STAR: Using Augmented Reality Transparent Displays for Surgical Telementoring

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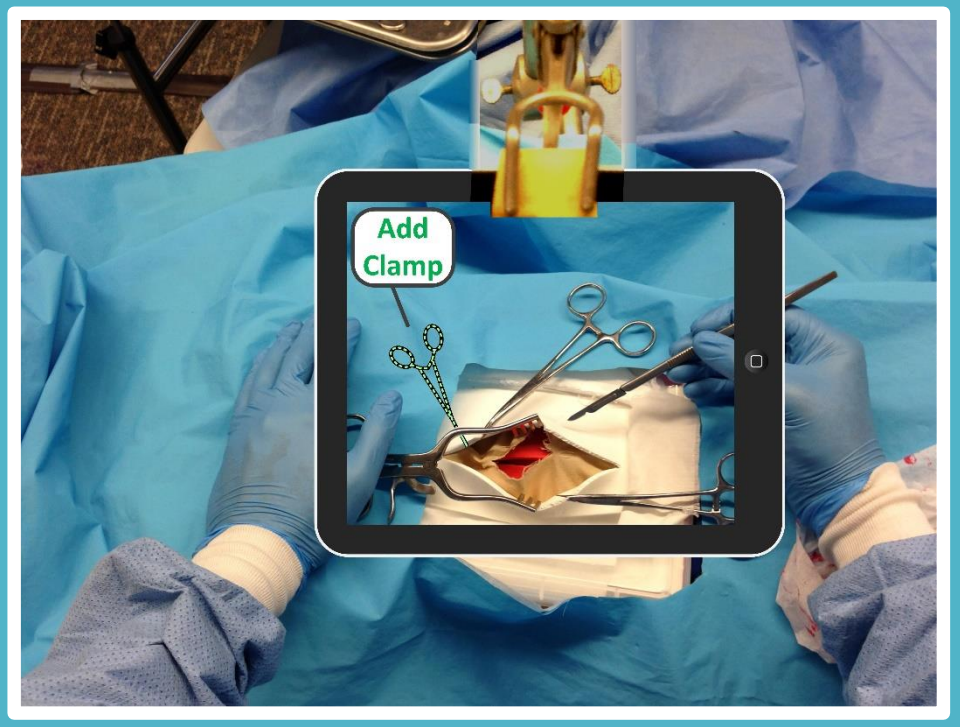
https://engineering.purdue.edu/starproj/



Overview

The importance and potential for telementoring

Some background on augmented reality (AR)

STAR: Our vision for surgical telementoring

Our first prototype of STAR

Current research: Transparent displays

Future work

What is telementoring?

Telementoring: a **mentor** giving **remote**, **live**, expert guidance to a **trainee** to perform a particular task.

Surgical telementoring: a mentor surgeon instructing a trainee surgeon how to do a surgical operation, **during that operation**.

Ideal telementoring feels like normal mentoring

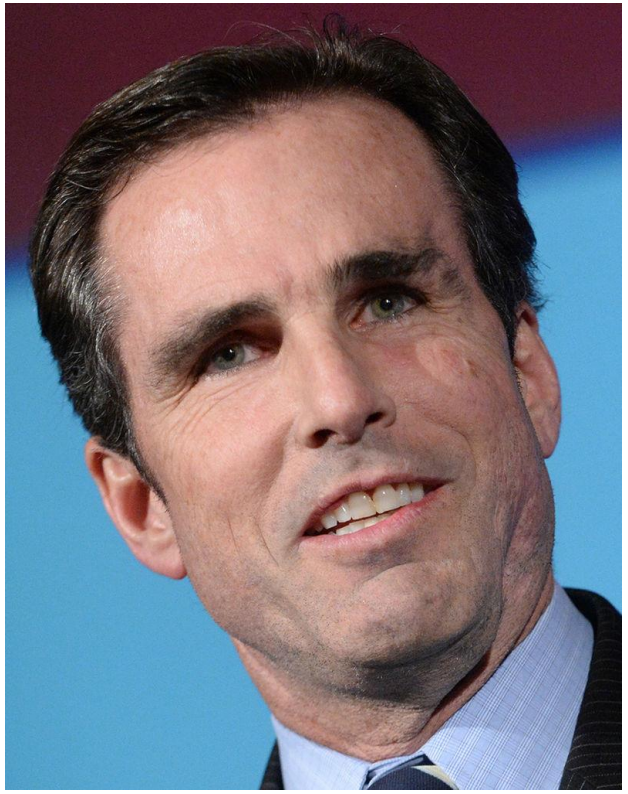
- Mentor and trainee should have a sense of co-presence
- “You see what I see”

Telementoring: why is it useful?

It allows for mentoring when co-location is not feasible

Telementoring helps overcome barriers of **time**, **distance**, and **available resources**

Uses of telementoring: military medicine



"After the IED exploded, a gunfight ensued and the helicopter pilots were instructed not to land. Unaware of who was on the ground and only knowing that someone needed help, these pilots turned down the radio, ignored the order, and landed. ***I was then taken to Baghdad, assessed, and then sent to Balad, where – within the hour – my skull flap was removed and my brain began swelling.*** *From Balad, I was sent to Landstuhl Regional Medical Center in Germany, a major way station for wounded soldiers en route to the United States."*

- Bob Woodruff, ABC correspondent

"War Surgery in Afghanistan and Iraq:
A Series of Cases, 2003-2007"

Other uses of telementoring

- Rural surgery
  - In the US or abroad, general surgeons in rural areas may have to treat a broad variety of conditions
  - Telementoring can help connect rural areas with urban areas with more access to specialist expertise in urgent cases
- Multiplying expert surgeon impact across many trainees
  - Telementoring is a force multiplier
  - Telementoring increases the impact a single expert surgeon can have
  - Telementoring “transports” an expert to wherever he/she is needed

Current limitations

Why isn’t telementoring used everywhere?

It’s still not as good as real, co-located interaction

Problem for the trainee: focus shifts

To follow an instruction, trainee must:

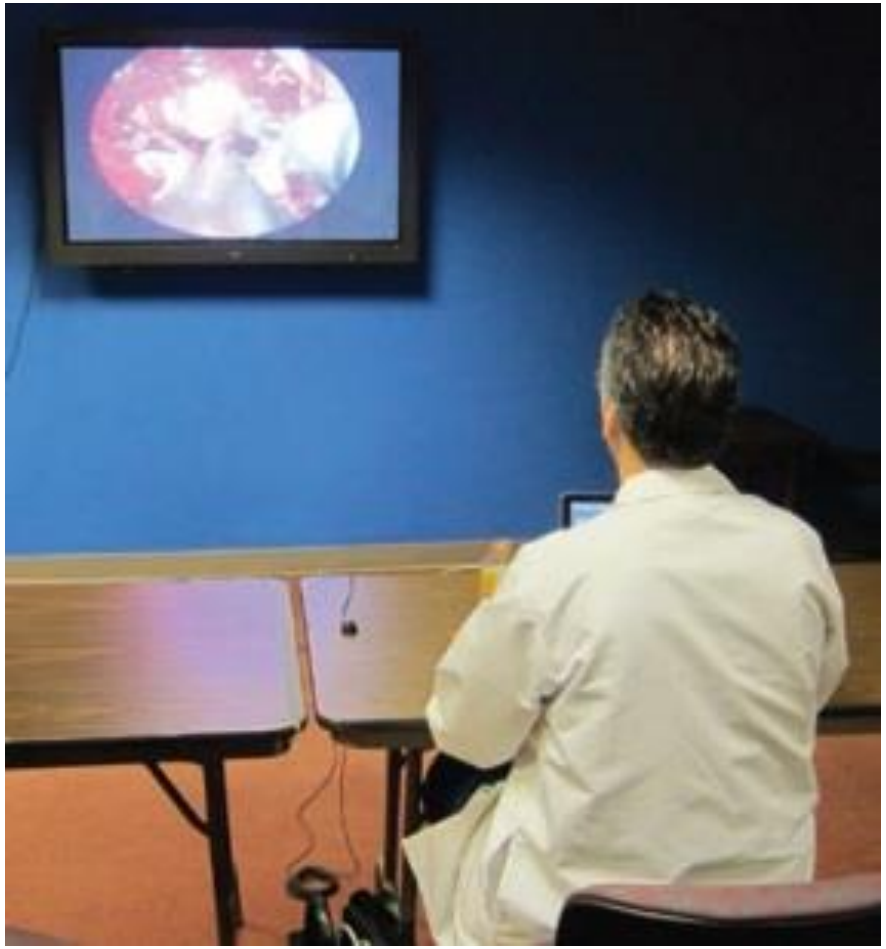
- Shift focus from operating field to monitor
- Memorize annotation
- Shift focus from monitor back to operating field
- Mentally remap memorized annotation
- Follow the instruction

Repeat for every instruction!

Adds unnecessary cognitive load to the trainee

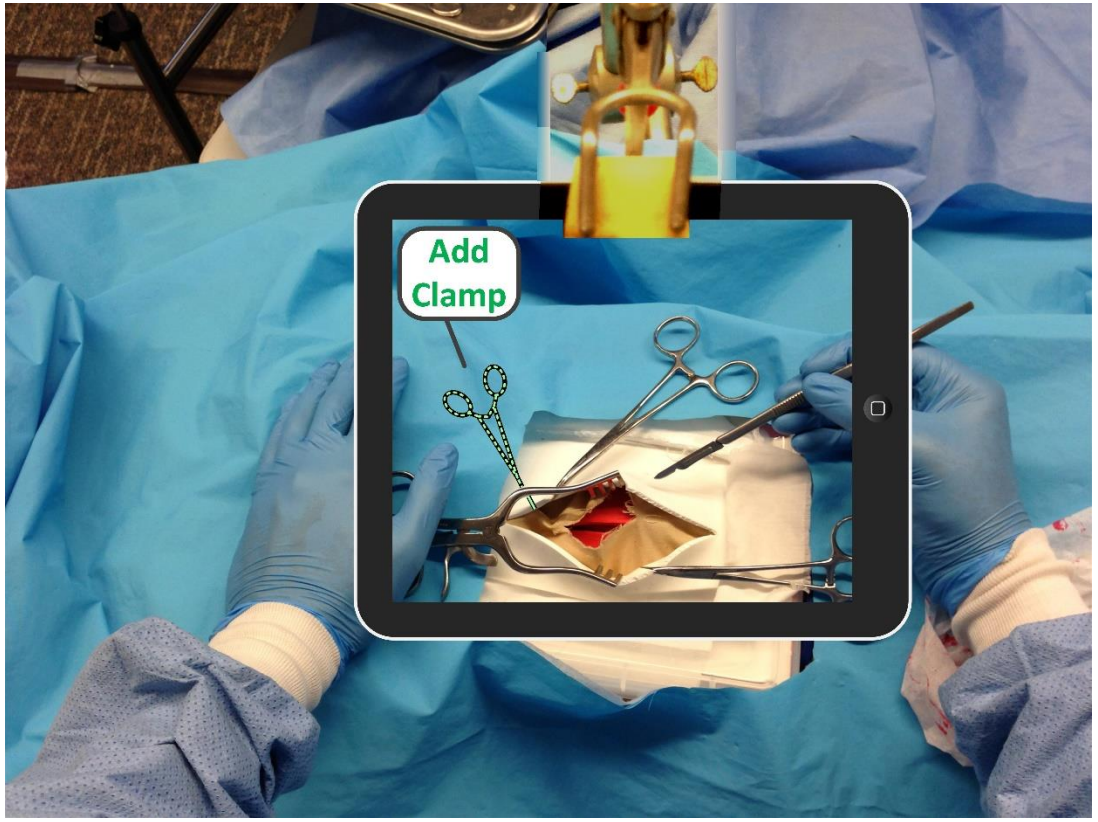
Problem for the mentor: limited interaction

- Mentor has limited tools for interaction
  - Audio channel
  - Drawing lines
  - No ability to gesture
  - No ability to “act out” a complex action and have the trainee see it
  - Hard for the mentor to put the operating field “in context”



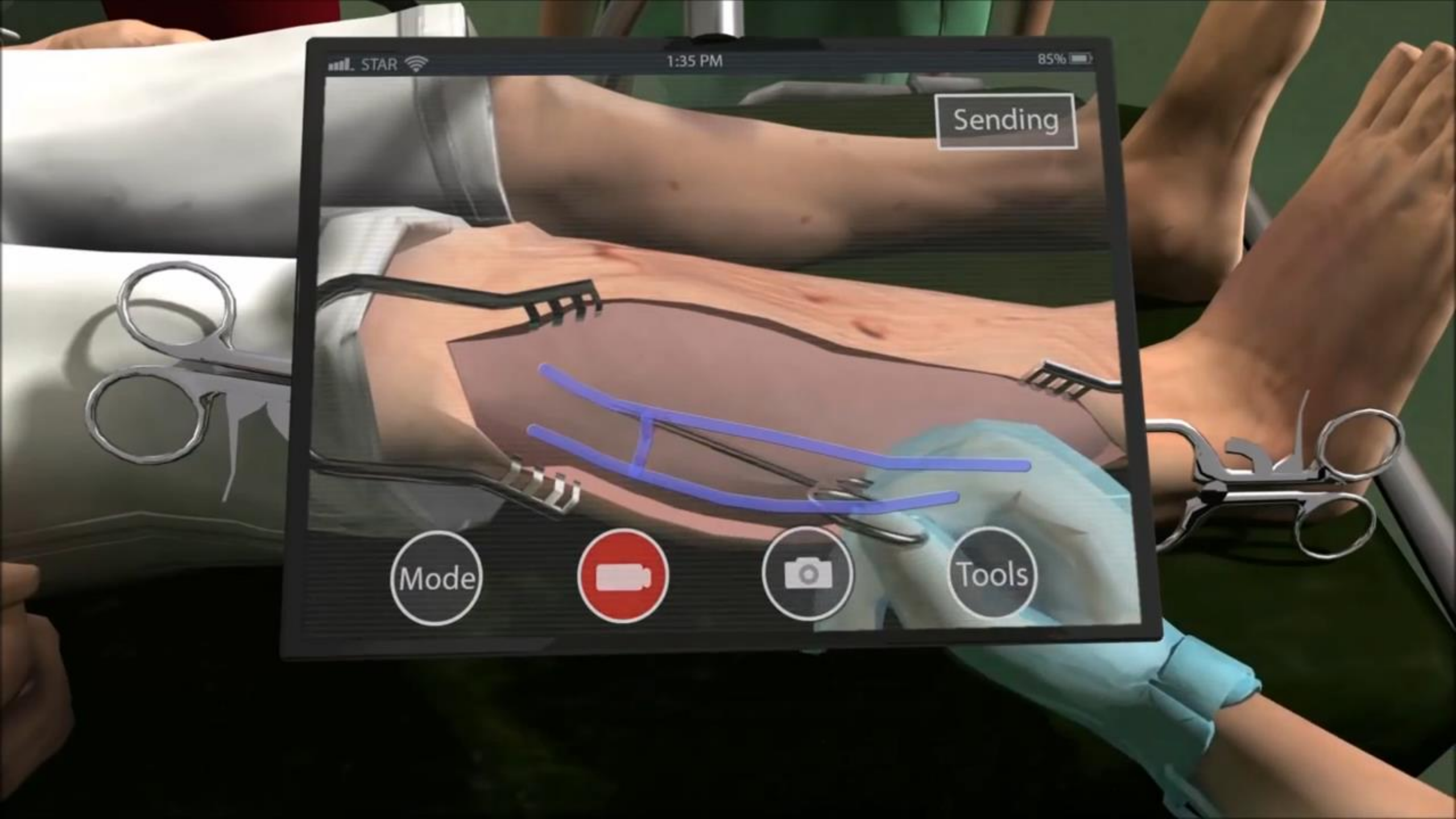
Avoiding focus shifts using an augmented reality transparent display

- Tablet between trainee and operating field
- Augmented reality overlays annotations directly on the video feed
- Trainee no longer needs to shift focus



Sending
Model
Tools


Receiving


STAR
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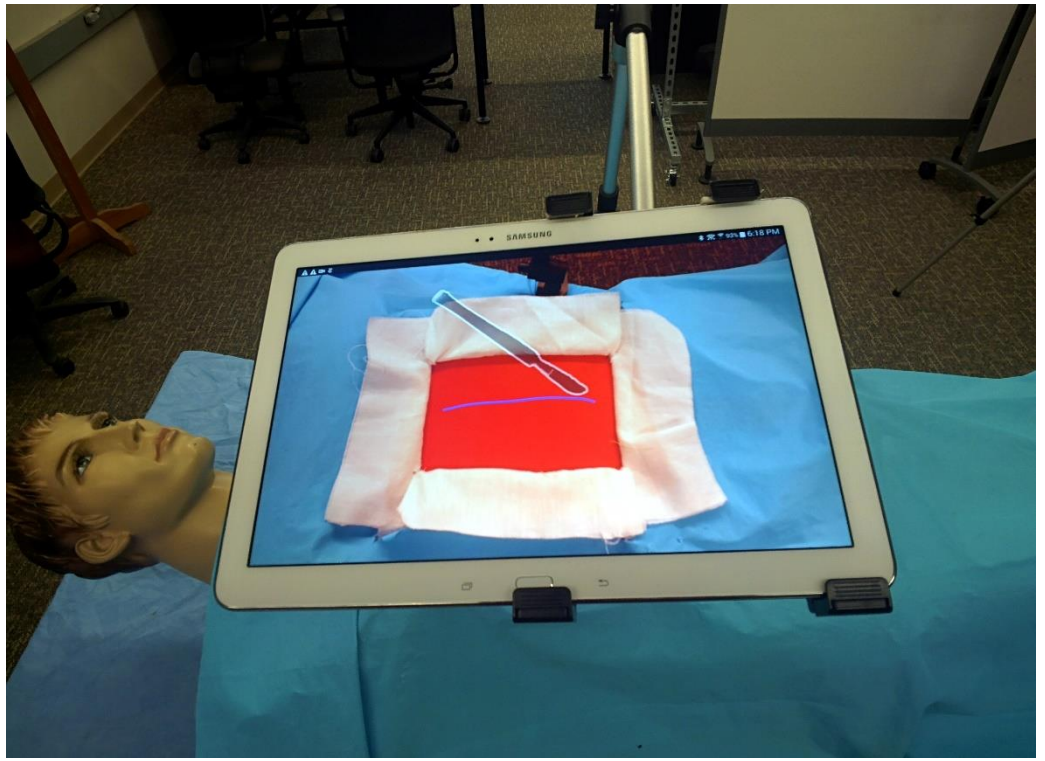
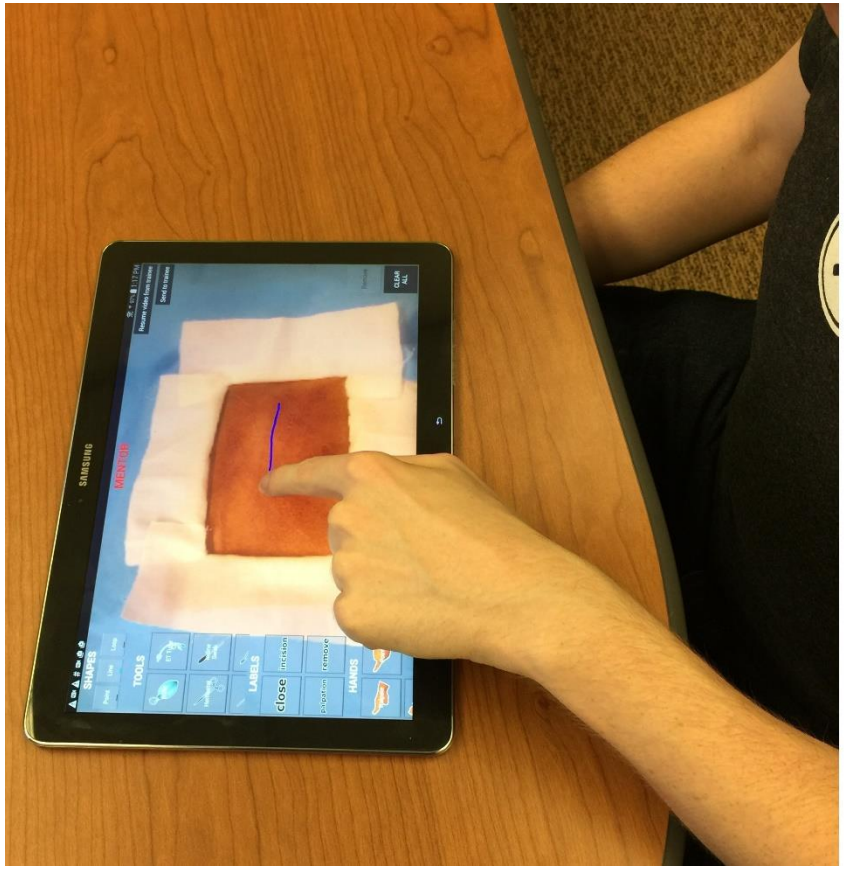
Sending
Mode
Tools

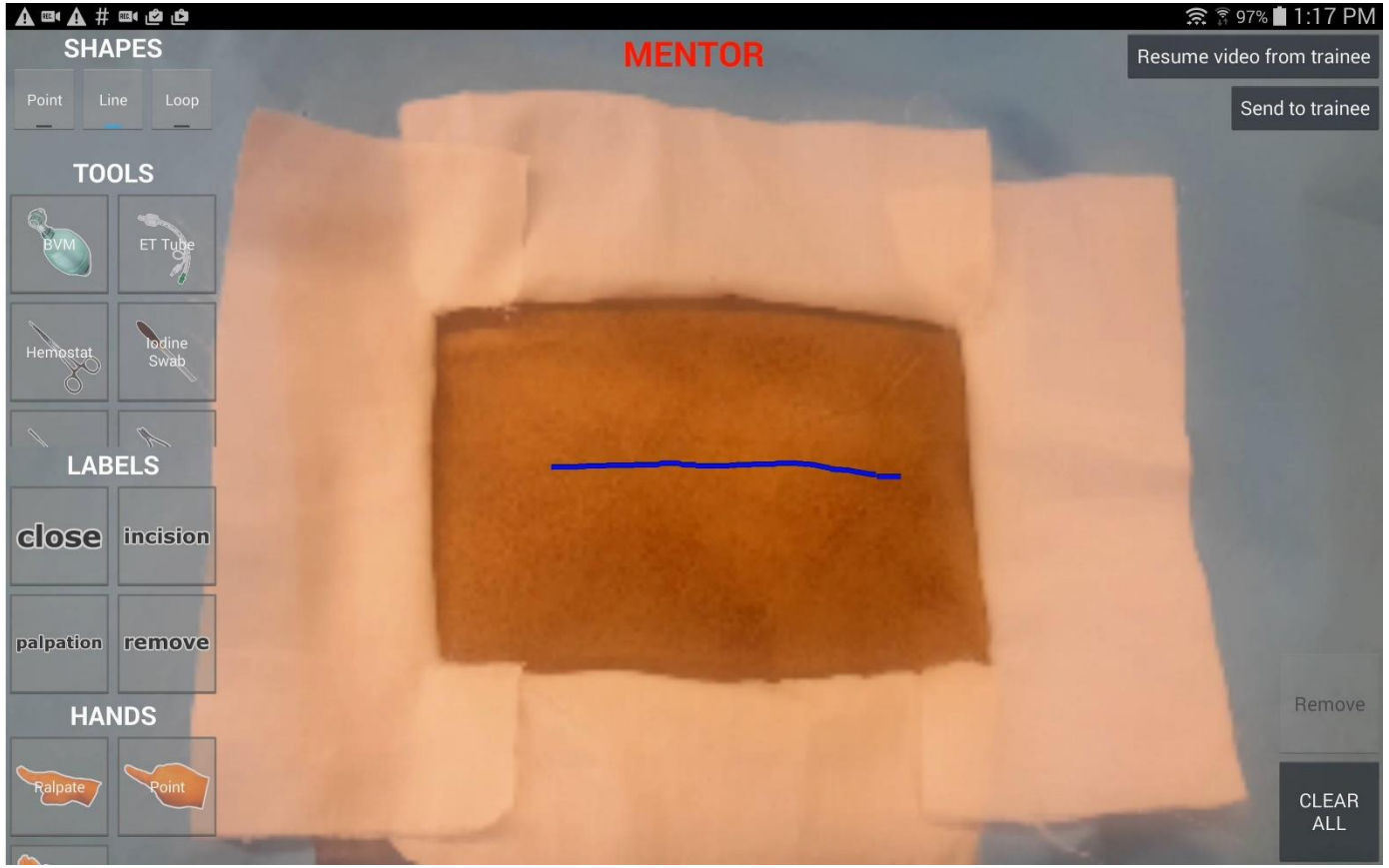
STAR prototype: trainee module



Andersen, D., Popescu, V., Cabrera, M. E., Shanghavi, A., Gomez, G., Marley, S., Mullis, B., & Wachs, J. (2015). Virtual annotations of the surgical field through an augmented reality transparent display. *The Visual Computer*, 1-18.

STAR prototype: mentor module





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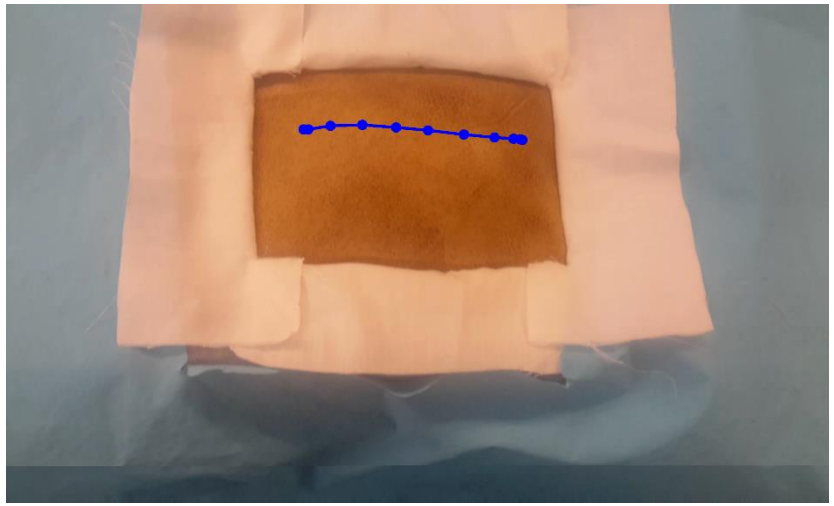
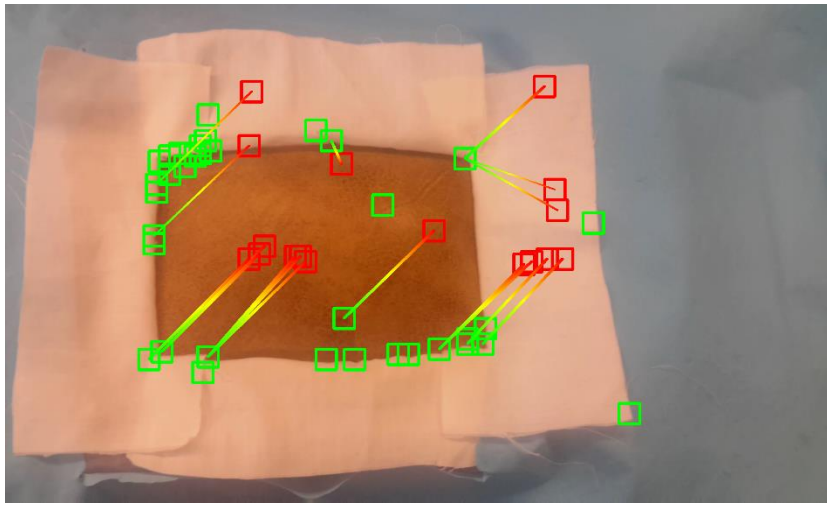
STAR prototype: annotation anchoring

Annotations should appear drawn onto the operating field, not fixed on the screen

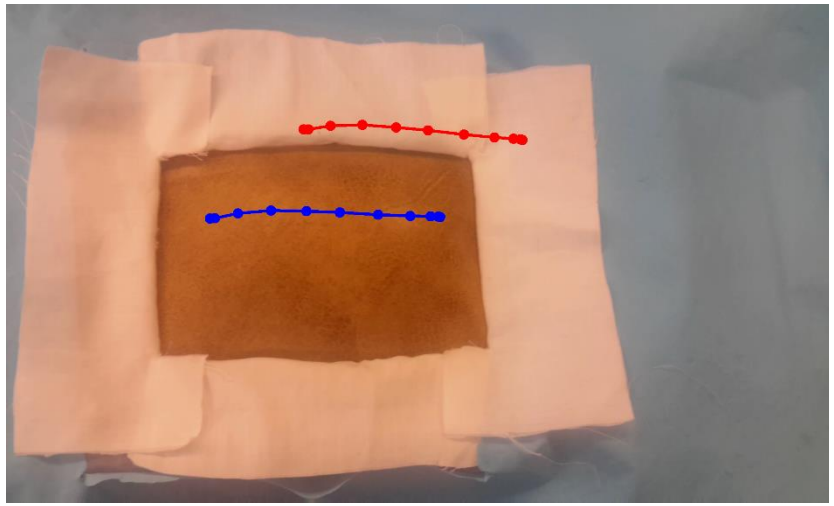
Annotations should update during tablet repositioning, occlusion, deformation



Mentor's reference frame



Finding correspondences using computer vision algorithms



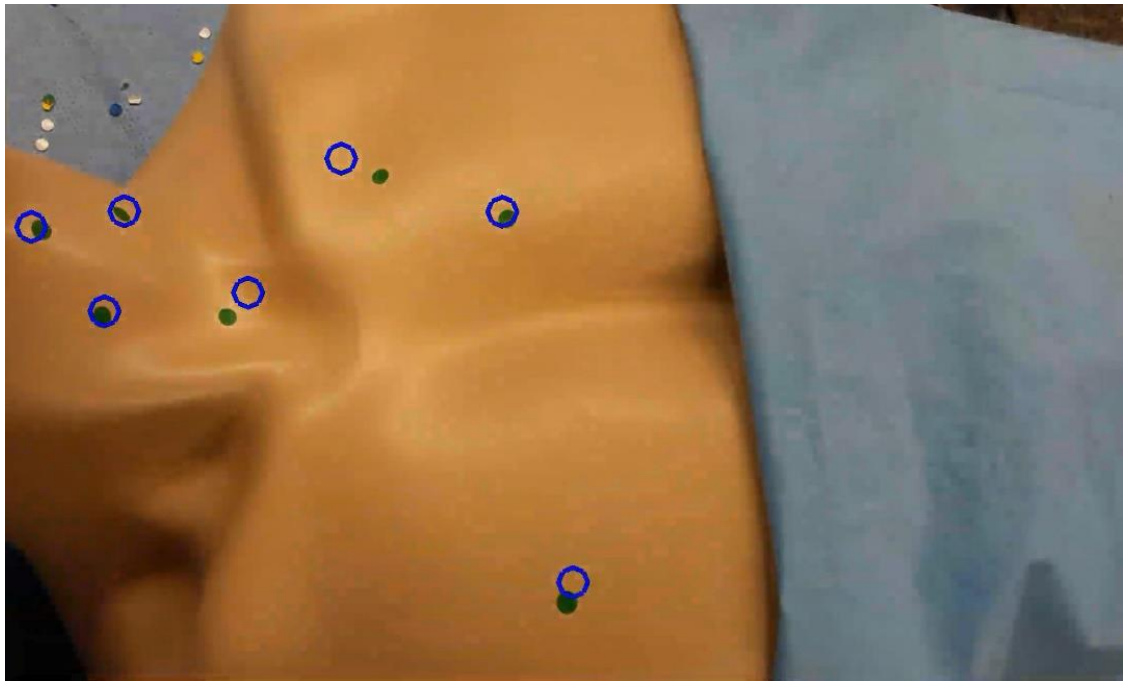
Trainee's current frame

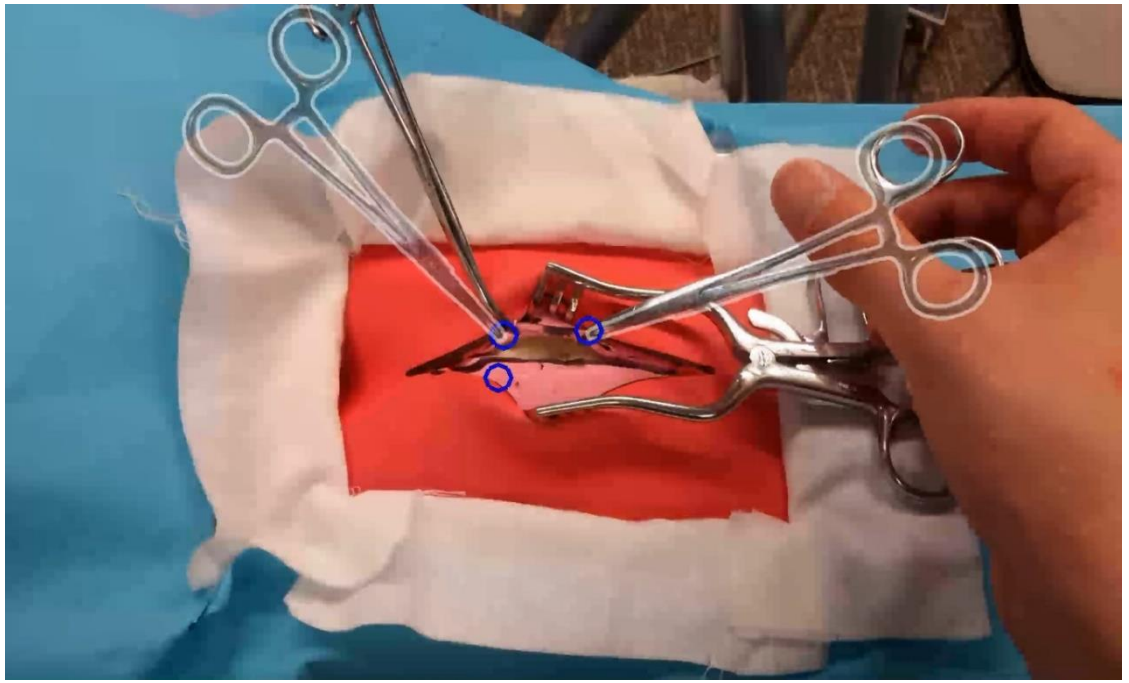
Andersen, D., Popescu, V., Cabrera, M. E., Shanghavi, A., Gomez, G., Marley, S., Mullis, B., & Wachs, J. (2015). Virtual annotations of the surgical field through an augmented reality transparent display. *The Visual Computer*, 1-18.

User study of STAR prototype

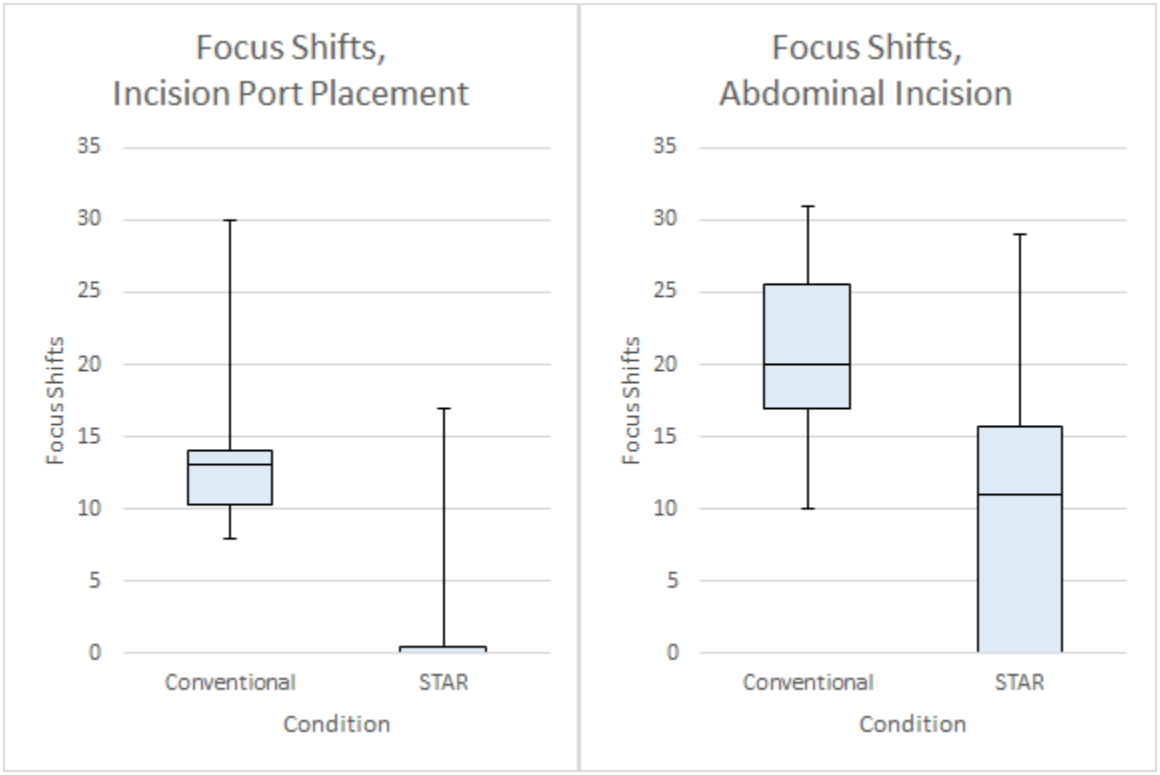
20 pre-med/med students at Purdue completed 2 tasks under simulated telementored guidance

Participants used either STAR or conventional telementoring approach

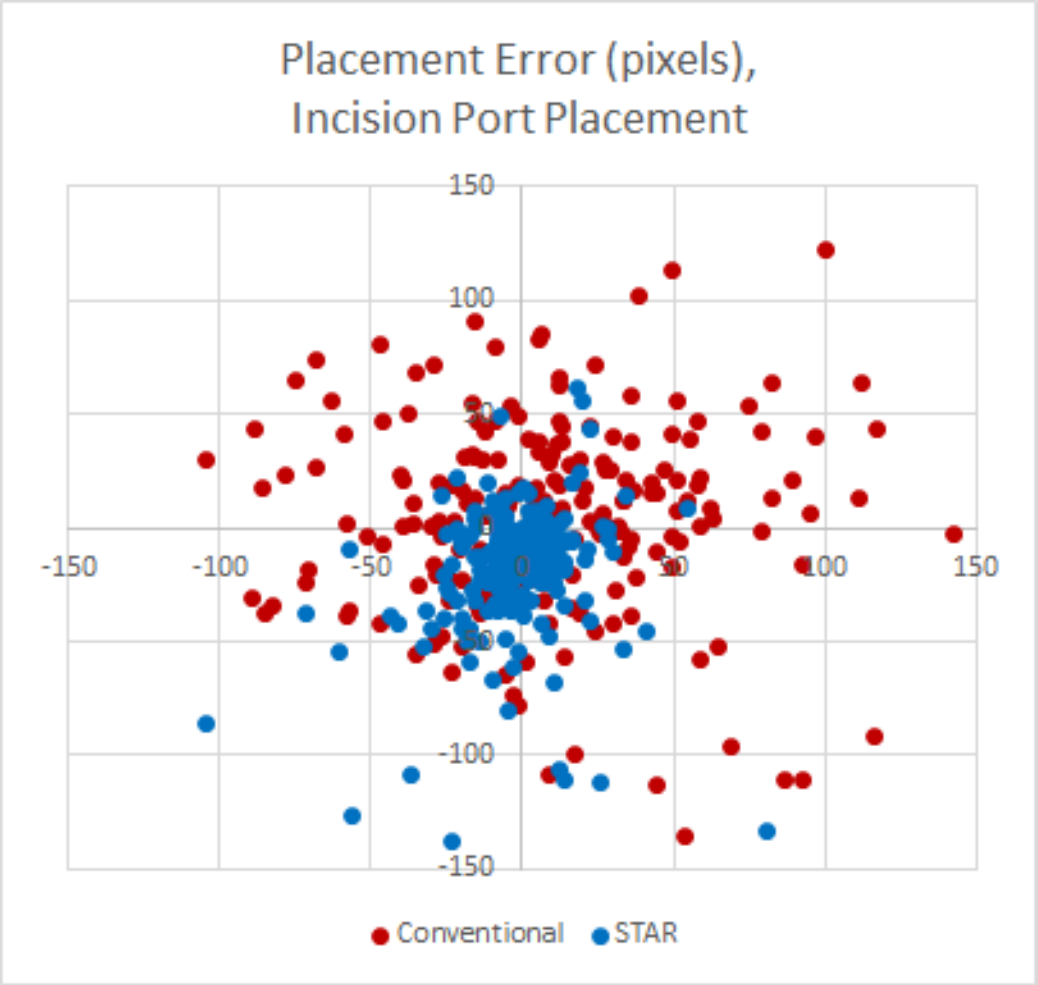


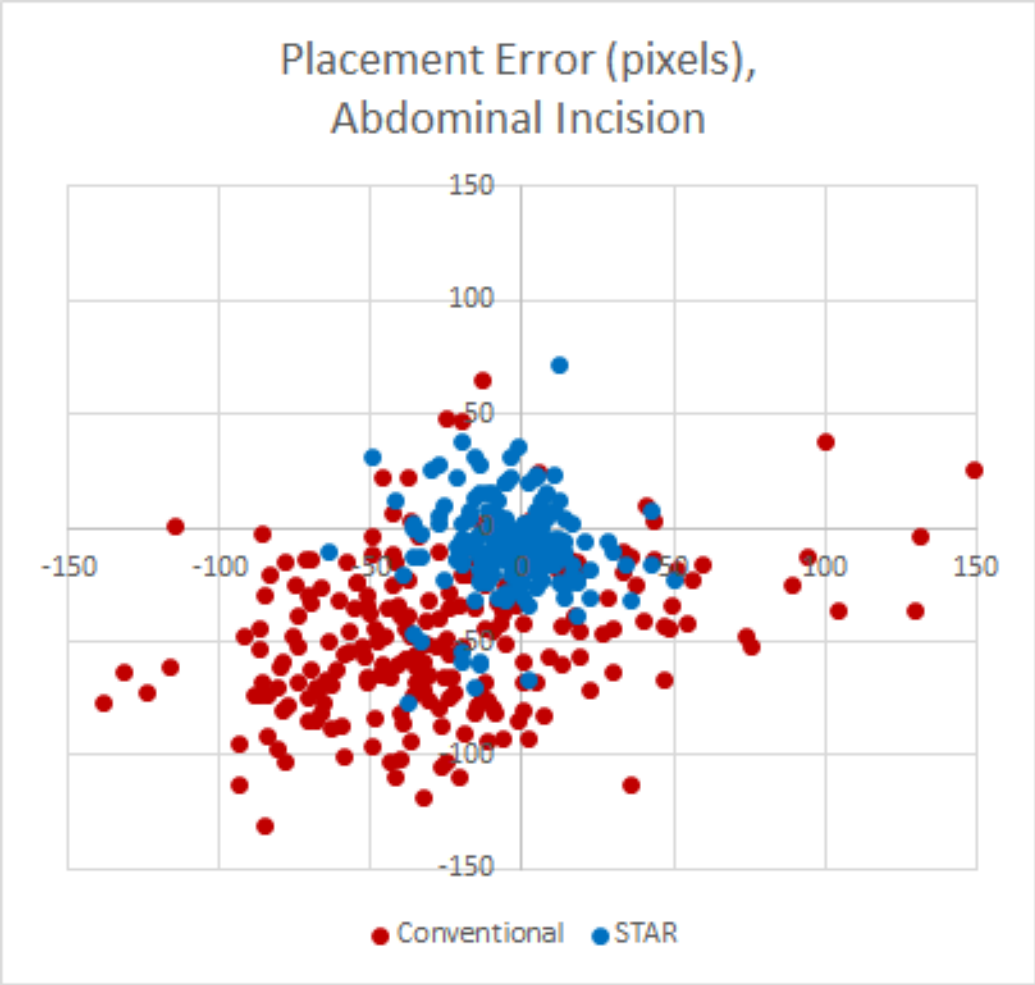


Results: focus shifts

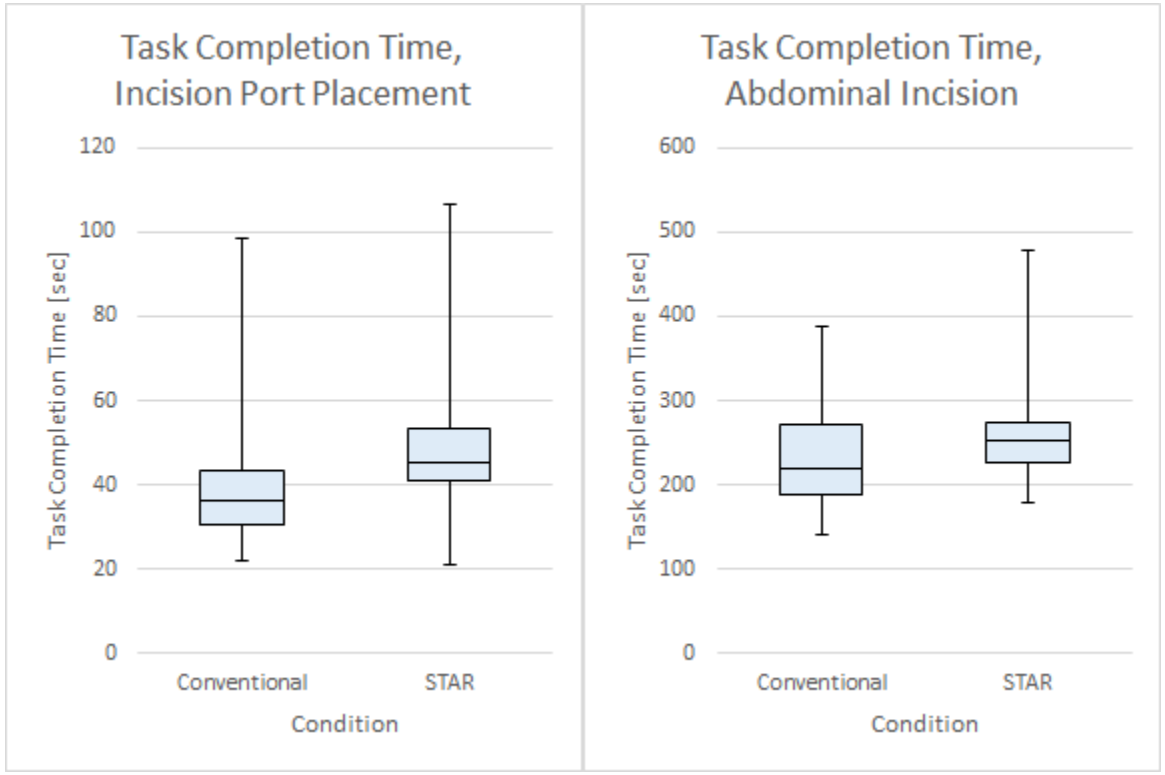


Results: placement error

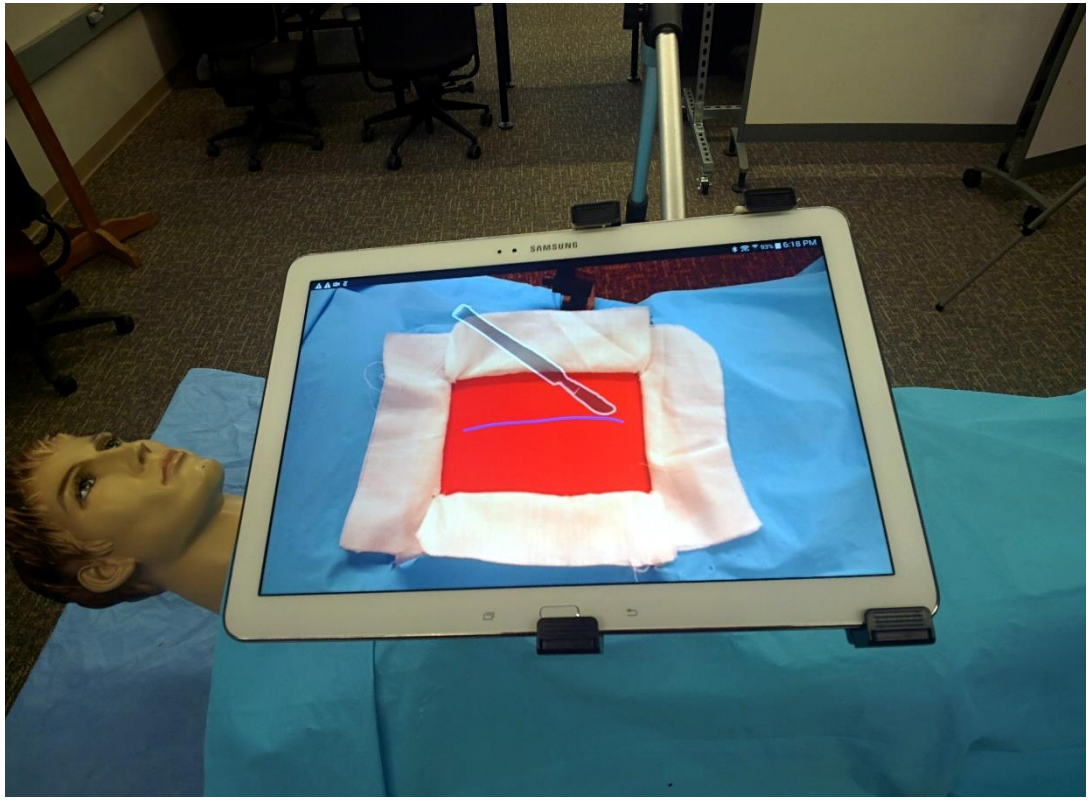




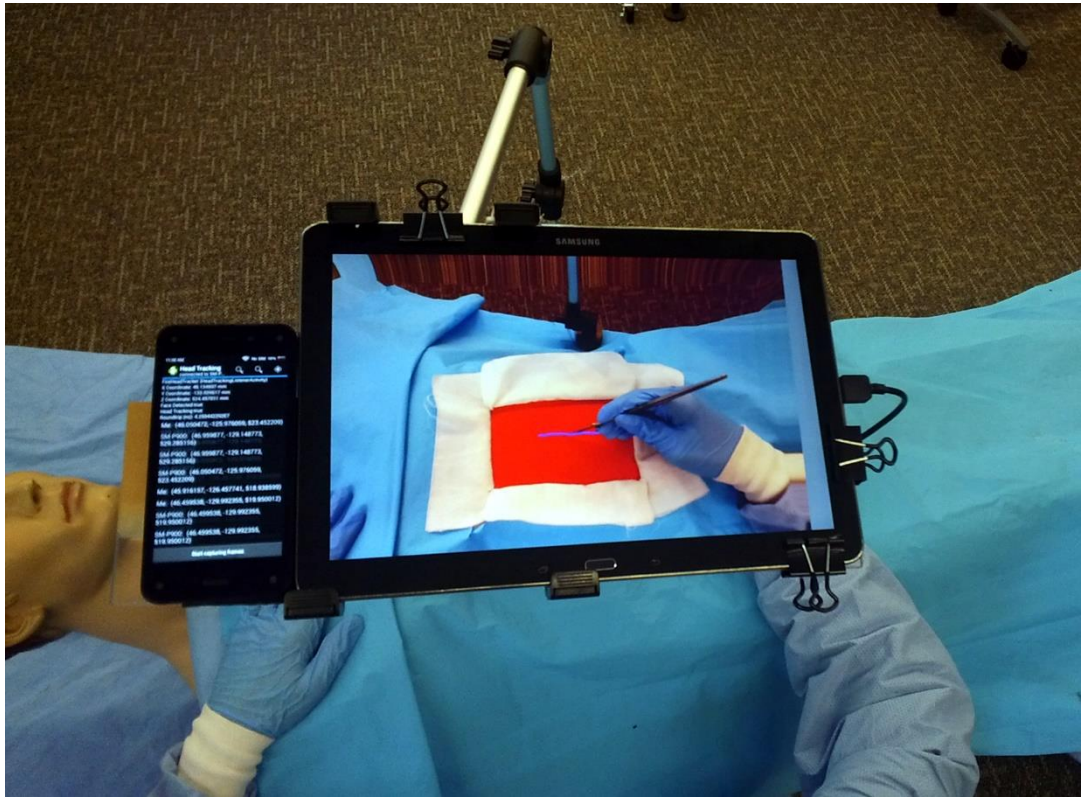
Results: task completion time



Making the display truly transparent



Approximate transparency
(Device-perspective rendering)



True transparency
(User-perspective rendering)

How to make a tablet disappear

Change the view based on head position

- This is the main difference between a window and a screen

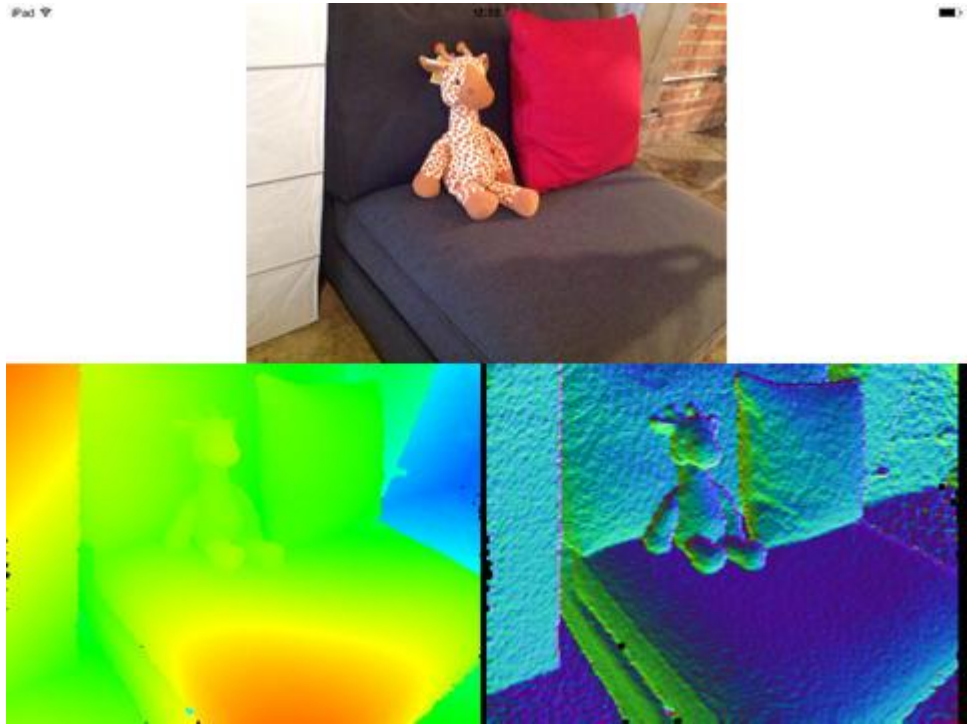
We use the Amazon Fire Phone

- 4 front-facing cameras triangulate the user's head position

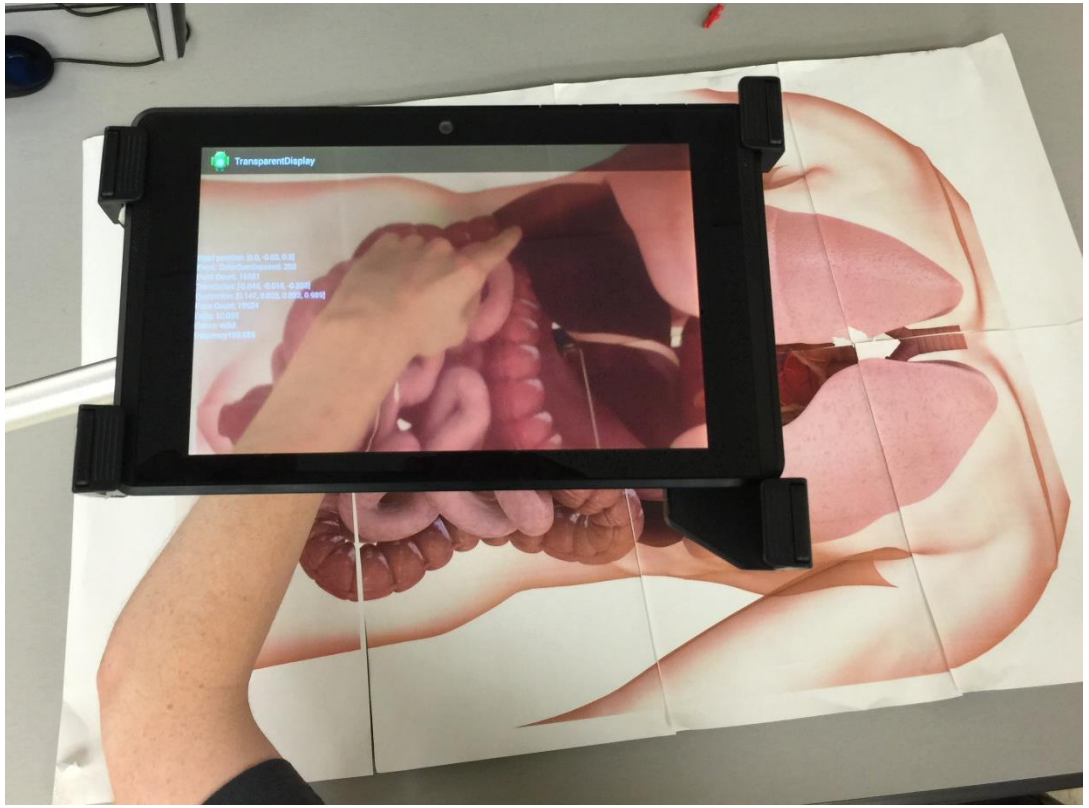
How to make a tablet disappear

Capture the 3D geometry of the operating field

We use the Structure infrared sensor to acquire depth



Transparent display: initial results

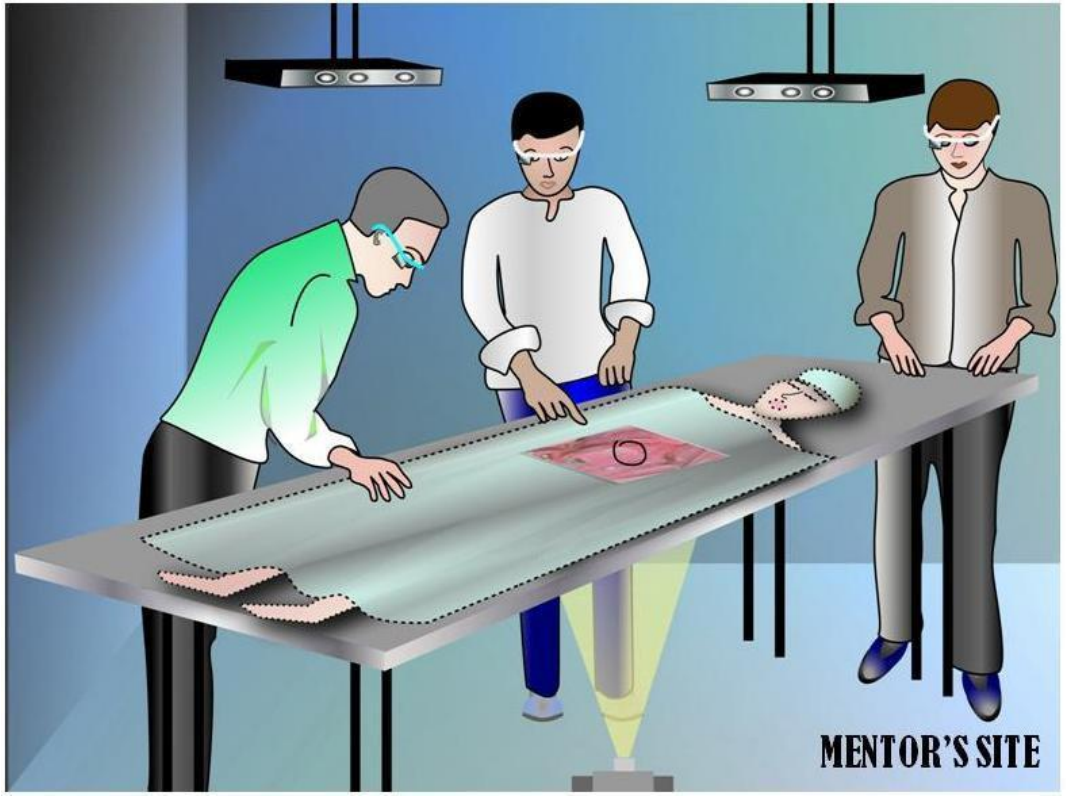


Future work: improving the mentor module

Provide the mentor with a life-size interaction table

Automatically interpret the mentor's gestures using "one-shot learning"

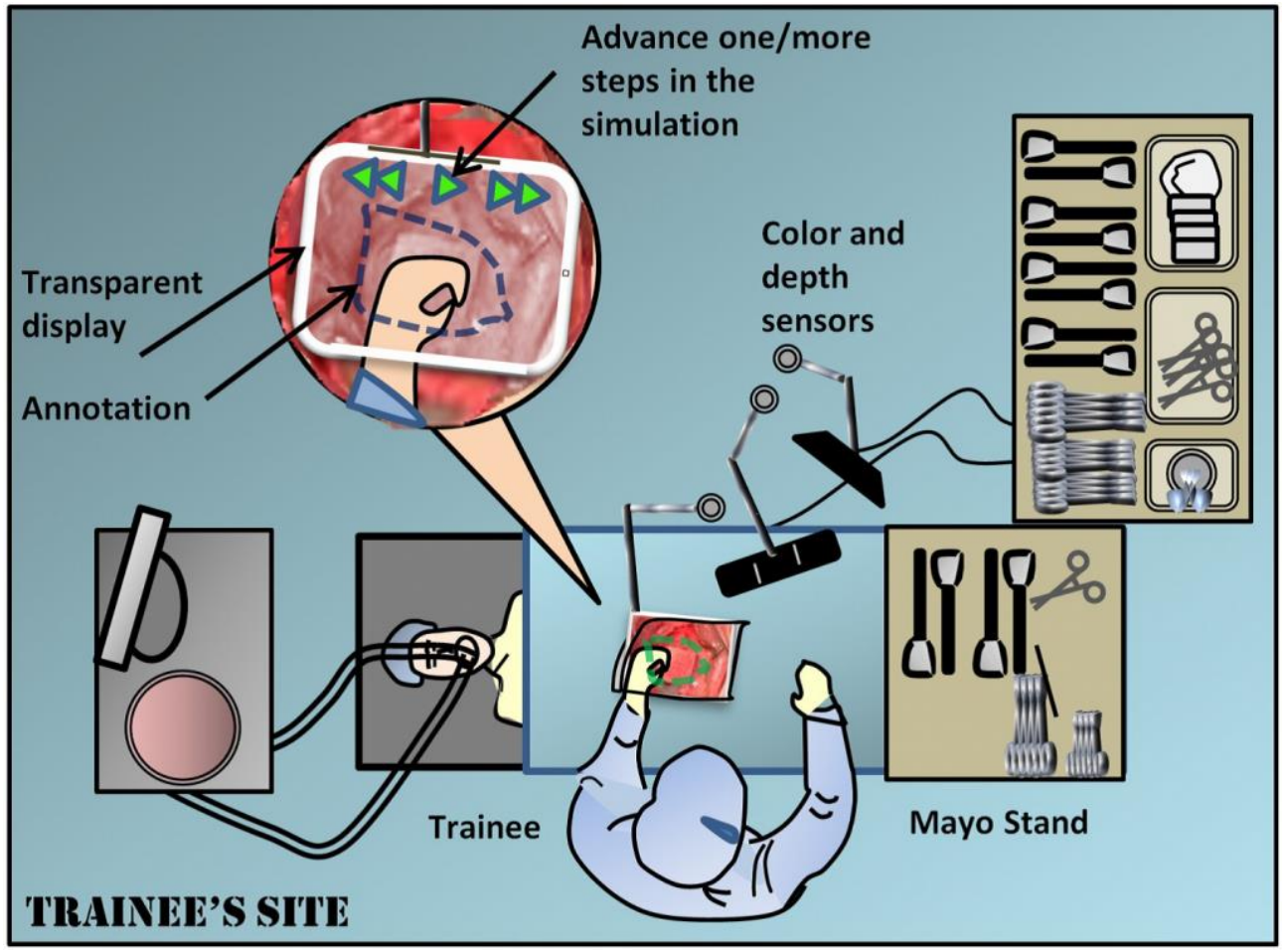
Currently compiling a lexicon of "typical surgeon interactions" from simulated telementoring



Conclusion

Surgical telementoring can save lives by bringing expertise wherever it's needed.

Through interdisciplinary, cutting-edge research, we are making the telementoring experience more effective.



Questions

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