AI and Negotiation

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MAS Coordination

Teamwork: Agents share a common set of goals and each contributes to the fulfillment of these goals through teamwork. No explicit modeling of individual agent utility

Capability-based: Agents discover others with desired functionality to form non-permanent ad hoc groups to solve a current problem; group members may belong to one or more groups simultaneously

Coalitions: Agents seek to maximize individual utility and group utility (coalition stability is an issue)

Coordination: Agents pursue their individual goals and utilities; coordination with others is done only to avoid harmful interactions (e.g. traffic)

Auctions: Agents seek to maximize utility; agents interact through centralized auctioneer.

Negotiation: Agents seek to maximize their individual utility but are willing to compromise; agents interact directly

Game Theoretic Interactions: Agents seek to maximize individual utility while taking into consideration other's options

Adversarial Interactions/Zero Sum Games: Agents seek to maximize own utility while minimizing utility of opponent

There is no single coordination technique that fits all applications

Elements of Negotiation

- Who the other party is (or who does it represent?) – agent "type"
- Party Goals -what kinds of outcomes they want to achieve
- Strategies to reach the goals
- Persuasion- how to convince the other party to accept a proposal
- Information sharing –how to get information from the other party

Elements of Negotiation Modeling

- Utilities
  - Goals
  - Motives
  - Values
- Agent-Internal States
  - Beliefs
  - Trust
  - Emotions
- Agent-Internal Reasoning
  - Encoding
  - Searching
  - Algorithm creation
- Behavior/Characteristics
  - Strategies
  - Tactics
  - Outcomes

Key Challenges in Negotiation Formalization

- Incomplete information
- Presence of multiple issues and potential tradeoffs
- Dynamic presence of future outside options
- Desire for Pareto optimal outcomes
- Computational tractability
- Cultural factors

Modeling Negotiation Process

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Analytic vs. Computational Models of Negotiation

- Analytic models
  - Mathematic models that provide guarantees of behavior & optimality
  - Developed by Economics & OR communities
- Computational models
  - approximation algorithms and heuristics that can be shown to be computationally tractable
  - Developed by Computer Science/AI community

Why Analytic Models?

Analytic models (typically Game Theoretic) simplify the negotiation process to sequences of offers and counter offers

- Simplification allows exact solutions with guarantees such as optimality
- Simplification allows *strategic* solutions incorporating other's expected behavior
- Specifies expected outcomes of negotiations (e.g. Nash equilibriums/Pareto optimality)

Weaknesses of Analytic Models

- cannot encompass the complexities of real negotiations
- assume that the negotiation process is well structured where actions occur and result in agreement or opting out
- Do not model the process of negotiation
- Assume utilities and preference structures are known
- Centralized, so poor at describing distributed decision making or information asymmetries

Multi-attribute Negotiations for Analytic Models

- Why is Multi-attribute negotiation important?
  - Necessary: In many situations, people have to negotiate multiple issues simultaneously
  - Beneficial: In some situations, to negotiate additional issues of common interest can benefit both negotiators; *win-win* outcomes

Process in Analytic Models

The Negotiation process can affect analytic models through choice of negotiation procedure

- Separate
  - Multi-attribute negotiation is treated as N separate negotiations
- Simultaneous
  - Issues are bundled in making offers
- Sequential
  - Issues are resolved in sequence

Findings for Procedure Choice

Under a wide variety of conditions simultaneous negotiation provides better solutions

But

Where there are information asymmetries sequential negotiation allows *signaling*

- Strong player signals strength to induce opponent to concede- Bak & Raff (1996)
- Issue-by-issue negotiation may arise with signaling &
- Agents negotiate large pie first- Busch & Horstmann (1999)

Findings for Procedure Choice (cont)

- Heterogeneous agents may have conflicting preferences &
- Time cost may lead to preference for incomplete (non-bundled) contract- Busch & Horstmann (1999)
- Joint concavity of payoffs may preclude issue-by-issue equilibrium offers- Lang & Rosenthal (2001)
- Issue-related breakdown may lead to advantage for issue-by-issue negotiation- Chen (2006), In & Serrano (2003)

Why Computational Models?

Computational models allow/enable us to:

- model *the dynamics* of the interaction
- make predictions about expected behaviors of others
- make extrapolations of behavior to those for which we do not have data
- consider properties of optimal strategies that the model may have identified
- shed light into the information processing of people involved in the collaboration and negotiation

Why Computational Models?

Computational models allow/enable us to:

- explore behaviors and generate hypotheses for theoretical constructs

- point to places where new data need to be collected

- perform "what if" analysis and examine the effect of additional variables which have not been studied

- the additional variables could be recent changes and unexpected events where decisions must be taken by decision makers and there is no time to collect data

Computational Models of Negotiation Tactics with Pareto Optimal solutions

- Convergence of optimal strategies and negotiation outcomes for linear utility functions with complete information- Faratin et al. (2002)
- Negotiation with nonlinear utilities & without knowledge of opponent utilities with near Pareto equilibrium results- Lai & Sycara (2008).
- Proof of convergence of above algorithm Zhang, Chakraborty, Sycara (2012)

Computational Models of Negotiation Tactics with Heuristic solutions

Choice of next offer

Offer on indifference curve most similar to opponent's previous offer- Faratin et al. (2002)

Machine learning to identify opponent's preference structure for choice of offer- Coehoorn & Jennings (2004).

Computational Models of Negotiation Tactics with Heuristic solutions (cont)

- Fuzzy constraints- Luo et al. (2003)
- Bayesian models of opponent- Zeng & Sycara (1998), Li & Tesauro (2003)
- Binary issues Robu et al. (2005), Chevaleyre et al. (200)

Why POMDP?

- Game theoretic models
  - find solutions in terms of equilibrium point concepts, but might be computationally intractable
- MDP (Markov decision process) modeling
  - assumes perfect information
- POMDP addresses the following key challenges:
  - POMDP is decentralized, i.e, each agent solves his own problem
  - POMDP provide a natural way to capture the sequential nature of the process
  - POMDPs can incorporate the effect of cultural factors in a natural way (e.g initial belief state)
- Paruchuri et al. (2009)- preliminary positive- requires immense amounts of data- 2K exchanges too few

POMDP-Based Negotiation Modeling

- Modeling challenges:
  - Modeling the transition function T: stochastic including the opponent's offers
  - The observation function O: could be stochastic since there could be noise in interpreting offers/communications of the opponent
  - The reward function R: function of the agent's type, its current offer and the action it takes
- Pros:
  - Agent maintains belief of the opponent
  - Refines the belief of opponent as negotiation progresses
  - Optimal negotiation strategy w.r.t. the existing data
  - Numerous factors can be considered
- Cons:
  - State space explosion as new factors considered: Computationally expensive
  - Optimality depends on the input model

Conclusions

- Computational models are based on the assumption that the agents in a negotiation have explicit utility functions
- assume that the agents completely or partially know their opponents utility function
- existing models either assume a simple utility function or focus on binary issue or cooperative negotiations
- Pareto-optimality and tractability have not been considered simultaneously in most of the models

Argumentation in Negotiation

Felipe Meneguzzi

AI Models of Argumentation

- Traditional Assumptions
  - Total rationality
  - Either
    - Total information
    - No information
- Argumentation as a form of theorem proving
  - Defeats relation is fully known

Logical Reasoning versus Argumentation

- Logical reasoning
  - Centralized
  - Monotonic: assumes underlying universal **truth**
- Argumentation
  - Dialogical
  - Non-monotonic: **beliefs** evolve as arguments are exchanged

Logical Reasoning versus Argumentation

- Logical Reasoning
  - If this is true $KB \models \alpha$
  - Then this must be true $KB \vdash_c \alpha$
  - No matter what you choose this $\vdash_c$ to be
- Argumentation
  - No $KB \models \alpha$
  - Sometimes $KB \vdash_{ca} \alpha$, sometimes $KB \vdash_{ca} \beta$
  - Depending on how you choose $\vdash_{ca}$
  - Element of strategy/planning for the calculus

Argumentation

- Process of exchanging **arguments**
  - syntactically similar to logical rules: preconditions → effects
  - semantically very different: arguments are either **convincing or not**
- Arguments can either
  - support certain facts
  - attack/defeat facts and other arguments

Argumentation-based Negotiation

- Uses arguments as a medium of **information exchange**
  - Information seeking/giving among agents
  - Reasoning about negotiation procedures
- Extends negotiation beyond simple exchange of offers
  - Persuasion-oriented information exchange towards modifying one's beliefs

Why ABN?

- Allows modeling of partial information about each participant's preferences
  - Strategic information exchange
- Allows dynamically evolving utility functions (as a result of argument-driven new beliefs)
  - Multi-issue negotiation
  - Revealing aspects of one's preferences, or support one's own beliefs opens opportunities for the other to refute
- Allows modeling of negotiation outside rationality framework (cultural factors, etc)

Current Research Issues on ABN

- Effective planning mechanisms for strategic use of arguments
  - Models of opponent preference structure (Sycara, 1991)
- Methods to evaluate the performance of ABNs
  - How to incorporate external information into an individual's argumentation framework (mathematical models)
- Modeling of the **convincing power** of arguments in different contexts
  - Defeats relationships are not known for all parties
  - Probabilistic in general

Culture in Negotiation

Katia Sycara

Who is the “other”?

- In individualistic (Western) societies, the person is isolated from the role; consequences:
  - the person will get into the role that the interaction requires
    - the person will represent his own interests in a person-to-person interaction;
    - the person will represent the interests of his organization in a business interaction
  - interaction among strangers that may not trust one another is possible (and is typically the case).

Who is the "other"?

- In collectivist cultures, where the person is embedded in different social networks,
  - it is often the case that negotiation interactions happen only within a social network, or must be initiated by a common acquaintance, and
  - when interactions happen the role of the other party may not be clear but must be elucidated during the interaction.
  - Negotiators spend lots of time at the beginning of the negotiation in "small talk" to gather information about the character of the other and build trust
  - Accountability to constituents (family, tribal group) is also an issue

Parties' Goals

- Parties goals are what type of results the parties are aspiring to
- in individualistic cultures goals tend to concern
  - material values (usually economic benefits)
  - be oriented towards self interested gains (getting a good deal for oneself)
  - harder bargaining tactics
- In collectivist cultures, "other-focused" goals
  - getting a good deal for both parties
  - and altruistic behaviors (getting a good deal for the other party) are important
  - relational capital
    - mutual liking, mutual knowledge, mutual trust, and mutual commitment to the relationship
    - payback is not viewed as immediate but come into play in the future
- Reciprocity appears to be a universal norm

Consequences of relational concerns

- **Accumulating relational capital may be** inconsistent with achieving economic capital**, at least in the short run**
- **Trust** plays a crucial role, especially in competitive interactions where the other players may not be trusted to keep their commitments or tell the truth about the deals they propose or arguments they make.
- Lack of trust can lead to negotiation breakdown and attitude shifts from win-win to win-lose interactions.

Ways to increase Trust

- establishing credibility and good reputation
- “speaking the other’s language”, not only understanding the terms but understanding the nuances;
- justifying one’s concessions and demands while emphasizing common gains;
- acts of reciprocity;
- unilateral concessions, or symbolic concessions for issues that are sacred values.

Sacred Values

- Sacred values: values (issues, resources, beliefs, practices) that are infused, in the minds of specific groups, of people with moral, spiritual and often religious components
  - identity-relevant
  - incorporate moral/religious components
  - drive action independently of its prospects of success
  - immune to cost/benefit consideration
  - when threatened, decisions to adopt cooperative vs. competitive/ violent strategies tend to be driven by moral intuitions

  - Example: Land becomes "sacred" in some cultures
- We expect that sacred values significantly impact collaboration and negotiation in cross-cultural interactions

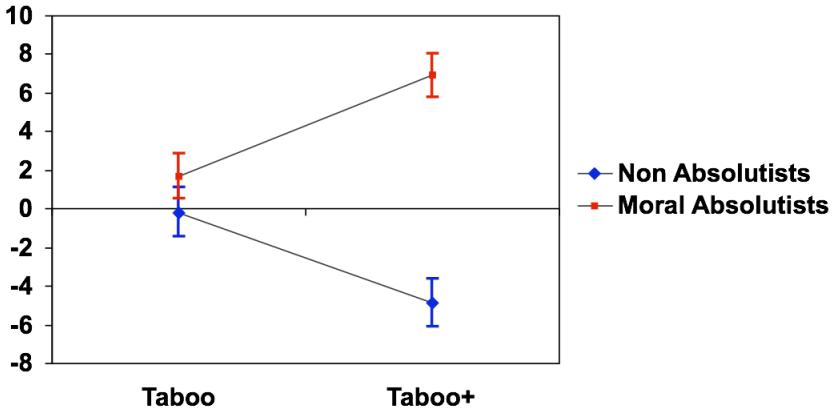
Better Deals Can Produce Worse Results (AGAF)

- Sample: 720 Palestinians in West Bank and Gaza
- Experiments compared reactions of *moral absolutists* versus *non absolutists* in terms of different deals
- Two deals
  - **Taboo deal**: "Suppose the United Nations organized a peace treaty between Israel and the Palestinians. Under this treaty Palestinians would recognize the sacred and historic right of the Jewish people to Israel. There would be two states - a Jewish state of Israel and a Palestinian state in 99% of the West Bank and Gaza."
  - **Taboo+**: "On their part, Israel will pay Palestine 1 billion dollars a year for 10 years."

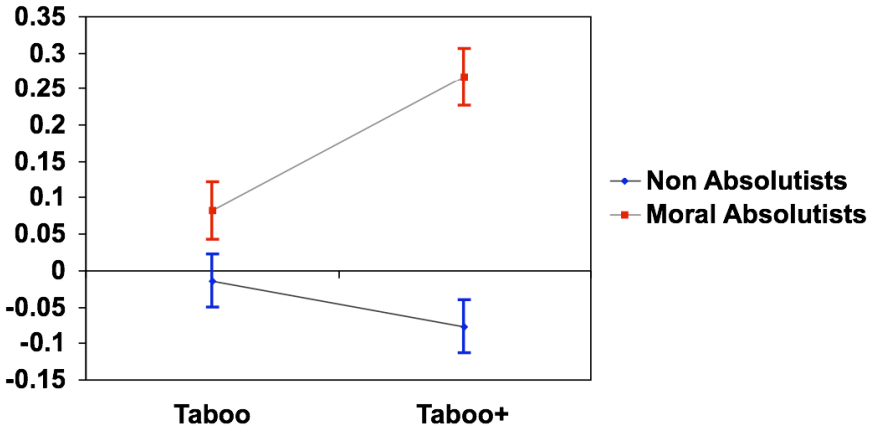
Better Deals Can Produce Worse Results

The results show attitudes toward Israel:

Violence



Anger & Distrust



Trusted Intermediaries

- In non-Western cultures, third parties are frequently involved because they should have a broader perspective that takes the whole context (e.g. concerns about the social network where the actors are embedded) into account.

Process orientation

- Part of the concern over relationship (as opposed to economic capital) is that the parties take care during the process to understand the interests and preferences of the other party.

Conflict Resolution Strategies

- Interests-based: identifies and attempts to satisfy the goals of all parties (collaborative/integrative approach)
- Rights-based (regulation-based): refers to external standards (norms, precedents, contracts, laws) to judge the fairness/ appropriateness of solutions
- Power-based: determining who is able to force their desired outcomes; force concessions from the other party

Way Forward

- Integrated framework accounting for a continuum of collaborative and conflict resolution behaviors
- Models of the process, not just the outcome
- Adaptation of cognitive schemata
  - lens for viewing cross-cultural interactions
- Determine cultural invariants across individual, local and national (e.g. Sacred Values)
- Enrich current negotiation models with communication, argumentation and learning to allow various degrees of agent rationality
- Human Evaluation

Questions

- What is the role of argumentation in negotiation?
- How to model the dilemma of information sharing?
- How to model human departures (eg biases) from prescriptive theories?
- Why are not negotiation support systems more prevalent in practice?
- What are appropriate metrics and procedures for evaluation of negotiation decision support systems?