Abstract: C-arm Positioning for Standard Projections During Spinal Implant Placement

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Fluoroscopy-guided trauma and orthopedic surgeries involve the repeated acquisition of correct anatomy-specific standard projections for guidance, monitoring, and evaluating the surgical result. C-arm positioning is usually performed by hand, involving repeated or even continuous fluoroscopy at a cost of radiation exposure and time. We propose to automate this procedure and estimate the pose update for C-arm repositioning directly from a first X-ray without the need for a patient-specific computed tomography scan (CT) or additional technical equipment. Our method is trained on digitally reconstructed radiographs (DRRs) which uniquely provide ground truth labels for an arbitrary number of training examples. The simulated images are complemented with automatically generated segmentations, landmarks, and with simulated k-wires and screws. To successfully achieve a transfer from simulated to real X-rays, and also to increase the interpretability of results, the pipeline was designed to closely reflect the actual clinical decision-making process followed by spinal neurosurgeons. It explicitly incorporates steps such as region-of-interest (ROI) localization, detection of relevant and view-independent landmarks, and subsequent pose regression. The method was validated on a large human cadaver study simulating a real clinical scenario, including k-wires and screws. The proposed procedure obtained superior C-arm positioning accuracy of $d\theta = 8.8° \pm 4.2°$ average improvement ($p_{t-test} \ll 0.01$), robustness, and generalization capabilities compared to the state-of-the-art direct pose regression framework [1].

References

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