# Comparison between payoff-based learning approaches for Nash equilibrium seeking

TECHNISCHE UNIVERSITÄT DARMSTADT

REGELUNGSMETHODEN & INTELLIGENTE SYSTEME

Bachelor's Thesis Proposal

## Description of the Problem and Background:

Game Theory (GT) is a branch of applied mathematics concerned with modeling games, that is, interactions among multiple players who are seeking optimal strategies. One of the most important strategic optimality concepts in GT is the Nash equilibrium. A Nash equilibrium is a set of strategies, one for each of the players, such that if any one of the players decides to not follow it, while all other players do, that player would only perform worse or equal to what they would have performed had they followed their individual Nash equilibrium strategy.

Although the definition of a Nash equilibrium is conceptually straightforward, determining such an equilibrium is often challenging in practice. The difficulty arises from the interdependence of the players' optimal strategies: the optimal strategy of one player depends on the optimal strategies of the other players, and vice versa. This makes the problem inherently coupled and the computation of Nash equilibria challenging, especially in high-dimensional settings. These considerations motivate the focus on the area of Learning in Games (LiG), and in particular the sub-topic of Nash equilibrium Seeking (NES), which studies how players iteratively adapt their strategies based on repeated interactions with the goal of developing algorithms that converge to Nash equilibria.

A central aspect of LiG is the issue of what information is available to the players. In many practical applications, the parameters influencing the players' performance are private. In other cases, these quantities are generated by physical processes that can only be measured experimentally, which could then also be affected by noise. Moreover, even when complete information is theoretically available, the associated analytical expressions for the performance may be very complex so that their explicit computation is impractical. These reasons prompt the development of payoff-based learning approaches for NES. In such approaches, it is assumed that the only available information is the observed payoff value.

Several payoff-based learning approaches for NES have been discussed in the literature, such as projected descent using gradient estimation, the zeroth-order extragradient method and extremum seeking approaches. These methods have a wide range of applications and are particularly relevant in decentralized economic and engineering settings, such as traffic networks, wireless communication systems, smart grids, energy markets, and autonomous vehicles.

## Tasks and Objectives:

- Conduct a review of the existing literature.
- Choose an application field.
- Implement and simulate the methods.
- Perform a comparative evaluation of the results.

## Prerequisites:

- Solid mathematical skills.
- Basic programming skills.

## Contact:

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