OVERVIEW

- Adversarial system definition
- Formalization of adversarial environment
- Connect four
- Risk
- Future work

BACKGROUND

Early work cooperation
Rise of BDI

Purpose:
Framework, not directly implementable

Overcoming horizon (2-p perfect information)
Multiple players
BACKGROUND

Game theory:
  Rational behavior
  Common Knowledge

Generality + Performance, both goals

Connect four: optimal known

Question: How does an agent tell if a situation is adversarial?

OVERVIEW

Presented in 2+ player 0-sum games

1. The agent wants to complete a given goal
2. Agent believes adversaries’ goals conflict
3. Agent believes adversaries intent on goals
4. Agent has belief of adversary profiles

FORMALIZATION
PARAMETERS
Reminder: not direct specification
Language: 1st order logic extension
A – agents   P – profiles   C - actions

MORE PARAMETERS
$T_n$ - time with strict ordering
Utility: $agent \times action \times time \rightarrow \mathbb{R}$ scaled $[0,1]$
$G_A$, set of all goals for $A_i$.  
TrH threshold for “goodness” action

PREDICATES
$Do(A_i, \propto, T_n)$ action $\propto$ will be completed by $T_n$
$Achieve(G_{A_i}^{\propto}, T_n)$ goal will be achieved by $T_n$
$Profile(A_i, P_{A_i}^N)$ $A_i$ has a profile for $A_j$
$Bel(A_i, 'prop', T_{prop})$ belief about prop.
$MB(A_i, 'prop', T_{prop})$ group belief

PREDICATES
$Int.To(A_i, \propto, T_n, T_{prop}, S)$ agent action intent.
$Int.Th(A_i, 'prop', T_n, T_{prop}, S)$ agent property intent.
Similarly for potential intent.
FULL CONFLICT

\[
\text{FulConf} \left( G_{\alpha}^*, G_{\beta}^* \right) \equiv \left( \exists \alpha \in \mathcal{C}_{\alpha}, \beta \in \mathcal{C}_{\beta}, T_\alpha, T_\beta \in T \right) \\
\left( \text{Achieve} \left( G_{\alpha}^*, \alpha, T_\alpha \right) \Rightarrow \neg \text{Achieve} \left( G_{\beta}^*, \beta, T_\beta \right) \right) \\
\lor \\
\left( \text{Achieve} \left( G_{\beta}^*, \beta, T_\beta \right) \Rightarrow \neg \text{Achieve} \left( G_{\alpha}^*, \alpha, T_\alpha \right) \right)
\]

PROPERTY 1

Goal decomposition
Achievement of a goal requires that all subgoals have been achieved.

PROPERTY 2

Highest eval when achieving a goal
All values returned from the evaluation (rel to util) are less than or equal to the value of achieving the goal.

PROPERTY 3

Beneficial nature of goal completion
Evaluation value of an action that completes a goal or subgoal must be greater than the threshold TrH.
SOME MORE DEFINITIONS
Relative strength projectable
Leader in the game
SetActions
Knowledge vs number of actions

AXIOM RECAP
1. The agent wants to complete a given goal
2. Agent believes adversaries’ goals conflict
3. Agent believes adversaries intent on goals
4. Agent has belief of adversary profiles

BEHAVIORAL AXIOM 1
If the agent can complete a goal by executing an available action, they should have a potential intent to execute that action.

BEHAVIORAL AXIOM 2
If there is no leader (3+ players) and an action prevents a player from achieving a goal, that action should be added to the potential intent list.
BEHAVIORAL AXIOM 3
If there is a SetAction with the closing state’s eval greater than TrH and the opponent’s eval of the closing state (projected) is lower than TrH, the SetAction should be added to the potential intent list.

BEHAVIORAL AXIOM 4
If there is an action that will not be highly beneficial to the opponent and will provide more information on their profile, add the action to the potential intent list.

BEHAVIORAL AXIOM 5
(Multilateral only)
If an alliance with other players can be formed such that the eval for a given action in the alliance set is greater than any non-alliance action. Add the alliance creation action to the potential intent list.
(creates new context)

BEHAVIORAL AXIOM 6
If there is an action that has a higher eval score than any other available action, add it to the potential intent list.
NOTES
1. No instruction on which action to use
2. Provides same performance as minimax given eval = util

CONNECT FOUR EXPERIMENT

CONNECT FOUR =? AA
1. The player wants to win (given)
2. There is only one winner
3. The player assumes the opponent also wants to win
4. The player can have knowledge of his opponent.

SIMPLE CONNECT FOUR AGENT PROPERTIES
1. Given $g_A^*_A = \{\text{get 3 in a row with at least one open side}\}$ subgoals required to complete primary goal
2. Based on proper Eval function winning game has highest value
3. Eval must return value above TrH for 3 in a row with one side open and four in a row.
IMPLEMENTATION
6 different agents, increasingly complex heuristics

Axioms 4 and 5 ignored.

RISK

Domain too complex for traditional search.

Recursive DAI each territory corresponds to a subagent.

Axiom 4 provided no improvement. (only four basic tactics were recognizable)
EXPERIMENT 2
Board: Randomized

EXPERIMENT 3
5 “easiest” agents fixed
Board: risk classic
1000 games each version

EXPERIMENT 4
Split by heuristic
Board: random
1000 games

FUTURE WORK
1. Creating a specific application using the specification given.
2. Move beyond zero-sum environments
3. Improved opponent modelling
4. State changing