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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

With the increasingly connected world, many systems can be modeled as games where dynamic agents interact noncooperatively with each other. Game theory is increasingly found to be useful to understand such systems. In general, there are two approaches in game theory: the descriptive approach, and the prescriptive approach. In the descriptive approach, the goal is to explain the behavior of agents in noncooperative situation. The descriptive approach can be found in economics or biology. In the prescriptive approach, the goal is to prescribe the behavior of agents in a noncooperative system such that the system behaves in a desirable manner. This approach can be found in engineering and computer science. In the first part of this thesis, using the prescriptive approach, we design Nash equilibrium seeking inputs for agents with multiple-order dynamics. We investigate the case of second-order dynamic agents and linear time-invariant dynamic agents in noncooperative games. In the second part, using the descriptive approach, we investigate the behavior of self-improving agents with quadratic payoff such that their payoffs are nondecreasing. We investigate the case where agents influence each other positively in the entire states, that is, the case of a game with totally positive externalities and the case where agents influence each other positively only in a certain set of positive externalities.

First, we design two Nash equilibrium seeking inputs for agents evolving under second-order dynamics. To develop the Nash equilibrium seeking inputs, we use tools from convex optimization and monotone operator. Inspired by the vanishing damping and Nesterov's gradient descent algorithms in convex optimization, we develop two Nash equilibrium seeking dynamics with similar forms to the corresponding optimization algorithms. Different from existing literatures that assume strong monotonicity on the pseudo-gradient, we prove convergence to the Nash equilibrium by assuming only cocoercivity condition on the pseudo-gradient. We note that the notion of cocoercivity is weaker than the notion of strong monotonicity. Furthermore, in the case of vanishing damping input, we are able to provide sufficient conditions for global uniform asymptotic stability for the Nash equilibrium.

Then, we consider the problem of Nash equilibrium seeking for agents with linear time-invariant dynamics. In this setting, first, we provide sufficient conditions for the existence and uniqueness of the Nash equilibrium of the game. Then, we use a passivation method to develop the Nash equilibrium seeking dynamics. By using the notion of incremental passivity, we construct a Lyapunov function to show the stability of the Nash equilibrium. Our approach can also accommodate a class of nonminimum phase linear time-invariant agents.

In the second part of the thesis, we begin by characterizing the behavior of self-improving agents in the game with totally positive externalities, that is the game where all agents influence each other positively everywhere in the state space. We show that if each agent evolves under affine dynamics and possesses quadratic payoff, then the class of pseudo-gradient agents coincide with the class of self-improving agents. In the case of self-improving agents with quadratic payoffs, we provide necessary and sufficient algebraic conditions for the game to have totally positive externalities. We also show that in such a game, there always exists a unique Nash equilibrium. Furthermore, we prove that if a certain condition relating the zeros of the pseudo-gradient and the equilibria of the dynamics holds, then the unique Nash equilibrium is asymptotically stable. Then, considering the pattern graph of the game, we show that if the pattern graph is connected, then the game by self-improving agents with totally positive externalities is a weighted identical interest game.

Then, we investigate the case of two pseudo-gradient agents with quadratic payoffs in noncooperative games. We introduced the set of positive externalities as the set where both agents influence each other positively. We show that the set of positive externalities is a union of convex polyhedra. Because the union of convex polyhedra is not necessarily connected, we provide sufficient conditions for connectedness of the set of positive externalities. When the set of positive externalities is a union of shifted polyhedral cones intersecting only at the unique Nash equilibrium, we show that this set is not a positively invariant set of the pseudo-gradient dynamics. However, we show that a certain subset of this set is a positively invariant set of the pseudo-gradient dynamics and provide sufficient conditions such that this subset of the set of positive externalities is positively invariant.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
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