Networks of Influence Diagrams (NID)

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What are NIDs ?

A formalism for decision-making that distinguishes between agents' models of each other.

NIDs can represent players'

- inconsistent and/or incorrect beliefs (that are not represented by a joint probability distribution)
- "I believe that you believe..." type reasoning.
- irrational behavior (choosing a non-optimal strategy)

NIDs provide algorithms for

- computing equilibrium given agents' beliefs
- learning parameters

Rock-paper-scissors Tournament [Billings 2002]

Automatic agents competed against each other for multiple rounds.

Nash Equilibrium players received expected outcome of zero.

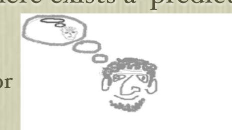
Opponent modelers did much better.

Straightforward prediction failed - opponents disguise their strategy and attempt to counter model you (meta deliberators).

John's Reasoning

Mary and John are playing rounds of rock-paper-scissors.
Suppose there exists a predictor P that depends on prior history

Strategy for John



Strategy for Mary

P=paper

BR(P) =scissors

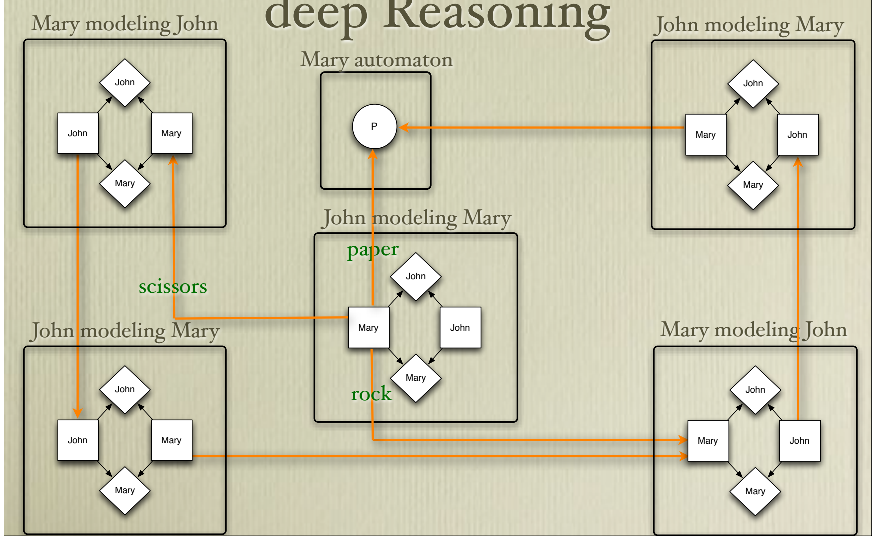
BR(BR(P))=rock

BR(BR(BR(P)))=paper

BR(BR(BR(BR(P))))=scissors

BR(..(P)..))=rock

John Modeling Mary's 2-level-deep Reasoning



For John to win...

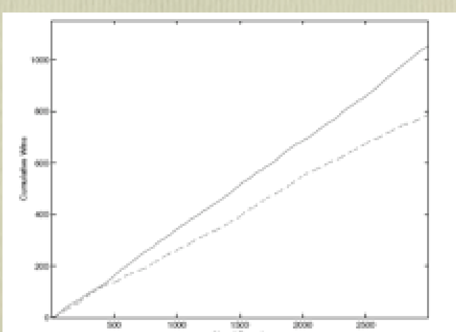
- must learn correct distribution over
  - predictor P
  - Mary's meta strategies (one, two or three levels of meta reasoning)

Mary's Play
Rock
Rock
Paper
..
..

Prob(P)	
Rock	0.6
Paper	0.2
Scissors	0.2

Prob(Meta)	
Follow P	0.2
BR(P)	0.5
BR(..BR(P))	0.3

Sample Run

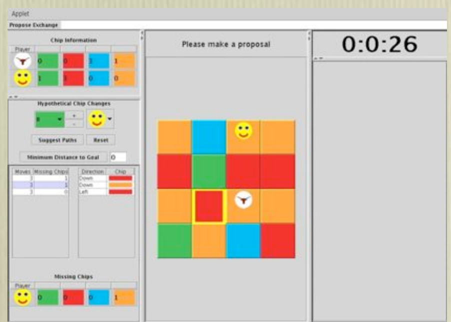


Learning to Negotiate with People

- People's strategies in strategic settings deviate from game theoretic predictions.
- People are affected by social factors (e.g., competitiveness, altruism) and dependency relationships (e.g., who needs whom)
- People vary in the way they are affected by social factors.
- Can we build a computation model for negotiation with people that will outperform game theoretic models ?

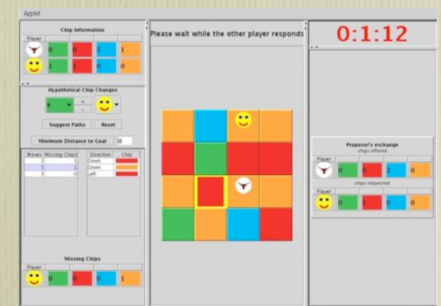
A take-it-or-leave-it Colored Trails Game

Proposal Phase : the proposer player must make an offer to the responder player



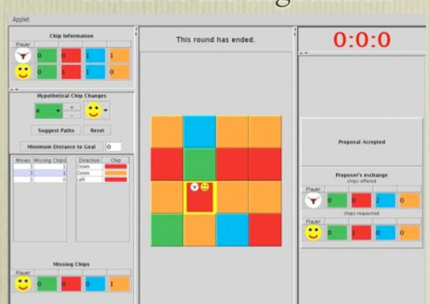
A take-it-or-leave-it Colored Trails Game

Response Phase : the proposer player must wait for a the responder's reply



A take-it-or-leave-it Colored Trails Game

Movement phase: both players are moved as close as possible to the goal square, given the result of the negotiation



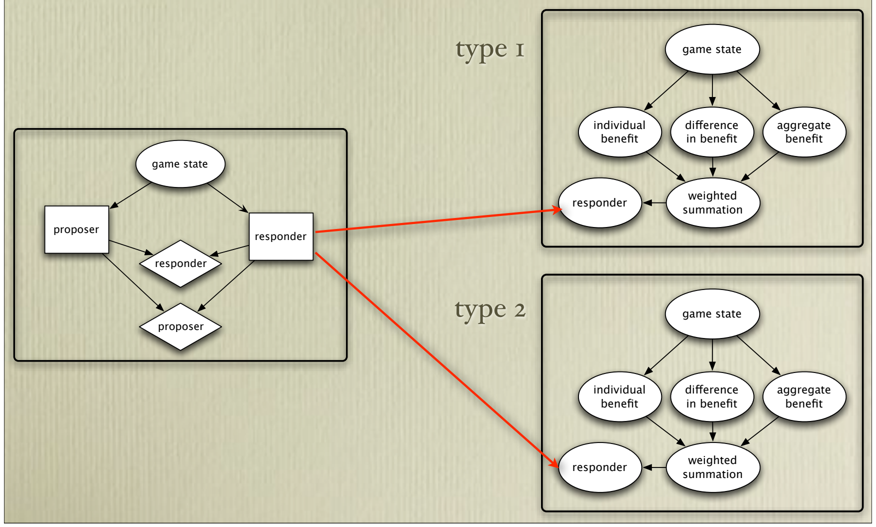
Social Preferences in CT

Responder's preferences for a potential trade are function of

- selfishness : individual benefit from trade
- social welfare : aggregate gains from trade for both players
- inequality : difference in gains of trade

Given a trade, social utility for deliberator is a weighted summation of its social preferences

Colored Trails NID



Using the CT NID to make a proposal

- select the offer that maximizes proposer's score given its beliefs about types of responders.
- learn the distribution over responder's types, as well as the weights for each type, by observing history of interaction.

Data Collection

32 subjects

192 different instances

Each instance consisted of game description, proposals, and response

Up to 256 possible proposals in each game

Games performance determined payment for subjects

Types of Proposers

Our learned social agent

Nash equilibrium

- choose proposal that maxinizes proposer's benefit and minimizes responder's benefit

Nash bargaining solution

- choose proposal that maximizes product of benefits from trade to both players

Humans

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Model Evaluation

We used two groups, each consisting of 5 human subjects and 3 computer players

We played 21 different games

Each game was played 4 times:

- proposer was one of four types
- responder was human

We aggregated the rewards of each type of proposer

Results

Model	Total Score	Exchanges Accepted	Exchanges Declined	No Offer
Learned Agent	2880	16	5	0
Nash Eq. Player	2100	13	8	0
Nash Barg. Player	2400	14	2	5
Human	2440	16	1	4

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Example

Model	Proposer's score	Responder's score
No Negotiation Alternative	75	150
Learned Agent	170	170
Nash Equilibrium Player	180	160
Nash Bargaining Player	150	190

Nash Equilibrium offer was declined

NB offer resulted in lower proposer utility

Conclusion

A language for representing agents' beliefs and decision making processes.

- captures uncertainty about what model is used to make decisions.
- define an equilibrium that allows agents to behave irrationally.
- can learn model parameters through observations.
- More natural and compact then traditional game theoretic models.

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