Development of an Augmented-Reality Interface for Virtual Monitor Display During Robotic Surgery: A Feasibility Study

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Background

Robotic-assisted surgery enhances precision through three-dimensional (3D) visualization and instrument control, significantly benefiting the surgeon. However, the same visualization advantages are not extended to non-surgeon personnel in the operating room, whose views are often compromised by glare or obstructed by equipment.

This study aims to address this gap by developing an effective Augmented Reality (AR) interface using an Apple Vision Pro (AVP) headset, integrated with the Da Vinci Surgical Robot. The AR interface is designed to project virtual monitors into the user's field of view, potentially improving visibility for non-surgeon personnel.

Methods

The system used a Network Device Interface (NDI) to transmit a virtual monitor to an Apple Vision Pro headset. The Intuitive Vision Cart outputs video signal via HDMI to a Kilo View N40 NDI transmitter, which encodes video and sends the feed over wired Ethernet to a Wi-Fi router. The router wirelessly transmits the signal to the Vision Pro headset, allowing non-surgeon personnel to view images on a virtual monitor.

Qualitative testing was performed by surveying (N=7) volunteers' opinions about the system's feasibility. Quantitative testing using a programmed reaction time test on a personal laptop was performed using 4 conditions (N=5): direct vision, in-room monitor, surgeon console, and AVP headset. Reaction times were analyzed using a linear mixed-effects model, accounting for repeated measures and the fixed effect of vision condition. Repeated pairwise comparisons were performed and analyzed using Tukey's post-hoc adjustment.

Results

Figure 1: Reaction Times Across Vision Conditions

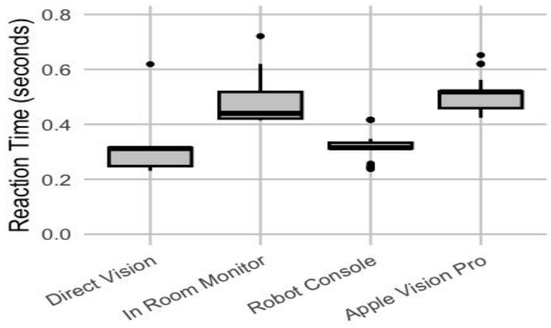


Figure 2: Schematic of Augmented Reality Interface for Virtual Monitor

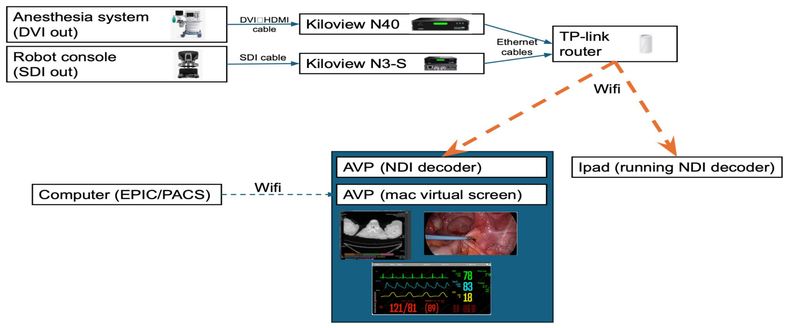


Figure 3a: Perspective of Circulating Nurse

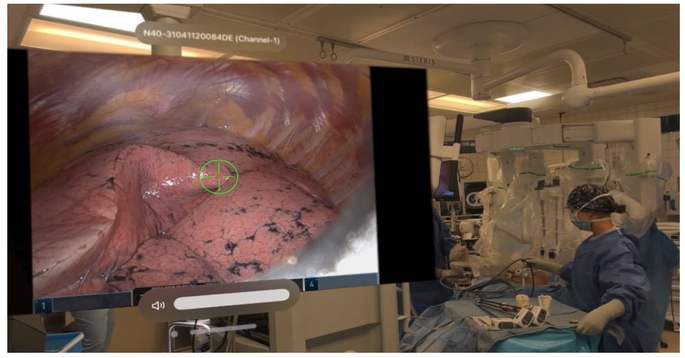


Figure 3b: Perspective of Beside Assistant

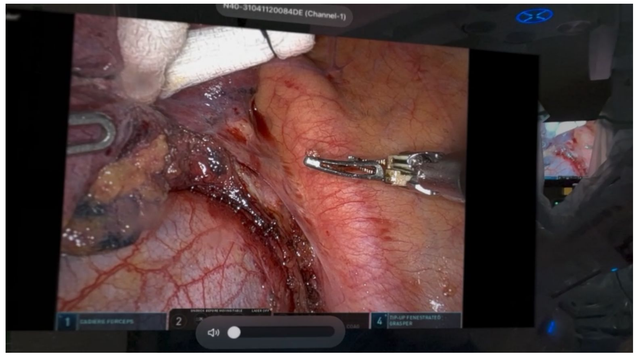
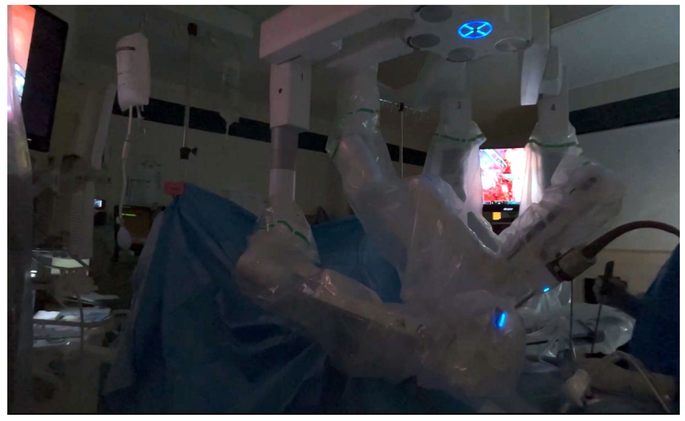
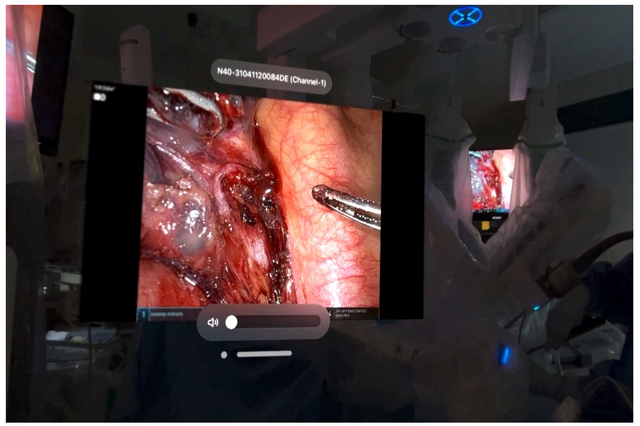


Figure 3c: Perspective of Beside Assistant With and Without Augmented Reality Interface





Results

Seven subjects tested the system, with qualitative feedback indicating satisfactory mobility, comfort, and image quality.
Five volunteers performed reaction time testing, revealing a significant reaction delay in all video image systems compared to direct vision ($p < 0.001$).

Conclusions

Augmented Reality monitors may offer similar or improved visualization to endoscopic images for non-surgeon personnel during robotic assisted surgery. Further study is necessary to demonstrate safety and efficacy profiles and to develop more efficient surgical workflows and better support for non-surgical personnel in robotic-assisted procedures.

Future Work

Prospective, comparative study of AR-based virtual monitors in the OR and during simulation, comparing traditional auxiliary monitors with AR-based monitors in terms of visibility, usability, and impact on non-surgical personnel's workflow.

Subjects: Non-surgical personnel (e.g., anesthesiologists, circulating nurses, surgical technologists, surgical residents, physician assistants, and medical students).

Structured questionnaires administered after each surgery using Surgery Task Load Index (SURG-TLX) along with qualitative interviews.

References

Wilson MR, Poolton JM, Malhotra N, Ngo K, Bright E, Masters RS. Development and validation of a surgical workload measure: the surgery task load index (SURG-TLX). *World J Surg*. 2011;35(9):1961-1969. doi:10.1007/s00268-011-1141-4