Tremor-Adaptive Assistive Dining Solution: A Robotic Arm Integrating Computer Vision and Active Stabilization for Enhanced Autonomy

Shao, Tianhao (School: Shanghai Starriver Bilingual School)

In the context of an increasingly technological society and a demographic trend towards an aging population, the challenge of aiding individuals with compromised hand functionality in conducting activities of daily living—such as self-feeding—has emerged as a critical societal concern. This study introduces a novel automatic feeding system, leveraging a 6-axis robotic arm that incorporates servo control, computer vision, deep learning, and filtering technologies. These components synergize to facilitate precise feature detection and efficient feeding under highly unstable conditions. The system features a versatile mechanical framework and an anti-shaking mechanism, employing inverse kinematics and gradient descent algorithms to achieve stable and accurate operation of the robotic arm. To counteract environmental vibrations, the system includes a dual-servo anti-tremor assembly, which has demonstrated a significant reduction in food spillage by 74%. The control mechanism integrates sophisticated algorithms, including Kalman filtering for the fusion of sensor data and predictive control, thereby improving the robotic arm's responsiveness and adaptability. For precise localization of facial features, the system utilizes 3D Time-of-Flight (TOF) cameras in conjunction with OpenCV and Dlib frameworks, applying neural network models to identify essential facial coordinates accurately. Furthermore, the integration of YOLO (You Only Look Once) algorithms for gesture recognition enhances the system's autonomy and interactive capabilities with users. This research has successfully developed an automated robotic feeding system through real-time data processing to assist individuals with neurological impairments in self-feeding, while adapting to their dynamic needs.

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