Stability and Chaos in Multi-Agent Reinforcement Learning

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Abstract

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Draft Outline

1. Introduction - Contributions
   - Analysis of Network Q-Learning with varying parameters and number of players
   - Show that the prevalence of chaotic dynamics remains unaffected by the number of players in the game
   - Show that QL cannot give chaos in 2 action matrix games
   - As an example: QL can stabilise the rock-paper-scissors game, for which RD is chaotic
   - Numerical Simulations to find the convergent behaviour in Network QL Games
   - Numerical Simulations to determine Lyapunov Exponents in Network QL Games
2. Preliminaries
   - Network Q-Learning Dynamics
   - Maximum Entropy Argument for Gaussian Payoffs
3. Stability of Q-Learning
   - *AH: For the sake of space it may actually be best to not present the equations themselves, but rather their visualisation*
   - Present numerical simulations of theory
4. Analysis of Q-Learning in 2 action games
   - Present discussion of results and what it means for the eigenvalues to have no imaginary component (*AH: Need to find a reference for this*) (cite original paper which looked at this problem for RD)
5. Experimental Evaluation
   - Construction of Numerical Experiments: Convergence and Lyapunov
   - Discussion: Correspondence with theory and implications for RL. Comparison with Sanders' result
6. Conclusion

Outline for Supplementary Material

(a) Introduction
(b) Dynamics of Q-Learning
(c) Generating Functional Analysis (same as what we already have)
(d) Stability of Q-Learning in 2x2 games
   - Proof that Q-Learning is invariant under linear transformations of the payoff matrix
   - Derivation of the Jacobian for Q-L (cite Piliouras for the diagonal elements)
   - Eigenvalue for non-zero fixed points, explaining why fixed points do not occur on the boundary. Show that they are real valued (cite result of eigenvalue of sum being sum of eigenvalues)
(e) Further Numerical Experiments
   - Lyapunov
   - Convergence