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Bio-inspired motion planning for reaching movement of a manipulator based on intrinsic tau jerk guidance

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Abstract This study proposed a bio-inspired motion planning approach for the reaching movement of a robot manipulator based on a novel intrinsic tau jerk guidance strategy, which was established by some cognitive science researchers when they studied motion patterns through biology. In accordance with the rules of human reaching movement, the intrinsic tau jerk guidance strategy ensures continuity of the acceleration; further, it also ensures that its value is zero at the start and end of the movement. The approach has been implemented on a three-degrees-of-freedom 3R planar manipulator. The results show that, within a defined time, both the position gap and attitude gap can be reposefully closed, and the curves of joint velocity, acceleration, and driving torque are continuous and smooth. According to the dynamic analysis, the proposed approach tends to consume less energy. The bio-inspired method has the potential to be applied in particular scenarios in the future, such as a mobile robot with a manipulator exploring an unknown environment.

Keywords Bio-inspired · Motion planning · Manipulator · Reaching movement · Intrinsic tau jerk guidance

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1 Introduction

Nowadays, robots are especially designed for repetitive or dangerous tasks that humans are unwilling or unable to do. Many designs of robots are inspired by animals or humans. Robot manipulators, modeled on the human arm, have been extensively applied in many fields, such as industrial assembly, biomedical assistance, and space exploration. Owing to the size limit or the extreme nature of environments, increasingly challenging tasks that are performed by human arms can be expected to be performed by robot manipulators. One of the challenges is that a robot manipulator must perceive contact efficiently, and guide and control its movement robustly to reach the contact or target point, with not only high spatial accuracy, but also high temporal accuracy.

Many existing motion planning approaches for robot manipulators are based on geometric curves, such as the cubic spline function, higher-order polynomial, or non-uniform rational B-splines. Piazzi and Visioli [1] proposed a spline-based trajectory planning method. Lippiello and Ruggiero [2] presented a 3D robotic ball catching algorithm based on high-order polynomial functions. Although the trajectories generated by these methods are smooth, it is difficult to satisfy both continuity of acceleration and lower computational complexity. There are also some trajectory optimization methods regarding the catching movement of robots, but their optimal performance may change under different application conditions [3, 4].

It is well known that, compared with the controller of a robot, the biological control mechanism of humans has evolved over millions of years. This mechanism allows humans to perform any agile motion with high spatial and temporal accuracy—for example, catching a flying baseball or capturing a mosquito fluttering in the air. Even newborns