Fast and Robust Inverse Kinematics of Serial Robots using Halley's Method

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Abstract

This talk presents a novel numerical inverse kinematics algorithm called the *Quick Inverse Kinematic*s or *QuIK* method. The QuIK method is a *third-order* algorithm that uses both the first and second-order derivative information to iteratively converge to a solution. Numerical inverse kinematics methods are readily implemented on any serial robot and do not rely on joint alignment. However, they typically are slower and less robust. The added second-order derivative term allows the QuIK algorithm to converge more rapidly and more robustly than other existing algorithms. A damped extension to the QuIK method is also presented to increase reliability near robot singularities. The QuIK methods are tested in terms of evaluation speed, reliability, and singularity robustness against the Newton-Raphson method in inverse kinematics, as well as several other modern inverse kinematics algorithms. The proposed QuIK methods outperform all other tested algorithms, with up to 75% faster evaluation speed and 8–35× fewer failures. The QuIK algorithms are otherwise similar to the Newton-Raphson methods and are proposed as faster and more robust "drop-in" replacements to existing modern inverse kinematic solvers. C++ and Matlab codebases are made available for public use.

Relevant Prior Publications:

S. Lloyd, R. A. Irani, and M. Ahmadi, "Fast and Robust Inverse Kinematics of Serial Robots Using Halley's Method," in IEEE Transactions on Robotics, 2022, doi: 10.1109/TRO.2022.3162954.

Author Biography

Steffan Lloyd is a Ph.D. candidate with the Department of Mechanical & Aerospace Engineering at Carleton University, under the co-supervision of Dr. Mojtaba Ahmadi at the Advanced Biomechatronics and Locomotion Laboratory (ABL) and Dr. Rishad Irani with the Multi-Domain Laboratory (MDL). Steffan received his B. Eng. degree in mechanical engineering from Carleton University, Ottawa, Canada, in 2015. He worked as a mechanical designer in aerospace robotics at Advanced Integration Technologies (AIT) in Umeå, Sweden, from 2016-2018, before beginning his Master's and Ph.D. work at Carleton University. His research interests are robotics, kinematics, and control, and his current Ph.D. works seeks to improve the feasibility of robotic machining through novel dynamic, kinematic, and control solutions.