Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA16228

Grantee name: Raimundo Julian SAONA URMENETA

Details of the STSM

Title: Robustness, Partial observations and applications

Start and end date: 01/02/2022 to 18/02/2022

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

For theoretical models to be used in practice, they must: (i) provide rigorous guarantees; (ii) be continuous upon perturbations; (iii) solve already existing problems; and (iv), be extensible to take more of reality into account. We aim to tackle each of these issues in different game-theoretical models.

In online-decision algorithms, a player must take irrevocable actions that determine their payoff. A natural objective to look at is the expected payoff of the player. Assuming a random order for the arrival of goods, various algorithms have been analysed, even in partial information settings. Yet, the optimal performance of the player, defined as a comparison with the revenue of an off-line algorithm, is a long and important open question. We aim to reduce the gap by analysing new classes of strategies and studying the hardness of instances.

Matrix Games is the simplest model of game. The stability of its value has been extensively studied in the past. A more realistic model is that of zero-sum Stochastic Games, where the value denotes the payoff player guarantee when they have infinite patience. This limit characterization makes it hard to study its stability upon, for example, stage pay-offs. We aim to translate some recent results on Matrix Games to zero-sum Stochastic Games using a recent characterization that links these two games.

Partial Differential equations model a wide range of phenomena. Some of them, for example the so-called Hamilton-Jacobi equations, can have a game interpretation. This opens the possibility of developing novel applications of Game Theory in the area of PDEs. Taking into account the recent development of highly non-trivial algorithms to solve discrete games, the biggest challenge is to prove a

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

correct discretization scheme for those games that represent PDEs. We aim to characterize classes of PDEs that: (i) do not exhibit fast numerical schemes (yet); (ii) can be represented as games; and (iii), those games can be solved efficiently.

Incorporating partial observations in game theoretical models is complex, even considering only one player. There has been a great interest in a particular one-player model called Partially Observable Markov Decision Process (POMDP) since it is a natural model that has been proven to be undecidable, but yet many computational results can be derived for some subclasses. We aim to identify relevant subclasses that are efficiently solvable.

Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

In this STSM, we have accomplished various objectives. In online-decision algorithms, we stablished a new upper bound for the Prophet Secretary problem. This was possible by studying a particular instance. We expect to generalize this instance. Also, we want to study the special case of non-adaptive strategies. If this succeeds, we would have shown that in order to improve the best lower bound, one needs to consider strategies that are dynamic in nature.

In the stability of zero-sum stochastic games, we have started a new collaboration with Luc Attia, PhD student of Miquel Oliu-Barton and there will be many collaborations taking place. We have started to analyse the stability of the discounted value. The techniques developed here are of key importance to analyse the uniform value. There will be many future collaborations taking place.

In the application of Game Theory to PDEs, we have identified some key difficulties that require further analysis. We obtained new literature to explore and some new names of researchers working in closely related fields, especially in Mean Field Games. We expect to lead a long research program on this topic.

In POMDPs, we have defined simple subclasses that should be decidable. Studying these classes is the first step to understand the difficulty of POMDPs. We have also stablished a collaboration with David Lurie, PhD student of Bruno Ziliotto.