444 Lecture 8.1 - Iterated Prisoners' Dilemma

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Prisoners' Dilemma

Basic Challenge:

- Each player is better off defecting;
- The players are collectively better off if both cooperate.

Tragedy of the Commons

- In a two-player setting, we normally call this Prisoners' Dilemma, or PD.
- In a multi-player setting it's sometimes called the Tragedy of the Commons.
- The story (which may be wildly ahistorical) is that everyone grazed their herds on the commons - which was a good thing to do or else the herd would die - but collectively this made the commons unusable.
- And in the standard story, private property was the solution to the tragedy.

Social Challenge

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- How do we get to cooperation?
- First question is whether in this case we should want to get to cooperation.
- Second question is whether this really is PD.
- Let’s assume that the answer in each case is yes, what do we do.

Change the Payouts

One possible social response is to change the payouts.

- Snitches get stiches is kind of a version of this response.

Change the Options

Another is to make it just impossible for everyone to do the defecting move.

- Enclosures are sort of like this.
- Just like with signaling games, the difference between making something expensive and making it impossible is a little vague, but it's useful conceptually to think of them as separate options.

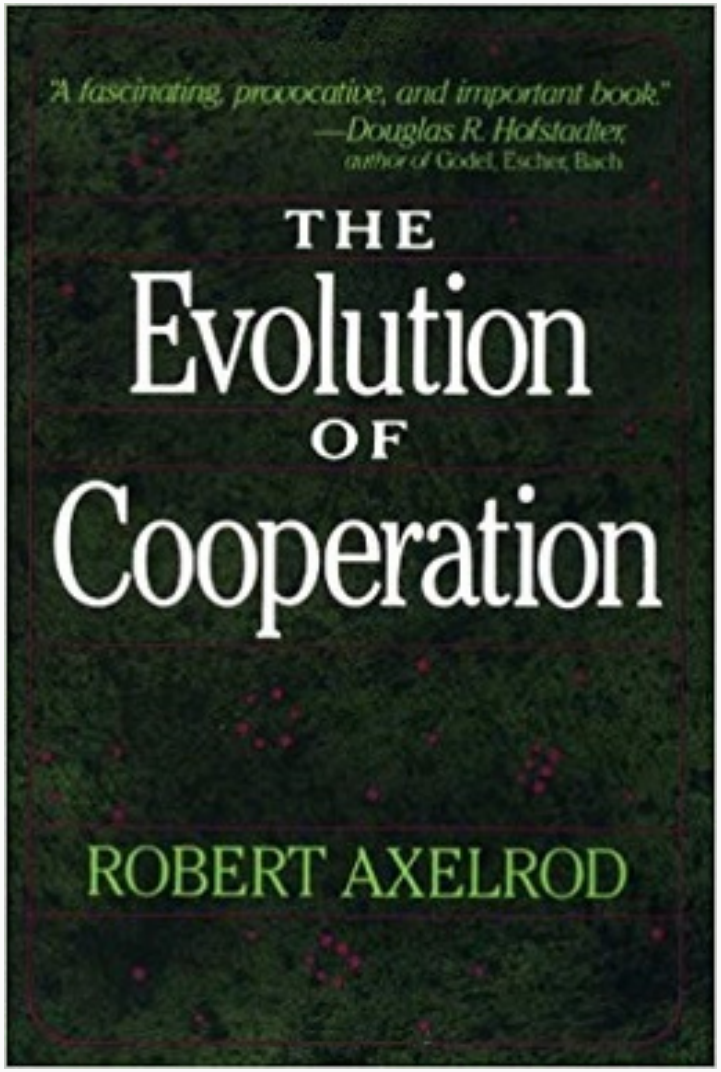
Iterate the Game

- But the simplest way to handle this kind of problem is to iterate the game.
- Arguably it is in everyone's interests to be cooperative if they will have to interact with the other players repeatedly.

Robert Axelrod

Robert Axelrod

The Evolution of Cooperation



Axelrod's Famous 1984 Book

The One Shot Game

Axelrod worked with this version of Prisoners' Dilemma (PD).

	c	d
C	3, 3	0, 5
D	5, 0	1, 1

Indefinite Iteration

In the fancier version of the game, he didn't tell people how long the game would go.

- Instead he just said there was a probability of it ending after each round; if I recall 0.005.
- This was used to avoid backwards induction reasoning.
- It turned out not to really mater a ton; no one uses backward induction reasoning in practice. But it's theoretically useful.

The Tournament

- There are n strategies submitted.
- Strategies are not quite full strategies in our sense; they just say what to do given what the other player did. (They don't account for possible errors in their own performance.)
- Each will play k rounds of PD with each of the other n-1 strategies.
- Their payouts will add up over the k(n – 1) rounds and the one with the highest total will win.

Cooperative and Competitive

- This is not entirely a cooperative game; ultimately if I'm a strategy I want to win, and that means I want the other strategy I'm interaction with to lose.
- But in the short run there is much to be gained by improving our mutual position vs the other n – 2 strategies.
- So in the short run there is a benefit to cooperation, even if we're ultimately rivals.

Iterated Axelrod Game

- Axelrod famously ran a tournament just like the one described here.
- But we can iterate the whole tournament in an interesting way.
- Imagine at the start each strategy is 1/n of the overall 'population'.
- After playing all these games, where each strategy plays k(n – 1) versions of PD, each strategy gets a score.
- In the next round, it's share of the population is a function of (a) its initial population, and (b) its score in this round.
- And in future rounds, one's score is a weighted average of how well one does in games against the other strategies, where the weights are given by their populations.

Evolution of Cooperation

- This is a useful model for thinking about the phenomena in the title of Axelrod's book: The Evolution of Cooperation.
- We want strategies that do well not just when the world consists of random strategies, but when the world consists of strategies that themselves could have survived at least a little bit of evolution.
- At a big picture level this doesn't change a lot about what does well in Iterated PD, but theoretically it could make a difference.
- Strategies that exploit dumb strategies could do well initially, but then fade away.
- Alternatively, some strategies could do badly against bad strategies, but if they survive initial rounds, do well when there are sophisticated strategies around.

Spatial Evolution

- To be even more realistic, you could imagine that each strategy lives ‘somewhere’ in a large grid.
- And at each round, each strategy plays with a weighted average of strategies that live nearby.
- This really does make a difference; some strategies that aren’t great against the world in general are fairly immune to invasion, and can even expand their territory under a range of conditions.

For Next Time

We'll go over the results of the Axelrod tournaments.