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**.
“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

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
STAR prototype: trainee module

STAR prototype: mentor module

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

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

System for Telementoring with Augmented Reality

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