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A high accuracy on-line estimation algorithm of five-axis contouring errors based on three-point arc approximation

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Abstract

High-accuracy on-line contouring error estimation plays a significant role in contouring accuracy control of multi-axis CNC machining. This paper focuses on developing a high-accuracy on-line estimation algorithm of five-axis contouring errors based on three-point arc approximation (TPAA). The nearest reference tool tip position related to the actual one is searched at first, then the tool tip position contouring error is estimated by the distance between the actual position and the arc formed by the nearest reference tool tip position and its two adjacent reference positions. Similar to the tool tip position, the TPAA algorithm is also conducted to estimate the tool orientation contouring error in the unit spherical coordinate system, where equal proportional factors of the tool tip position and the tool orientation arc-lengths are adopted to ensure the synchronization of the tool tip position contouring error and the tool orientation contouring error. The proposed contouring error estimation algorithm is adapted to different trajectory types and has higher estimation accuracy than linear segment approximation (LSA) algorithm for trajectory segments with high curvature. Various experiments with different testing tool paths are performed on an in-house developed five-axis experiment platform to verify the effectiveness of the proposed algorithm, and the results show that the proposed TPAA algorithm can estimate contouring errors with higher accuracy than existing algorithms based on the curvature arc iterative (CAI) algorithm and the LSA algorithm.

Keywords: Five-axis, contouring errors, three-point arc approximation, CNC, tool path

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