ABSTRACT

This study presents the implementation of a Feedforward Neural Network model for trajectory planning on a 3-DOF SCARA robotic arm performing autonomous pick-and-place tasks. The objective of this research is to analyze the accuracy of the end-effector’s trajectory relative to the ideal straight-line path from the starting point to the target point, as well as the smoothness of the motion through jerk measurements. The neural network-based trajectory planning model was trained using synthetic trajectory data in Cartesian coordinates, augmented with Gaussian noise and deviation-based labels. The trained model was integrated with an STM32F407 microcontroller and implemented in real-time, where the generated Cartesian waypoints were converted into joint angle commands through inverse kinematics.

When the trajectory planning model is applied, the end-effector path achieves a deviation value of 0.21 cm to 0.34 cm from the ideal straight line, whereas when each joint is only commanded to move from the start position to the end position, the deviation value is 2.41 cm to 10.37 cm from the ideal straight line. However, the average jerk also increases due to more segmented joint movements caused by the large number of closely spaced waypoints. When the trajectory planning model is applied, joint J1 experiences an average absolute jerk of 0.31 rad/s^3 to 0.48 rad/s^3 and J2 of 0.56 rad/s^3 to 0.85 rad/s^3, whereas when each joint is only commanded to move from the start to the end position, joint J1 experiences an average absolute jerk of 0.36 rad/s^3 to 0.23 rad/s^3 and J2 of 0.21 rad/s^3 to 0.62 rad/s^3. Overall, this implementation demonstrates that the neural network-based model improves the trajectory accuracy of the 3-DOF SCARA robot's end-effector relative to the ideal straight-line path, although trade-offs in motion smoothness must be considered.

Keywords: trajectory planning, neural network, SCARA robot, jerk analysis.

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