How a Genetic Algorithm Learns to Play Traveler's Dilemma by Choosing Dominated Strategies to Achieve Greater Payoffs

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Outline

Traveler's Dilemma

Scientific American Magazine June 2007

http://www.scientificamerican.com/

- The game was formulated in 1994 by Kaushik Basu.
- American Economic Review, Vol. 84, No. 2 May 1994.
- Scientific American Magazine, June 2007.

Traveler's Dilemma

- An airline loses two suitcases belonging to two different travelers, Lucy and Pete. Both suitcases contain identical antiques.
- A manager tasked to settle the claims explains that the airline is liable for a maximum of $100 per suitcase.
- The manager separates both travelers and asks them to write down the amount of their value, at no less than $2 and no larger than $100.
- If both the travelers write down the same number, the company reimburse both travelers that amount, otherwise the smaller number will be taken as the true dollar value...
- ... and both travelers will receive that amount along with a bonus /malus: + $2 will be paid to the "honest" traveler and -$2 to the person who wrote the highest price.

Traveler's Dilemma

Question:

What number should the travelers write? What number would you write?

Nash Equilibrium

Nash Equilibrium

In game theory, the Nash equilibrium describes a kind of optimal strategy, informally defined as that set of strategies (one for each player) such that no player can do better by choosing a different strategy while keeping the others strategies fixed.

In a two player game, it would be a pair of strategies p, q such that:

$$\begin{cases} \pi(p', q) \leq \pi(p, q) & \forall p' \neq p \\ \pi(p, q') \leq \pi(p, q) & \forall q' \neq q \end{cases}$$

Nash Equilibrium for Traveler's Dilemma

Lucy:

Pete:

(1)...I should write $100...

Nash Equilibrium for Traveler's Dilemma

Lucy:

Pete:

(2)...I should write $100..

Nash Equilibrium for Traveler's Dilemma

Lucy:

(3)...if he thinks the same, then if I write $99 I'll get a little bit more money: $101

Pete:

Nash Equilibrium for Traveler's Dilemma

Lucy:

Pete:

(4)... if she thinks I'll say $100 she will probably say $99, In that case I could do better by writing $98, to have $100..

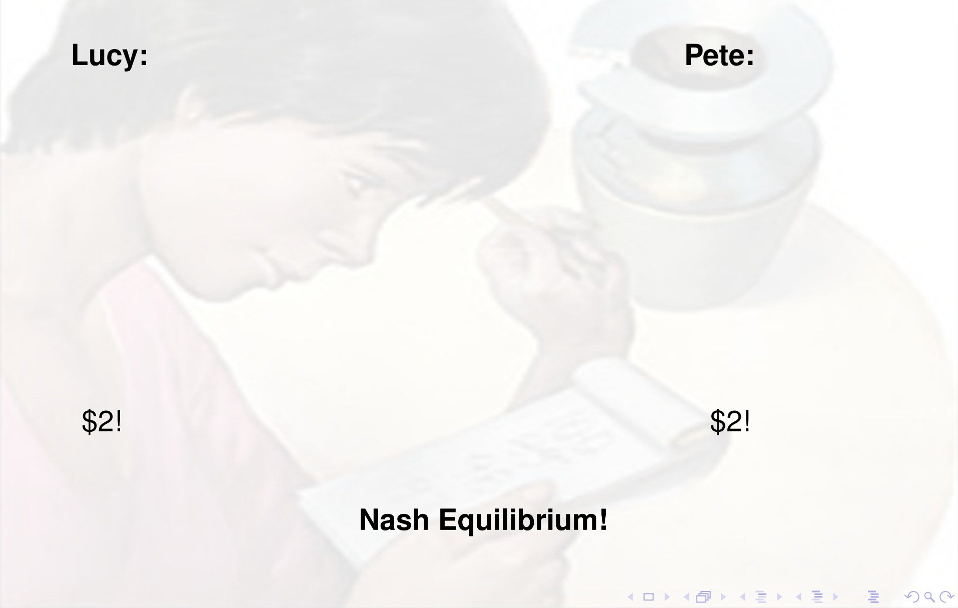
Nash Equilibrium for Traveler's Dilemma

Lucy:

Pete:

(5)...if he thinks the $98, I could deviate to $97 and earn $99..

Nash Equilibrium for Traveler's Dilemma



Lucy: $2!

Pete: $2!

Nash Equilibrium!

Nash Equilibrium in Traveler's Dilemma

- It is the best thing to do no matter what the other player does.

Nash Equilibrium in Traveler's Dilemma

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- Highly implausible that they would really go all the way down to 2. When the game is played experimentally most participants select much higher values, usually close to $100.

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- 1965 Reinhard Selten proposed subgame perfect equilibrium to eliminate equilibria which depend on non-credible threats.

What happens... really?

A celebrated lab experiment by Capra,Goeree,Holt and Gomez. (University of Virginia) with economics students and using real money:

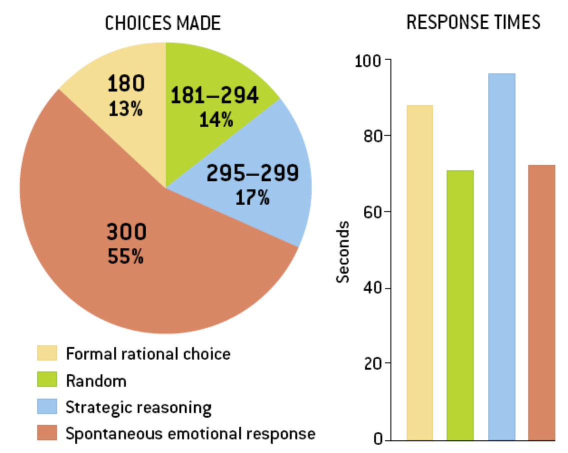
- Choices between 80 and 200 cents.
- Different penalties and rewards

- The experiment confirmed the intuitive expectation...
- Player would not play the Nash equilibrium strategy of 80c.
- With a reward of 5 cents, the players' average choice was 180, falling to 120 when the reward rose to 80 cents. Web-based experiment confirmed.

Why?

- The thought processes that produce this pattern of choices remain mysterious
- Altruism, socialization and faulty reasoning guide most individuals' choices

Rubinstein: 4 sets of possible choices for 4 different cognitive process:



Link to Mr. Hingston presentation

- Iterated Prisoner's Dilemma for Species
- How can cooperation evolve?
- Evolution rewards the selfish.

Repeated Traveler's Dilemma and G.A.

- A population of 100 players is set up.
- Each player chooses an answer for each match using a of probability distribution and plays against a random opponent.
- The best players (greater total payoff in the current generation) have a greater probability to be selected for the next generation.

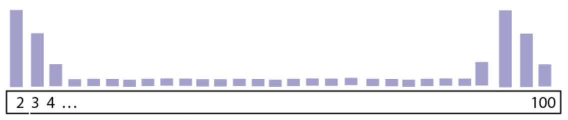
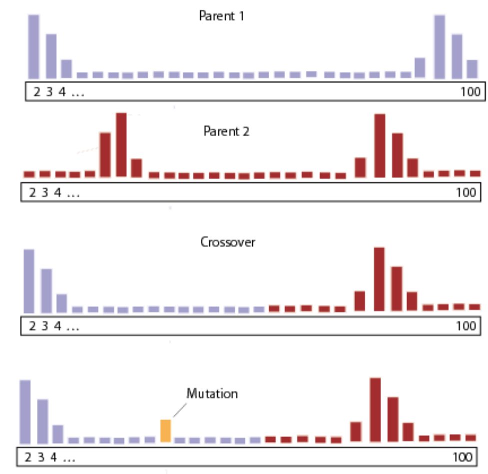


Figure: Example of a genome used in the G.A.

Mutation and crossover

- Two individuals are chosen to mate.
- Their genomes are combined using a crossover operator.
- A gene is chosen randomly and a mutation value is added to it.



Results

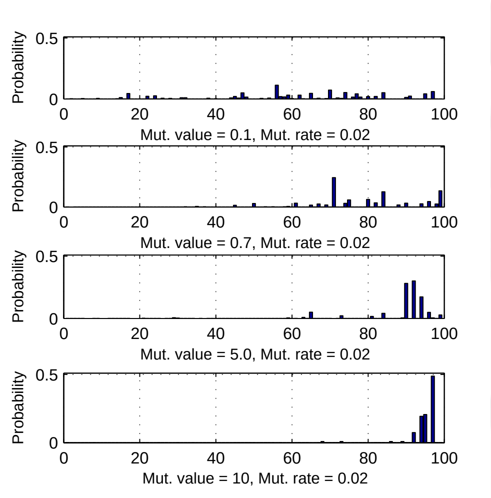


Figure: Average strategy after 5000 generations using different mutation values.

Results

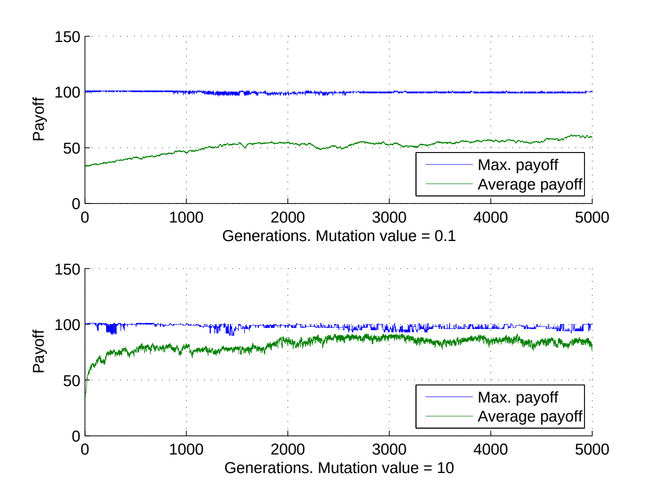
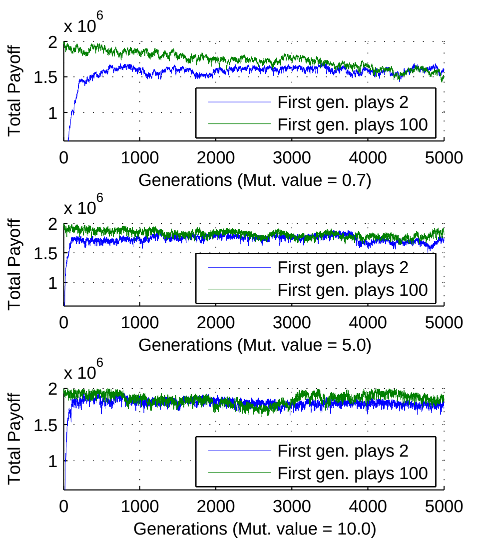


Figure: Average and maximal payoff for each generation.

Convergence with different initial values

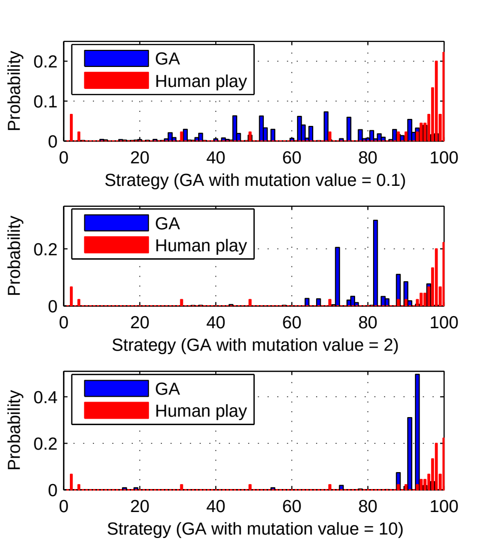


GA vs Human strategy

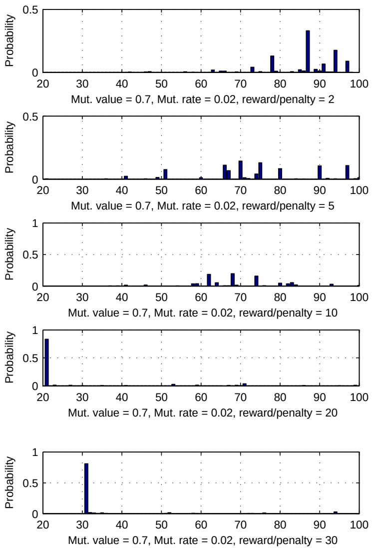
Strategy	Entry	Strategy	Entry	Strategy	Entry
2	3	88	1	96	3
4	1	90	1	97	6
31	1	93	1	98	9
49	1	94	2	99	3
70	1	95	2	100	10

Table: Distribution of human strategy described in Becker, Carter and Naeve. (Hohenheim)

GA vs Human strategy



Convergence varying rewards and penalties



Conclusions

- In this paper, we proposed a genetic algorithm to search over the probability space for the distributions that maximize the average payoff in repeated game sessions.
- Even if changing the rewards and penalties should theoretically have no impact, in practice, it has. The algorithm showed the same behaviour without having any a priori knowledge about the game. This probably means that the reasons of this effect are not exclusively psychological.
- The results show forms of convergence to equilibrium distributions.
- Possibility to apply probabilistic methods and convergence analysis.

Conclusions

Thank you!