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Optimizing Mobile Robot Navigation Through Neuro-Symbolic Fusion of Deep Deterministic Policy Gradient (DDPG) and Fuzzy Logic

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Abstract
Mobile robot navigation has been a sector of great importance in the autonomous systems research arena for a while. For ensuring successful navigation in complex environments several rule-based traditional approaches have been employed previously which possess several drawbacks in terms of ensuring navigation and obstacle avoidance efficiency. Compared to them, reinforcement learning is a novel technique being assessed for this purpose lately. However, the constant reward values in reinforcement learning algorithms limits their performance capabilities. This study enhances the Deep Deterministic Policy Gradient (DDPG) algorithm by integrating fuzzy logic, creating a neuro-symbolic approach that imparts advanced reasoning capabilities to the mobile agents. The outcomes observed in the environment resembling real-world scenarios, highlighted remarkable performance improvements of the neuro-symbolic approach, displaying a success rate of 0.71% compared to 0.39%, an average path length of 35 m compared to 25 m, and an average execution time of 120 s compared to 97 s. The results suggest that the employed approach enhances the navigation performance in terms of obstacle avoidance success rate and path length, hence could be reliable for navigation purpose of mobile agents. © The Author(s), under exclusive license to Springer Nature Switzerland AG 2024.

Author Keywords
DDPG; Fuzzy logic; Mobile robot navigation; Obstacle avoidance; Simulation

Index Keywords
Air navigation, Computer circuits, Fuzzy inference, Learning algorithms, Mobile robots, Reinforcement learning; Complex environments, Deep deterministic policy gradient, Deterministics, Fuzzy-Logic, Mobile Robot Navigation, Obstacles avoidance, Policy gradient, Rule based, Simulation, Systems research; Mobile agents

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