ABSTRACT

Thesis title: Pose Estimation of Surgical Instruments using Convolutional Neural Networks for MIS Applications

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Accurate detection and pose estimation of surgical instruments are critical for computer-assisted interventions (CAI) and robotic-assisted surgeries. This research proposes an innovative method for detecting and estimating the pose of multiple surgical tools using the YOLOv8-pose model. A comprehensive dataset comprising images of clippers, irrigators, and scissors was meticulously collected and annotated to train the model, facilitating precise localization and orientation estimation of these instruments during laparoscopic procedures.

The performance of the model was assessed using a test dataset across four variants of YOLOv8-pose. Notably, the YOLOv8n variant, characterized by its lightweight architecture with only 3 million parameters, exhibited superior performance in both pose estimation and object detection tasks. For pose estimation, it achieved a Precision of 91%, Recall of 93%, mean Average Precision at IoU 0.5 (mAP@0.5) of 97.9%,

and mAP@0.5-0.95 of 88.7%, underscoring its capability to reliably track surgical instruments. In terms of object detection, the model recorded a Precision of 97.9%, Recall of 96.0%, mAP@0.5 of 99.2%, and mAP@0.5-0.95 of 64.6%, demonstrating robust identification and real-time tracking of multiple instruments in surgical settings.

These findings affirm YOLOv8n as an exceptionally efficient model for real-time surgical instrument tracking and pose estimation, rendering it highly suitable for integration into robotic-assisted and minimally invasive surgical systems. Furthermore, this study establishes a foundation for extending the

methodology to encompass additional surgical instruments, thereby advancing automation and precisionin AI-driven surgical technologies