Effective Choice in the Prisoner's Dilemma by Robert Axelrod

CAP 6675 Fall 2017

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Prisoner's Dilemma (PD)

- 2 players
- 2 choices
  - Cooperate
  - Defect
- No communications
- Payoff Matrix

TABLE 1
Payoff Matrix for Each Move of the Prisoner's Dilemma

		Column Player	
		Cooperate	Defect
Row Player	Cooperate	3,3	0,5
	Defect	5,0	1,1

(The payoff to the row player is given first in each pair of numbers.)

[1]

Summary - Goal

- Find out strategies to triumph in iterated Prisoner's Dilemma game

- Iterated Prisoner's Dilemma (IPD)
  - Play Prisoner's Dilemma repeatedly
  - Remember all previous choices
  - Grand total payoffs from each iteration

Summary – Motivation

- “Gain deep understanding of how to be effective in partially competitive and partially cooperative environment”[1]

Summary – Method

- A computer tournament participated by game theory experts
- Decision rules implemented in programs
- In game history choices access
- Games run as a round robin, each player paired with each other player, itself, and RANDOM
- Number of Players: 14
- Length of game: 200 and 5 times
- Payoff points for each move:
  - Mutual cooperation: 3
  - Mutual defection: 1
  - Defecting player: 5; Cooperating player: 0
- Overall point of a player: average total payoffs per game

Summary - Results

- TIT FOR TAT

the simplest rule and the winner

  - Cooperate initially
  - Perform the same choice the other player did in last iteration

TABLE 2
Tournament Scores

Player \ *Other Players*	TIT FOR TAT	TIDEMAN AND CHIERUZZI	NYDEGGER	GROFMAN	SHUBIK	STEIN AND RAPOPORT	FRIEDMAN	DAVIS	GRAASKAMP	DOWNING	FELD	JOSS	TULLOCK	(Name Withheld)	RANDOM	*Average Score*
1. TIT FOR TAT (Anatol Rapoport)	600	595	600	600	600	595	600	600	597	597	280	225	279	359	441	504
2. TIDEMAN AND CHIERUZZI	600	596	600	601	600	596	600	600	310	601	271	213	291	455	573	500
3. NYDEGGER	600	595	600	600	600	595	600	600	433	158	354	374	347	368	464	486
4. GROFMAN	600	595	600	600	600	594	600	600	376	309	280	236	305	426	507	482
5. SHUBIK	600	595	600	600	600	595	600	600	348	271	274	272	265	448	543	481
6. STEIN AND RAPOPORT	600	596	600	602	600	596	600	600	319	200	252	249	280	480	592	478
7. FRIEDMAN	600	595	600	600	600	595	600	600	307	207	235	213	263	489	598	473
8. DAVIS	600	595	600	600	600	595	600	600	307	194	238	247	253	450	598	472
9. GRAASKAMP	597	305	462	375	348	314	302	302	588	625	268	238	274	466	548	401
10. DOWNING	597	591	398	289	261	215	202	239	555	202	436	540	243	487	604	391
11. FELD	285	272	426	286	297	255	235	239	274	704	246	236	272	420	467	328
12. JOSS	230	214	409	237	286	254	213	252	244	634	236	224	273	390	469	304
13. TULLOCK	284	287	415	293	318	271	243	229	278	193	271	260	273	416	478	301
14. (Name Withheld)	362	231	397	273	230	149	133	173	187	133	317	366	345	413	526	282
15. RANDOM	442	142	407	313	219	141	108	137	189	102	360	416	419	300	450	276

[1]

Summary - Conclusions

- Properties of successful rules:
  - Niceness - “to cooperate as long as the other player does”[1]
    - Example rules with niceness: TIT FOR TAT, TIDEMAN AND CHIERUZZI, NYDEGGER, GROFMAN, SHUBIK, STEIN AND RAPOPORT, FRIEDMAN, DAVIS
  - Forgiveness - “to be somewhat forgiving”[1]
    - Example rules with forgiveness: TIT FOR TAT, TIDEMAN AND CHIERUZZI, NYDEGGER
    - Example rules without forgiveness: FRIEDMAN, DAVIS, FELD, JOSS, TULLOCK
  - Optimism - “to be optimistic about the other player’s responsiveness”[1]
    - Example rules without optimism: DOWNING
- Kingmakers - determine the rank orders among rules in top group
  - Example rules: GRAASKAMP, DOWNING

Summary – 2nd Tournament

- Number of Players: 62
- Length of game: average 151 and 5 times
- Winner: TIT FOR TAT
- Properties of successful rules:
  - Niceness
  - Forgiveness
  - Provocability[2]

Review – Strength 1

- Provided an example in table format to assist explanation on how the game goes between TIT FOR TAT and JOSS, which illustrates the cause of the echo effect, and the degree of the echo effect could go

TABLE 3

Illustrative Game Between TIT FOR TAT and JOSS

moves	1- 20	11111	23232	32323	23232
moves	21- 40	32324	44444	44444	44444
moves	41- 60	44444	44444	44444	44444
moves	61- 80	44444	44444	44444	44444
moves	81-100	44444	44444	44444	44444
moves	101-120	44444	44444	44444	44444
moves	121-140	44444	44444	44444	44444
moves	141-160	44444	44444	44444	44444
moves	161-180	44444	44444	44444	44444
moves	181-200	44444	44444	44444	44444

Score in this game: TIT FOR TAT 236, JOSS 241

Legend: 1 both cooperated
2 TIT FOR TAT only cooperated
3 JOSS only cooperated
4 neither cooperated

[1]

Review – Strength 2

- Implemented additional experiments based on the analysis of tournament results, to demonstrate the robustness of the conclusion

  - TIT FOR TWO TATS (a more forgiveness version of TFT)
  - LOOK AHEAD (an artificial intelligence tree searching algorithm)
  - REVISED DOWNING (a version of DOWNING with optimism)

Review – Strength 3

- Provided detailed summary of all submitted rules so that audience can verify the conclusions by identifying those 3 key attributes easily from those rules

Seventh Place with 473.4 points is a thirteen-line program by James W. FRIEDMAN of the Department of Economics, University of Rochester. This rule cooperates until the other player defects, and then defects until the end of the game. This strategy was described in the context of the Prisoner's Dilemma by Harris (1969). Its properties in a broader class of games have been developed by Friedman (1971). [1]

Review – Place to be improved 1

- Can perform tournament by increasing the length of each game, to mitigate the chance of having biased results
    - End-game effects
    - Probabilistic based rules

Review – Place to be improved 2

- Can provide more examples and analysis to support why attribute *optimism* plays a key role to win the game
  - DOWNING is the only counter example
  - No examples from top-ranking rules

Review – Place to be improved 3

- Can use a better method to determine the rank order of rules, rather than use the average total payoffs per game, to present the rule's performance more accurately
  - Multiple types of rules
  - Single game domination

Review – Extension 1

- Allow participants to submit multiple entries for the game
    - Coordination
    - Communication

Review – Extension 2

- Change game form so each entry plays with all other entries in parallel
    - Global information
    - Dynamic strategy

Questions?

References

1. Robert Axelrod “Effective Choice in the Prisoner’s Dilemma” Journal of Conflict Resolution. Vol. 24 No. 1, March 1980 3-25, Sage Publications, Inc.
2. Robert Axelrod “More Effective Choice in the Prisoner’s Dilemma” Journal of Conflict Resolution. Vol. 24 No. 3, September 1980 379-403, Sage Publications, Inc.