Not reproducing Axelrod's original tournament

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Abstract

The Iterated Prisoner's Dilemma is a model used to understand the emergence of cooperation in complex situations. One of the first papers on this topic presented the results of a computer tournament.

This paper presents the unsuccessful attempts made to reproduce these results. As well as describing the general conclusions as it pertains to game theory a discussion about reproducibility of scientific research will also be given.

1 Introduction

The Prisoner's Dilemma was first described in [4] and is represented using the following matrix and constraints:

$$A = \begin{pmatrix} R & S \\ T & P \end{pmatrix} \qquad T > R > P > S \qquad 2R > T + S \tag{1}$$

The constraints ensure a social dilemma where rational actions lead to a Nash equilibrium where both players obtain less than a coordinated outcome. Choosing the first row or column are referred to as "cooperating" whereas choosing the second row or column are referred to as "defecting".

The repeated version of the Prisoners Dilemma: the Iterated Prisoners Dilemma has given rise to a large amount of research. A systematic review of this research is available at [5]. The initial pieces of this body of work relate to the 2 computer tournaments run by Robert Axelrod in the 1980s. These were originally reported in [1, 2] but subsequently lead to [3] which has over 45,500 citations.

The winning of both of the above tournaments was a strategy called Tit For Tat: a strategy that starts by cooperating and then just mimics the previous move of the opponent.

In the next section of this paper an attempt to replicate the work of Robert Axelrod will be described.

2 Results

Previous work by the authors includes the design and continued maintenance of the Python axelrod library [6]. This library is written following best practices in software engineering, most notably that tests are written for all code to ensure accurate behaviour. Secondly, this library is open source which has allowed it to have a large number of contributors this not only adds to the diversity of the code base (specifically to the large number of strategies available) but also further ensures its correctness.

The descriptions of the strategies in Robert Axelrod's first paper [1] are all that is available to be able to reproduce the work: the source code is not available. Some of these are not precise, for example here is a quote from the paper describing one of the strategies:

> "This rule plays Tit for Tat except that it cooperates on the first four moves, it defects on the last two moves, and every fifteen moves it checks to see if the opponent seems to be playing randomly. This check uses a chi-squared test of the other's transition probabilities and also checks for alternating moves of CD and DC."

What is specifically meant by "alternating moves of CD and DC" is ambiguous.

Following careful investigation of the paper the strategies have been implemented in the `axelrod` library and so the tournament can be rerun.

Figure 1 shows the result of a given run of the tournament.

This shows that the results are not actually reproduced. There are a few reasons for which this could be the case:

1. The implementation of the strategies do not correspond to the descriptions in [1].
2. The stochastic effects.
3. The descriptions in [1] do not correspond to the results reported.

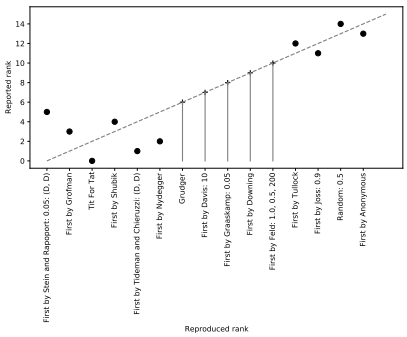

Figure 1: The reproduced results of Axelrod's first tournament.

The first reason is unlikely: a blog post was published at:

`https://vknight.org/blog/posts/reproducing-axelrods-first-tournament/`

due to the open nature of this research project some details were improved in implementations.

To rule out the second reason the tournament was run over a large number of repetitions. The best number of strategies who obtained the same rank was 11 and this occurred less than 0.002 **percent** of the time.

3 Conclusion

This paper presents a study aiming to reproduce the work of Axelrod's first tournament. To the best of the authors' knowledge it is not possible to reproduce these results.

Whether or not the research is reproducible corresponds to an ongoing conversation in modern scientific research [**?**]. Perhaps a more interesting questions is whether or not the overall conclusions remain the same. One of the main conclusions from the victory of Tit for Tat was that cooperation can emerge in complex situations. Figure **??** shows the overall cooperation rate through the evolutionary process through replicator dynamics: cooperation still emerges.

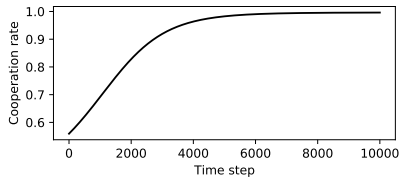

Figure 2: The evolution of the cooperation rate for the tournament of Figure 1

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