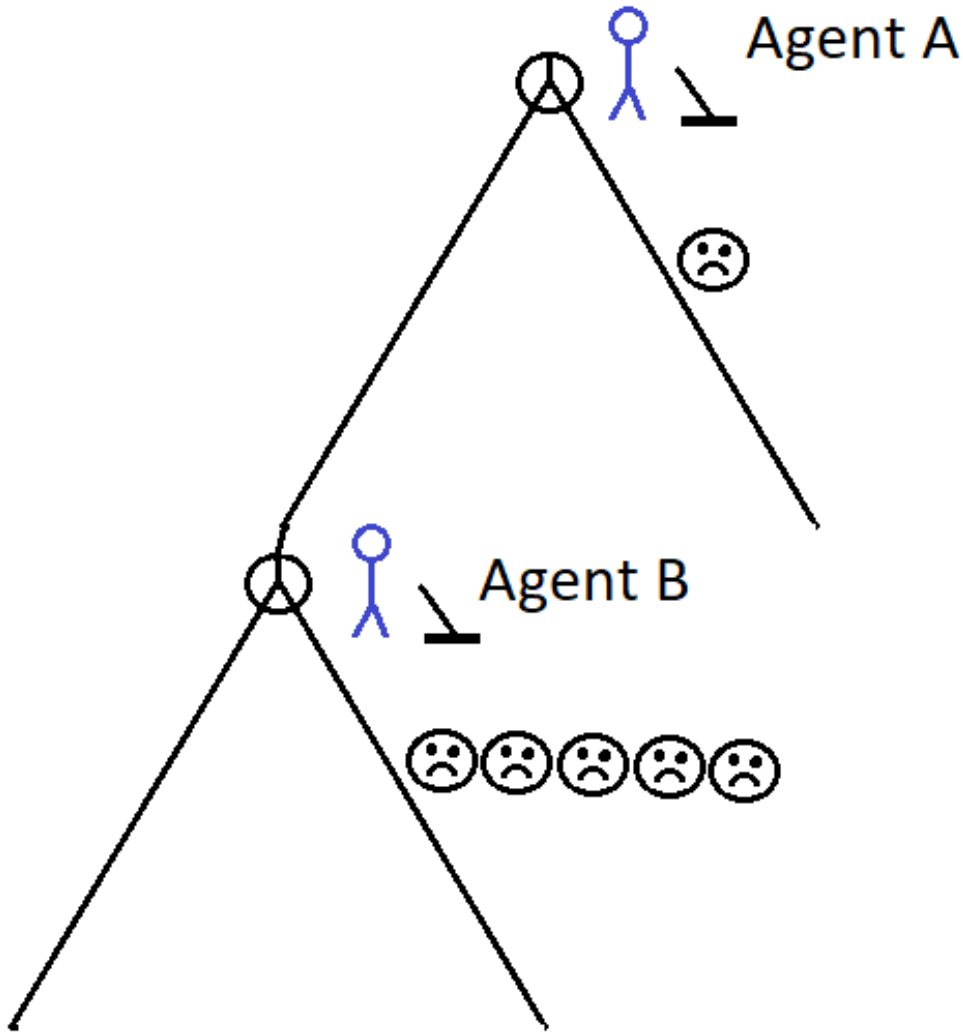
T: Scheduling Turn-Taking

- Turn taking is a simple case of the scheduling function.
- Each agent is able to act only after all agents preceding it have acted.

1. Add n new variables $turn_0 = \bot, ..., turn_n = \bot$.
2. Determine which agent (X) acts first (can be seeded). Set $turn_X = \top$.
3. For all $o_i \in \pi_X$:
   - Append $\wedge turn_X = \top$ to the precondition of o_i.
   - Append $\wedge turn_X = \bot \wedge turn_Y = \top$ to the effect of o_i [1].

[1] Where $turn_Y$ is a seeded successor agent.

Example 1: Double trolley problem



Example 1: Double trolley problem

$$\Pi = (\Theta, T, u,)$$

$$\Theta = (\pi_A, \pi_B)$$

$$\pi_A = (V_A, I_A, O_A, \gamma_A)$$

$$\pi_B = (V_B, I_B, O_B, \gamma_B)$$

$$V_A = V_B = man, men, tram, leverA, leverB$$

$$O_A = \{pullA, advanceA\}$$

$$pullA = (\top, leverA = l \triangleright leverA = r \wedge leverA = r \triangleright leverA = l)$$

$$O_B = \{pullB, advanceB\}$$

$$pullB = (\top, leverB = l \triangleright leverB = r \wedge leverB = r \triangleright leverB = l)$$

$$s_0 = (man = alive \wedge men = alive \wedge tram = start \wedge leverA = r, landleverB =$$

$$\gamma_A = \gamma_B = *$$

Example 1 analysis

What constitutes a morally permissible planning task?

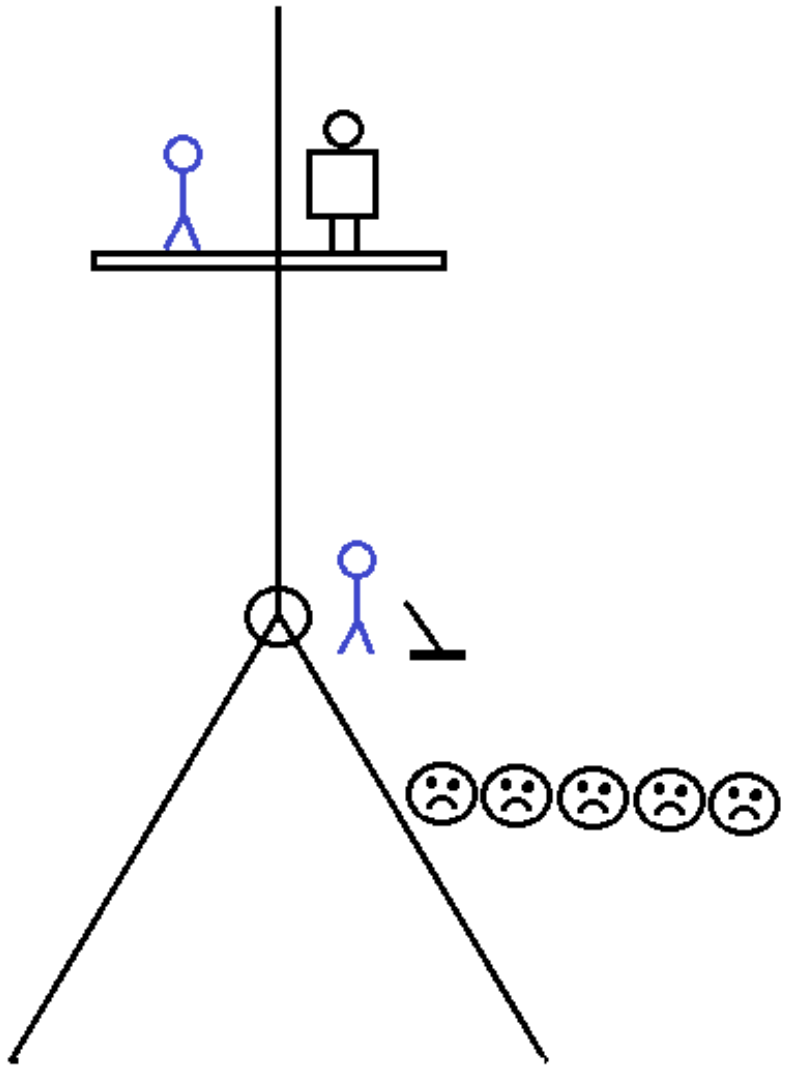
- In single-agent setting: sufficient to show that the action sequence does not lead to or result in the agent performing an action that is morally impermissible.
- In multi-agent setting: potential for more nuanced evaluation on a *per agent* basis.

Definition

A single-agent plan π is morally permissible, according to the deontological principle, iff for all a_i, $u(a_i) \geq 0$

- By this definition, as in the single-agent case, all possible plans are permissable as no action in this example is intrinsically bad.
- Things change with our second example.

Example 2: Double trolley fat-man problem



Example 2: Double trolley fat-man problem

$$\Pi = (\Theta, T, u,)$$

$$\Theta = (\pi_A, \pi_B)$$

$$\pi_A = (V_A, I_A, O_A, \gamma_A)$$

$$\pi_B = (V_B, I_B, O_B, \gamma_B)$$

$$V_A = V_B = man, men, leverB$$

$$O_A = \{pushA, advanceA\}$$

$$pushA = (man = onBridge \triangleright man = deadOnTrack)$$

$$O_B = \{pullB, advanceB\}$$

$$pullB = (\top, leverB = l \triangleright leverB = r \wedge leverB = r \triangleright leverB = l)$$

$$s_0 = (man = alive \wedge men = alive \wedge tram = start \wedge, landleverB = r)$$

$$\gamma_A = \gamma_B = *$$

Example 2 analysis

Definition

A plan π is morally permissible, according to the deontological principle, iff for all a_i, $u(a_i) \geq 0$

- By this definition, any plan that involves the action *push* is will be morally impermissible.
- However, from the perspective of Agent B, any action he takes is not impermissable, and no action he takes could have prevented Agent A from performing the *push* action.
- Perhaps it is worth distinguishing between overall permissibility of a planning task and permissibility of a planning task wrt. some agent or set of agents within that planning task.

Multi-agent Moral Permissibility

Definition

A multi-agent plan π is morally permissible wrt. an Agent X, according to the deontological principle iff, for all agent-action pairs (X, a_i), $u(a_i) \geq 0$.

Definition

A multi-agent plan π is morally permissible, according to the deontological principle iff, for all Agents X, the partial plan for agent X is morally permissible.

$\pi =$	wrt. A	wrt. B	Overall
$(A, push), (B, pull)$	$\bot$	$\top$	$\bot$
$(A, push), (B, \neg pull)$	$\bot$	$\top$	$\bot$
$(A, \neg push), (B, pull)$	$\top$	$\top$	$\top$
$(A, \neg push), (B, \neg pull)$	$\top$	$\top$	$\top$

Do-no-harm in multi-agent planning

Definition

A single agent plan π is morally permissible according to the do-no-harm principle iff, for all $v = d$, if $s_n \models (v = d)$ and $u(v = d) < 0$, then for all plans obtained by deleting a subset of the actions in π, $v = d$ still holds in the final state.

- In a multi-agent plan, open to the same considerations as the deontological approach.
- What is another agent performs an action with a harmful effect, should that invalidate this agent's adherence to that principle?

Do-no-harm in multi-agent planning

Definition

A multi-agent plan π is morally permissible wrt. Agent X, according to the do-no-harm principle, iff, for all $v = d$, if $s_n \models (v = d)$ and $u(v = d) < 0$, then for all plans obtained by deleting a subset of the actions performed by X in π, $v = d$ still holds in the final state.

Definition

A multi-agent plan π is morally permissible, according to the do-no-harm principle iff, for all $v = d$, if $s_n \models (v = d)$ and $u(v = d) < 0$, then for all plans obtained by deleting a subset of the actions in π, $v = d$ still holds in the final state.

$\pi =$	wrt. A	wrt. B	Overall
$(A, push), (B, pull)$	$\bot$	$\top$	$\bot$
$(A, push), (B, \neg pull)$	$\bot$	$\bot$	$\bot$
$(A, \neg push), (B, pull)$	$\top$	$\top$	$\top$
$(A, \neg push), (B, \neg pull)$	$\top$	$\bot$	$\bot$

Utalitarianism in multi-agent planning

- Significantly harder.
- If other agents actions are deterministic, then a reduction from the multi-agent to the single agent case can be done in polynomial time.
- If other agents are random, then average or worst case estimates may suffice.
- If however, the other agent has actions dependent on the current agent, an intuitive way of distinguishing individual agent contributions to overall moral utility of the final state becomes difficult.
- Evaluation of ethical contributions of subplans (as in do-no-harm and deontic cases) would only provide a heurisic-like estimate.
- How would non-determinism be handled in the single-agent case?