



Reinforcement Learning: Emerging Trends and Future Research Directions

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ABSTRACT

Reinforcement learning (RL) is a small solved part of sequential decision-making theory, and has emerged over the last ten years as one of the most active and productive fields of research in the field of artificial intelligence (AI). It has propelled advancements across various fields, including game playing, robot control, and the recently explored application of aligning large language models with human goals. This paper provides a brief overview of the research field in a structured way. First, it presents the formalism of the Markov decision process and the main classes of algorithms developed on top of it, and subsequently analyzes six research directions that are driving the field today, namely deep reinforcement learning, model-based reinforcement learning, offline reinforcement learning, multi-agent reinforcement learning, reinforcement learning from human feedback for language-model alignment, and safe and robust reinforcement learning. It then summarizes some typical application areas (robotics, autonomous driving, healthcare, communication networks, and games) and introduces some open problems: sample efficiency, reward design, generalization, and safety verification. It ends with the presentation of future research opportunities such as hybrid models-based/model-free architectures, online/offline training pipelines, scalable ways of human supervision, and RL approaches for future communication networks.

Keywords: Reinforcement learning, deep reinforcement learning, offline reinforcement learning, multi-agent systems, reinforcement learning from human feedback, safe reinforcement learning, Markov decision process, autonomous systems.