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Phenomenology of Minority Games in Efficient Regime

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We present a comprehensive study of the utility function of the minority game in its efficient regime. We develop an effective description of the state of the game. For both the step-like payoff function g(x) = sgn(x) and the proportional function g(x)=x, we explicitly represent the game as the Markov process and prove the finiteness of number of states. We also demonstrate boundedness of the utility function. Using these facts we can explain all interesting observable features of the aggregated demand: appearance of strong fluctuations, their periodicity, and existence of preferred levels.

Detailed analysis

Minority game (MG) was designed as a microscopic model of adaptive behavior observed in multi-agent systems. The MG is a typical bottom-up construct and therefore the usual definitions of the game first specify rules of behavior for individuals. Then, piecing together microscopic variables, one defines higher-order quantities characterizing grander systems. Despite the simplicity of the basic rules of taking decisions by agents, adaptive abilities and phenomenology of populations playing MGs appear to be surprisingly interesting and their properties are nontrivial. It was shown that the MG exhibits different modes of behavior, depending on the game parameters: the random, cooperation, and herd. The latter case is characterized by a small strategy space compared to the overall number of agents. Our study of this regime is motivated by the interesting phenomenology observed in numerical simulations and the lack of satisfactory interpretations of them. In our previous work we found, in a different context, that the crucial role in the explanation of observable behavior in the MG is played by the utility function. Therefore, we further exploit the utility to study the phenomenology of MGs in their efficient regime.

Conclusions and Future Work

MG is a stochastic, multi-agent model where some interesting phenomena are observed only for large populations. The analysis of each set of parameters requires the processing of copious sets of realizations of the game but no synchronicity, and therefore no heavy data traffic during execution, is needed between them. Using the EGEE infrastructure we were able to study the MG in the deep efficient mode. Our results are based on more than 7000 runs, where each lasted from few minutes to few hours. We observed interesting collectivity in agent behavior and provided the detailed mathematical explanation.

Impact

Depending on the payoff function g(x), the game is driven by different dynamics which requires different methods of the analysis. For the step-like payoff function g(x) = sgn(x), we explicitly represent the game as the Markov process and prove the finiteness of number of states. Since the MG represents a system with many degrees of freedom, the dimensionality of states is expected to be large. We demonstrate the boundedness of the utility function which allows for the substantial reduction of the number of state parameters and simplification of the state description. For the step-like payoff the state is reduced to (i) a history of m minority

decisions and (ii) utilities of all pairwise different strategies. For the proportional payoff, $g(x) = x$, the number of states is still finite and the utility remains bounded, but effective analysis requires a different concept of state. In such a case, the state is based on the order of utilities in the ordered list instead of their values. Using these representations we can explain all interesting observable features of the aggregated demand: the appearance of strong fluctuations, their periodicity, and the existence of preferred levels.

Keywords

Minority game; adaptive system; Markov process; de Bruijn graph; EGEE infrastructure

URL for further information

http://kargul.polgrid.pl

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