Understanding Effects of Visual Feedback Delay in AR on Fine Motor Surgical Tasks

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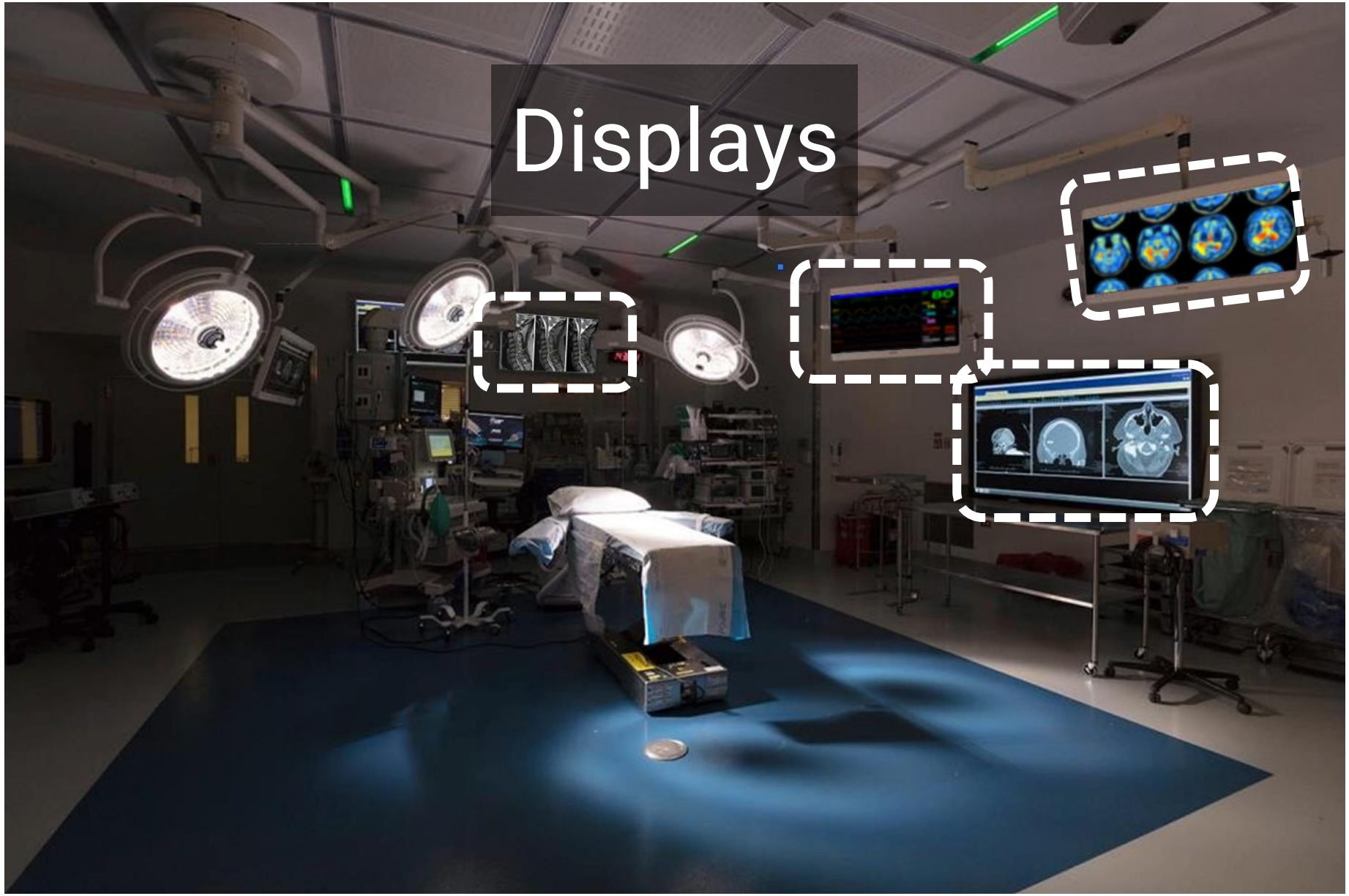
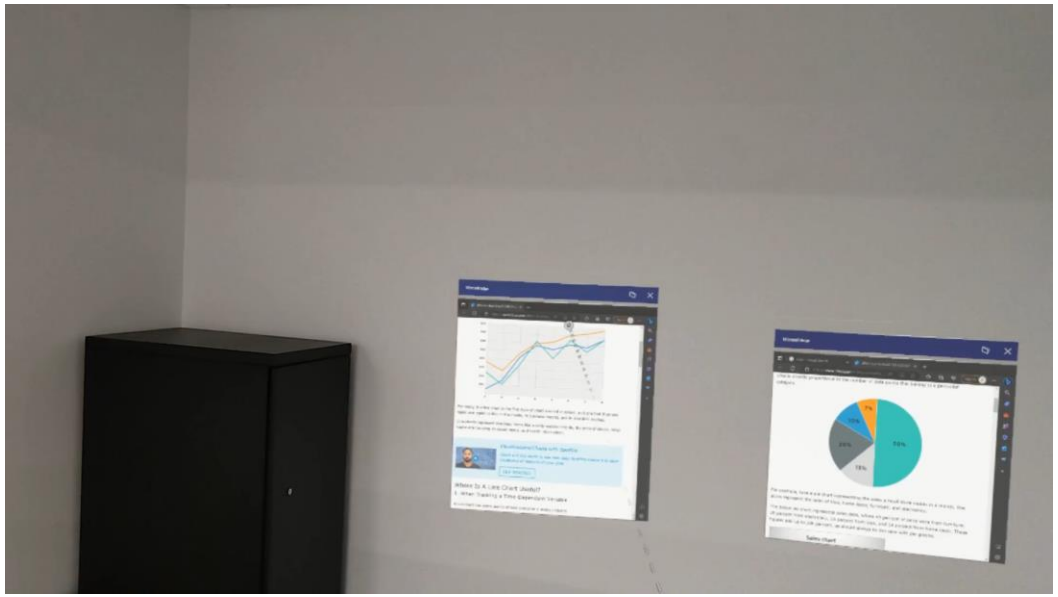

Displays

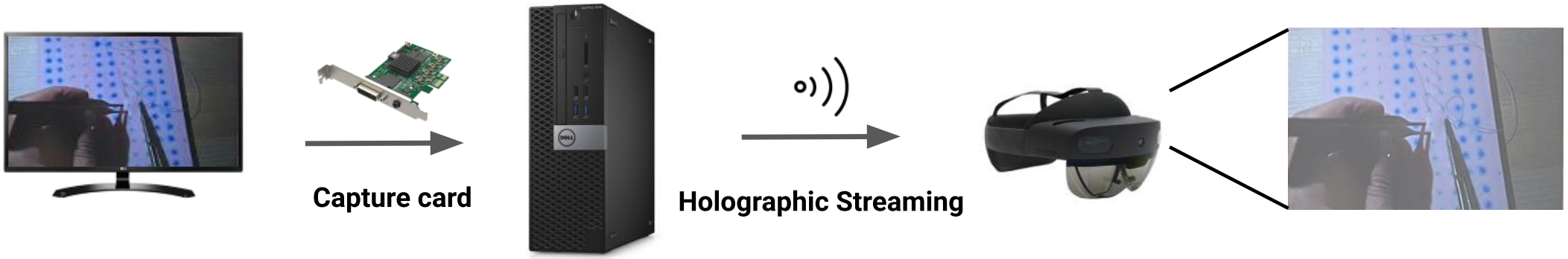
Augmented Reality Displays are Ergonomic



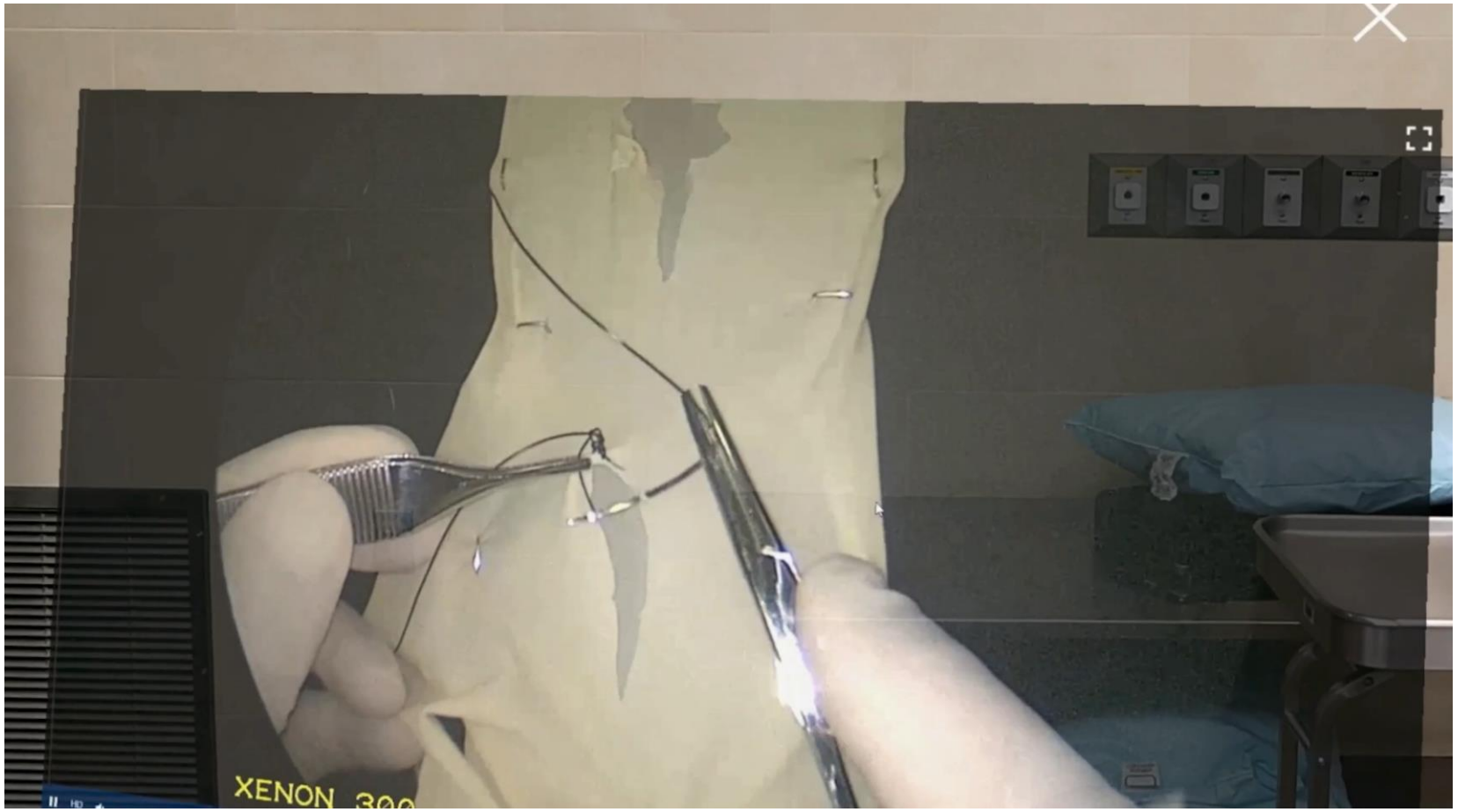
Position

Scale

System Pipeline



Problem? Visual Delay or Latency

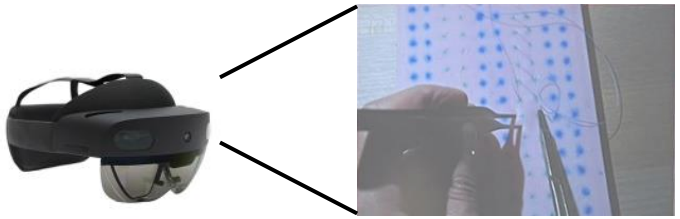


End-to-End Latency

- How long it takes an action to reflect on the display

Surgical Stream

~50 ms



AR Headset (HoloLens 2)

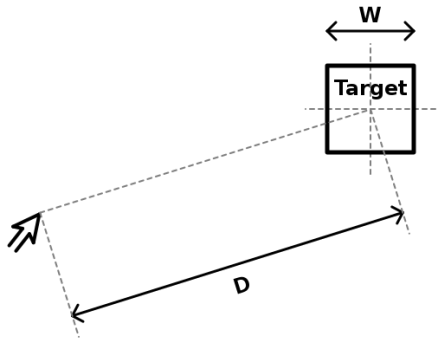
~100 ms

- **RQ1:** how latency impacts **motor task performance** for an AR display?

- **RQ2:** how does latency impact **users' perception** for an AR display?

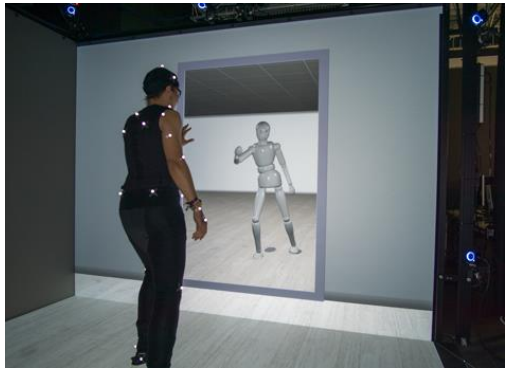
Compared to a conventional display

Latency Impacts Motor Performance



Fitts' Law

FPS Games

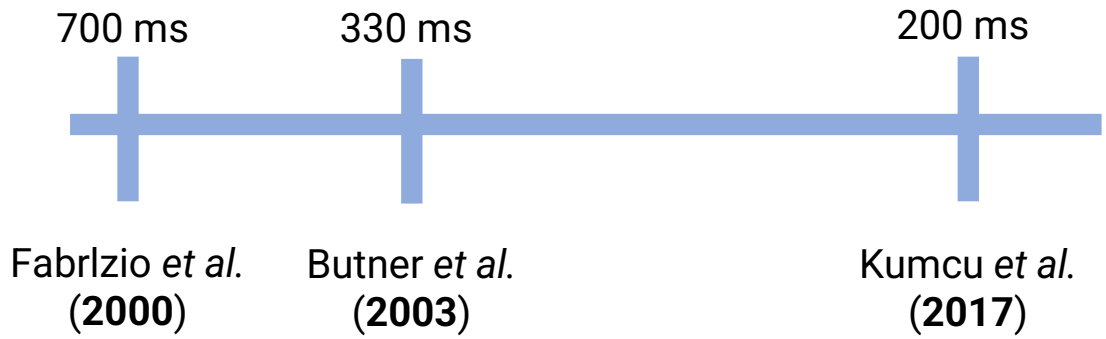


VR Avatars

Surgical Training

No Golden Threshold

- Prior research reports a wide range of acceptable latency thresholds



- We have a baseline to compare against, ~50 ms

Methods

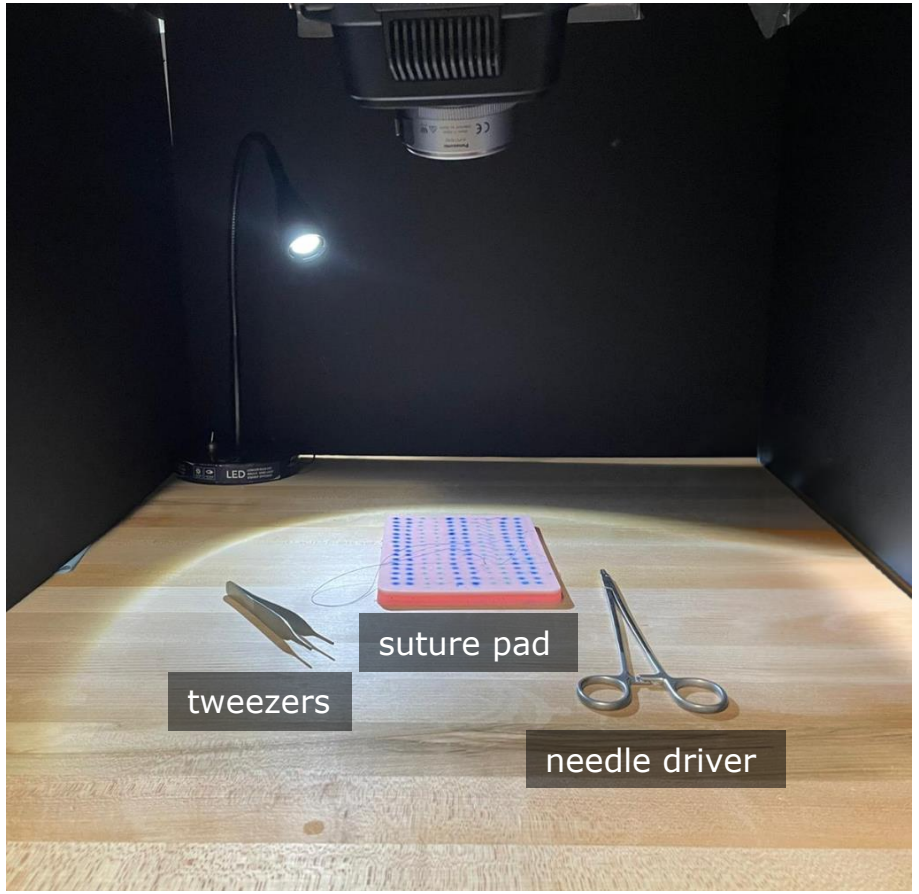
Study Design

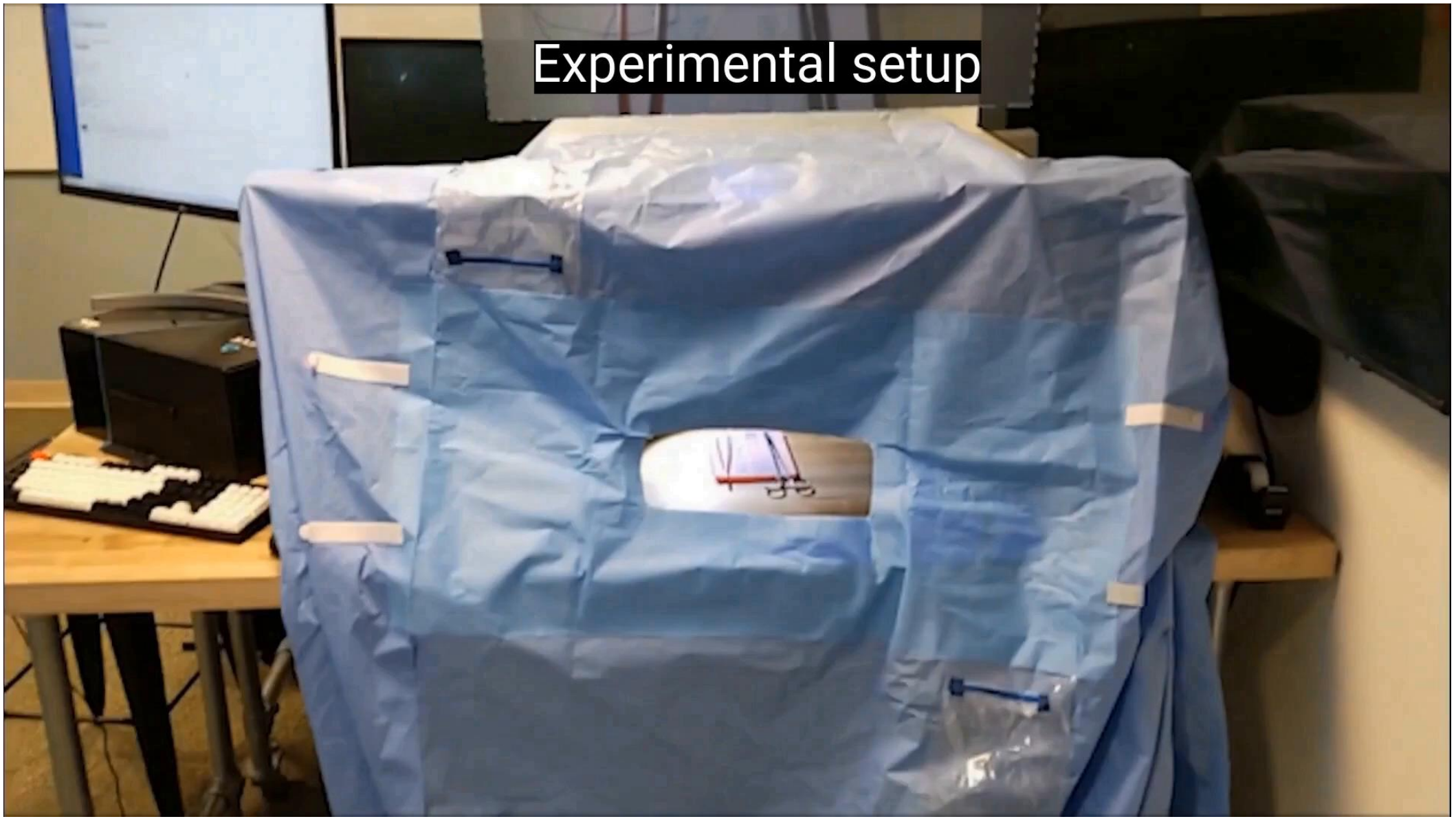
- Within-subjects study
- N = 20 (18 males, 2 females)
- Participants were surgical residents

Monitor	HoloLens
50, 100, 150, 200 (ms)	100, 150, 200 (ms)

Task

- Throwing uninterrupted sutures
- 1cm x 1xcm grid
- Three minutes per task




Experimental setup

Results

Motor Task Performance

- Both **display type** and **latency level** impact **number of sutures**

- **No statistical difference** between
  - Monitor 100ms – HoloLens 100ms
  - Monitor 50ms – HoloLens 100ms

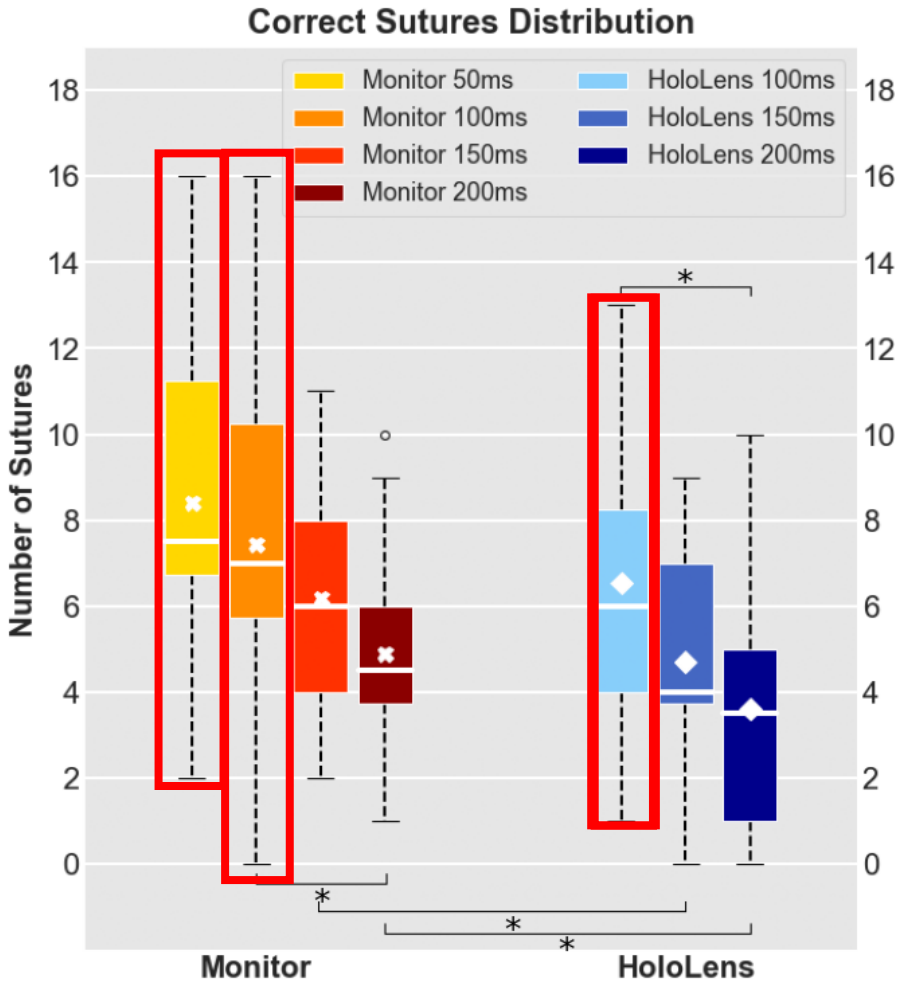


Figure 4

Task Load

- **Display type** or **latency level** do **NOT** impact task load

- More **experience** less surgical task load

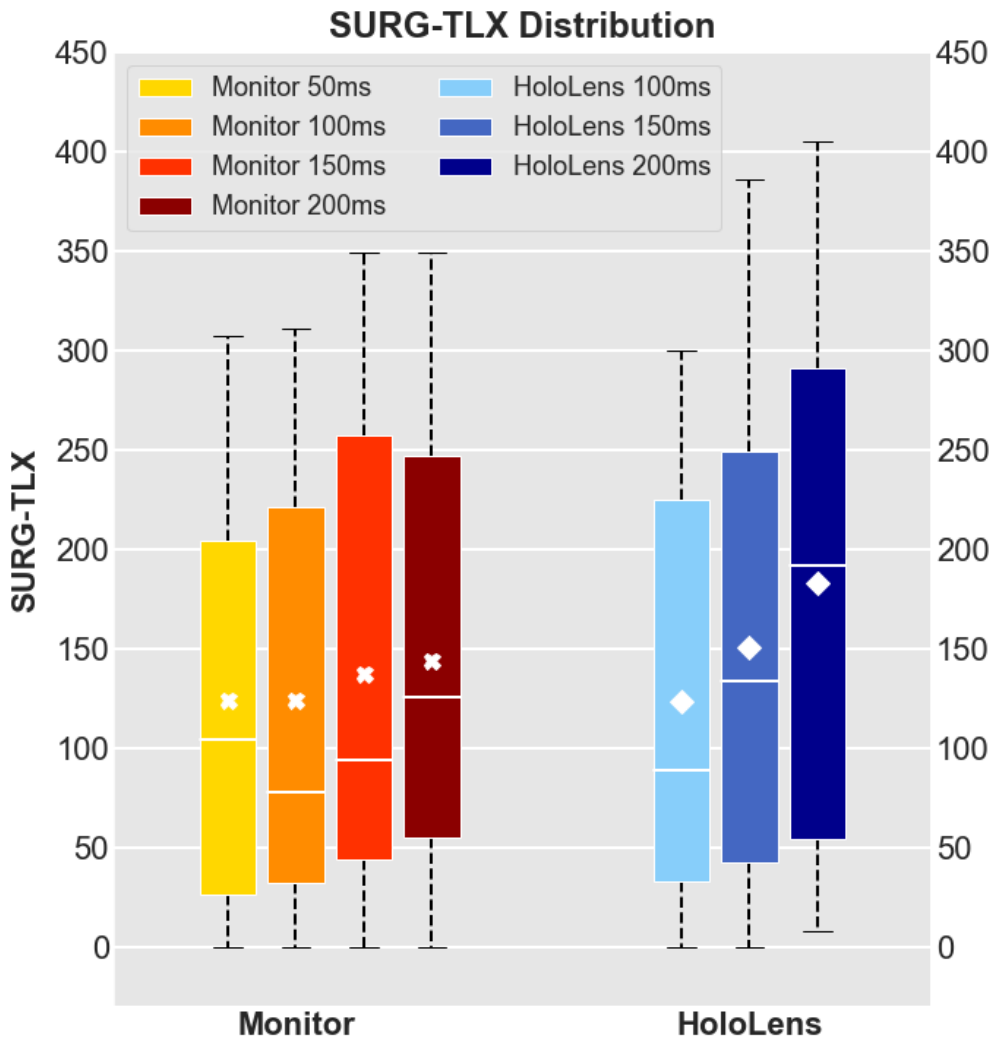


Figure 6

Discussion

Experts can adapt

- Surgeons changed their behavior when encountered with high latencies
- Visual feedback indicators can further reinforce this behavior change

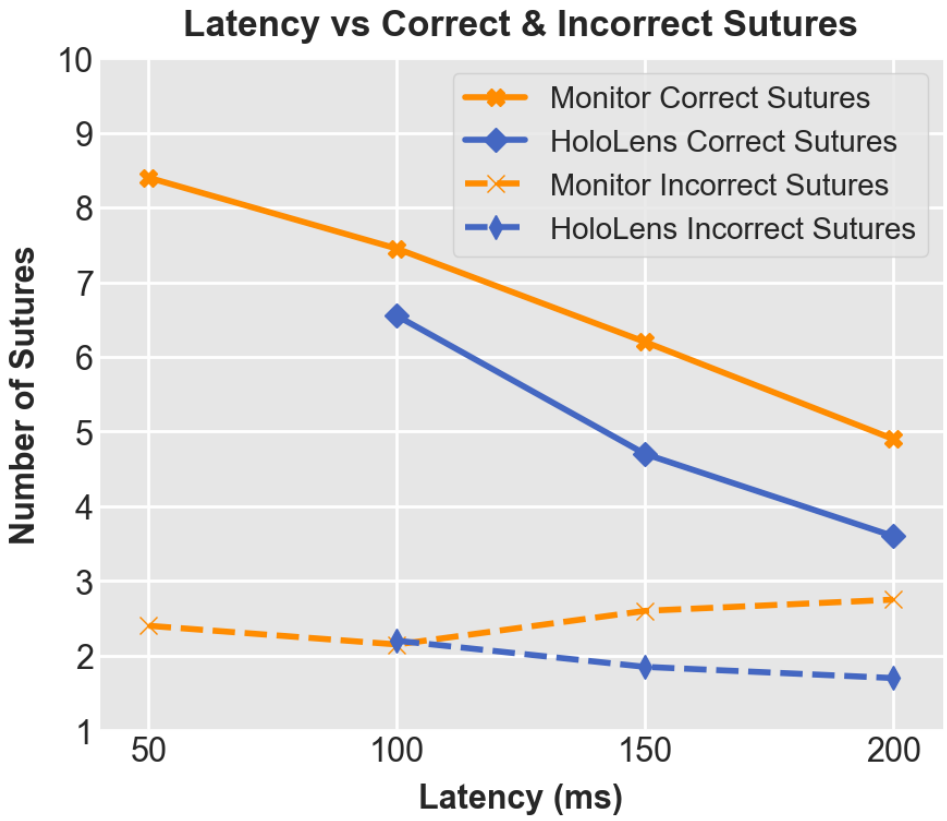
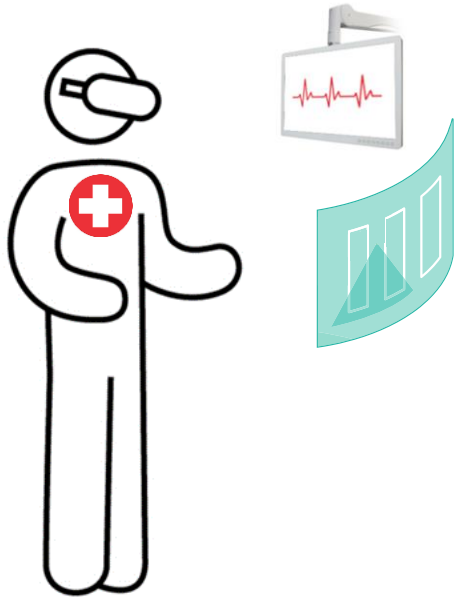


Figure 5

A contemporary solution

- Hybrid setups
- AR displays for latency sensitive surgical streams



AR in the OR

- Comparable performance for both display types for lower latency levels
- No surgeon felt that 100 ms HoloLens would risk patient safety

Thank you!

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