Abstract

Learning to make optimal decisions under uncertainty is the central objective of reinforcement learning (RL), encompassing a broad spectrum of problems from simple stateless action selection, as in multi-armed bandits, to complex sequential decision making in high-dimensional environments. Regardless of their complexity, these problems are unified by the challenge of learning effective behaviour from sparse or limited interaction with the environment, where every action must be chosen with incomplete knowledge of its long-term consequences, and exhaustive exploration is often impractical. This makes it essential to generalize from limited data and to leverage underlying patterns or structure, whether in actions, states, or trajectories, to guide learning. This thesis explores how granular computing, through techniques such as rough set-based approximations, abstraction, and clustering, can provide a principled framework for structuring the learning process and enhancing efficiency in various RL settings. In this thesis, for bandit problems, rough set theory is employed to dynamically group arms into lower, upper, and boundary approximations of a rough set, thereby guiding exploration toward promising options and accelerating convergence. For discrete-state RL problems, a novel state space clustering technique is proposed. Using this state space clustering technique and cluster prototype selection mechanism, hierarchical abstractions are constructed, which make the policy iteration and value iteration algorithms efficient by substantially reducing computational cost while maintaining solution quality. For Monte Carlo methods in Reinforcement Learning, a rough set-inspired state abstraction framework is proposed. The proposed framework compresses long trajectories into transitions between clusters and speeds up convergence in Monte Carlo methods. Collectively, these contributions in this thesis illustrate how granular computing can enhance learning efficiency across diverse RL settings.

Keywords: Granular Computing, Reinforcement Learning, Multi-Armed Bandits, Rough Set, Abstraction, Clustering, Monte Carlo Methods