AI-Driven Wearable Systems for Detecting Medication Preparation Errors in Operating Rooms

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Abstract

Medication errors during surgical procedures are a significant, preventable threat to patient safety, with the burden falling hardest on resource-constrained settings where safeguards such as barcode-assisted medication administration are difficult to deploy. Wearable, AI-driven camera systems have been proposed as a passive, low-cost alternative for detecting medication preparation errors without disrupting clinical workflow, but no prior study had evaluated such a system end to end, from a GPU-trained model to an affordable, field-deployed embedded device. This thesis closes that gap. The research collected and annotated a large-scale, first-person video dataset of anesthetic drug preparation across high- and low-resource operating-room settings in the United States and Uganda; developed and evaluated computer-vision models for syringe and vial drug-label recognition and mismatch detection, achieving 99.6% sensitivity and 98.8% specificity in the United States and mAP50 of 0.86 in Uganda; formally benchmarked these models on the deployed Raspberry Pi hardware, finding they do not reach real-time throughput (34× to over 1,700× slower than GPU-measured figures) and that this gap is driven primarily by the change in clinical environment rather than by lighter detector architectures; and designed, fabricated, and field-evaluated a low-cost wearable platform, valued by ten Ugandan anesthesiologists in field testing. The work contributes a large annotated dataset, a validated detection framework, the first formal GPU-to-embedded-hardware benchmark for this system class, and a field-tested wearable platform, providing a foundation for future clinical translation.