Real-Life Application Domains: Breakout Session Summary

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Decision Making in Adversarial Domains Workshop
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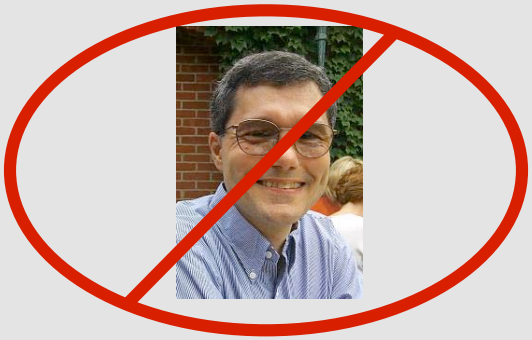
Nau Directions



Assigned questions

- Advances needed to transition from game environments to real world?
- Scalability issues?
- Knowledge Management?
- How would a decision system interact with a real domain?
- How to take the user into account?

Goal for each group

Prepare a report to present Tuesday afternoon

- What's good?
- What's bad?
- Grand challenges?

Our Approach

Introductions

1. Name, affiliation
2. Why are you here?

Discussion focus

1. What are real-world adversarial domains?
2. Adversarial problem categories and dimensions
3. What advances are needed to transition from toy to real-world environments?
4. What benefits may result from closing these gaps?

Definition of adversarial decision-making environments (draft)

- Environments in which agents act so as to conflict with your goals

Introductions

Some interests

- **Making a connection between game theory and application/practice**
  - Identifying how practice (e.g., example plans) can inform theory (e.g., to obtain behavioral guarantees)
  - Learning how mathematical formalisms can be applied to real-world adversarial domains
- **Implications**
  - How the presence of adversaries affects decision making
    e.g., collaborators with different objectives
  - Understanding the broader implications of military actions
    e.g., so as to not make more enemies
- **System design/development**
  - Improving your system design's robustness in the presence of adversaries
  - Building a decision environment from formal models
  - Identifying how adversarial reasoning can impact the design of planning applications so as to help people manage complex dynamics
- **Knowledge acquisition/integration**
  - Acquiring knowledge (e.g., adversarial models and domain models, from data or experts) for automated decision making in adversarial domains
  - Integrating adversary models in decision making domains so as to integrate their actions, intent, anticipation, and to support proactive responses
  - Acquiring/applying constraints on group decision making (e.g., domain rules)

1. What are real-world adversarial domains?

Examples

- **Good Reflective Examples**
  - ❑ Real-time strategy games
  - ❑ Military simulations (e.g., symmetric, asymmetric)
  - ❑ Gov't vs gov't conflicts (various)
  - ❑ Economic adversarial domains (e.g., national, business)
  - ❑ Team sports (e.g., RoboCup, Davis Cup)
  - ❑ Competitions (e.g., Poker)
- **Good Non-Reflective Examples**
  - ❑ Biology (e.g., World vs. virus)
  - ❑ Computer security
- **Non-Examples**
  - ❑ Traffic simulation ; lacks adversary
  - ❑ Chess, hopscotch, swimming ; not “real-world”
  - ❑ Asteroid crashing ; non-intelligent

1. What are real-world adversarial domains? (cont.)

Characterization

- **Characteristics**
  - ❑ Adversary (e.g., varying in: structure, number, objective functions)
    - ➢ Intentional vs. noise
  - ❑ Bounded resources
    - ➢ Physical limitations (e.g., time, financial, space)
    - ➢ Cognitive limitations (e.g., memory, computational power)
  - ❑ Decision granularity
    - ➢ Decision making at multiple levels
    - ➢ Horizon (e.g., Strategic, operational, tactical)
  - ❑ Emotional component (e.g., aggressive, passive)
  - ❑ Imperfect information

    e.g., uncertain, ambiguous, redundant, irrelevant, conflicting
  - ❑ Intractable (NP) but can be approximated
    - ➢ Domains usually have multiple sub-optimal solutions
- **Non-characteristics**
  - ❑ Perfect information tasks
  - ❑ Deterministic (non-chaotic) tasks
  - ❑ Complete (e.g., rule-based) domain theory is available

2. Adversarial problem categories and dimensions

Categories

- Toy
- Testbeds (e.g., military simulations, datasets)
- "Real-world" problems

Dimensions

- Degree of information available ; Perfect/imperfect
- Degree of determinism ; Deterministic/stochastic
- Degree of symmetry ; Goals, actions, info
- Model sophistication/accuracy ; Ability of opponent to model you
- Scale (e.g., #players, amount of resources, amount of info, …)
- Type of information structure
  - Markov assumption ; Toy domains assume this
  - Static environment ; # of adversaries, probabilities
- Boundary condition ; Closed vs. open
- People involved ; Eventually

Desired system functionality

- Robustness against initial conditions, uncertainty, partial info
- Identification of required information (to make decisions)
- Insights (i.e., in your and adversary's decision processes)
  - Explanations

3. What advances are needed to transition from toy to real-world environments?

A partial list

- Obtain analyses of real-world task domains (and data sources)
  - Task analysis (for specification, including inputs)
  - Metrics (e.g., satisficing solutions)
    - Adversarial modeling (e.g., culture, intent, capability/resources)
    - Knowledge representation
      - Representation selection/transition (e.g., abstraction, approximation)
      - Merging representational forms (e.g., multiple modalities)
- Algorithmic modeling (e.g., for uncertainty)
  - e.g., steps between MDPs and POMDPs, dynamic & rapid learning
    - Reasoning (e.g., temporal, uncertainty, quantification)
- Multi-attribute utility functions (e.g., elicitation, rep'n, reasoning)
- Encouraging community growth
  - e.g., terminology, portable/shareable problems, data, and software
- Calibration/validation paradigm

4. What benefits may result from closing these gaps?

Benefits

- Military:
  - Improved (e.g., group) understanding and decision making
  - Adversarial neutralization (e.g., computer viruses)
  - Conflict avoidance
- Games:
  - Greater entertainment value
  - Poker: Higher profits!
- Corporate:
  - Increased sustainability, stability, and $success
- Society:
  - Medical breakthroughs (e.g., disease response)
  - Cultural understanding
  - Team cooperation (e.g., small-group, national, international)
- Science & technology:
  - Multi-agent systems
  - Algorithmic advances
  - Cognitive architectures

Done: Questions?