Real-Time Motion Assessment for Remote Rehabilitation Using Monocular 2D Pose Estimation

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Abstract:

Demand for accessible physical therapy has accelerated interest in tele-rehabilitation models that can extend monitoring and coaching beyond the clinic. Bibliometric analysis confirms a rapid intensification of research in this domain during the COVID-19 era, evidenced by numerous publications peaking between 2019 and 2021. Real-world telehealth physical therapy programs also show meaningful uptake and patient acceptability.

To bridge this gap and enhance therapeutic adherence, this study proposes an AI-driven tele-rehabilitation system that delivers objective, scalable motion analytics using consumer-grade cameras. The architecture integrates YOLOv11 to perform robust 2D human pose estimation from monocular RGB video, transforming raw visual inputs into structured biomechanical indicators, including joint angles, range of motion (ROM), and movement symmetry. Model performance is evaluated by quantifying keypoints localization accuracy and the stability of derived clinical metrics under rehabilitation-relevant motion variability. By digitizing motion assessment, the framework aims to support continuous monitoring, early detection of compensatory patterns, and greater operational efficiency in telehealth services.

Keywords:

Tele-rehabilitation, human pose estimation, motion analysis, yolo.