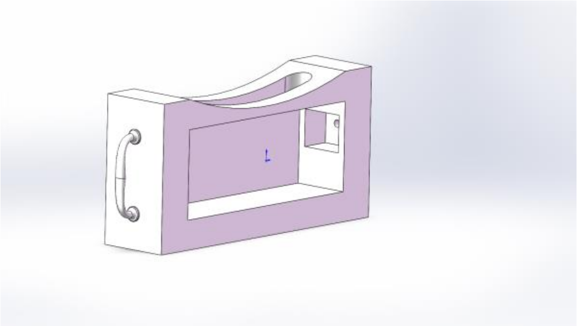
# Patch Ultrasound
## -Background Reading Presentation

Team: Shuran Zhang, Yuanwu He
Mentors: Keshuai Xu, Prof. Emad Boctor

# Project Overview-Patch Ultrasound

**Aims:** We aim to develop components (Patch Ultrasound and user interface design) to realize a hand-free 4th generation ultrasound in OB/GYN applications.

- Hands-free
- Multi-angles
- Remote control



# Background Reading


- [1] Wang, Y., Lim, R.S.A., Zhang, H. et al. Optimizing the light delivery of linear-array-based photoacoustic systems by double acoustic reflectors. Sci Rep 8, 13004 (2018). https://doi.org/10.1038/s41598-018-31430-5

- [2] Andrew W. Kirkpatrick, Ian McKee, Jessica L. McKee, et al. Remote just-in-time telementored trauma ultrasound: a double-factorial randomized controlled trial examining fluid detection and remote knobology control through an ultrasound graphic user interface display. The American Journal of Surgery, Volume 211, Issue 5, 2016, Pages 894-902.e1. https://doi.org/10.1016/j.amjsurg

- [3] Black, David; Yazdi, Yas Oloumi; Hadi Hosseinabadi, Amir Hossein; Salcudean, Septimiu (2021): Human Teleoperation - A Haptically Enabled Mixed Reality System for Teleultrasound. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.15175869.v1

# Paper Selection

SCIENTIFIC REPORTS

OPEN

## Optimizing the light delivery of linear-array-based photoacoustic systems by double acoustic reflectors

Received: 9 May 2018
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Yuehang Wang[1], Rachel Su Ann Lim[1], Huijuan Zhang[1], Nikhila Nyayapathi[1,2], Kwang W. Oh[2] & Jun Xia[1]

The following approaches and results are acquired from the paper [1].

[1]: Wang, Y., Lim, R.S.A., Zhang, H. *et al.* Optimizing the light delivery of linear-array-based photoacoustic systems by double acoustic reflectors. *Sci Rep* **8,** 13004 (2018). https://doi.org/10.1038/s41598-018-31430-5

# Summary of the Problem and Method

Longer travel distance

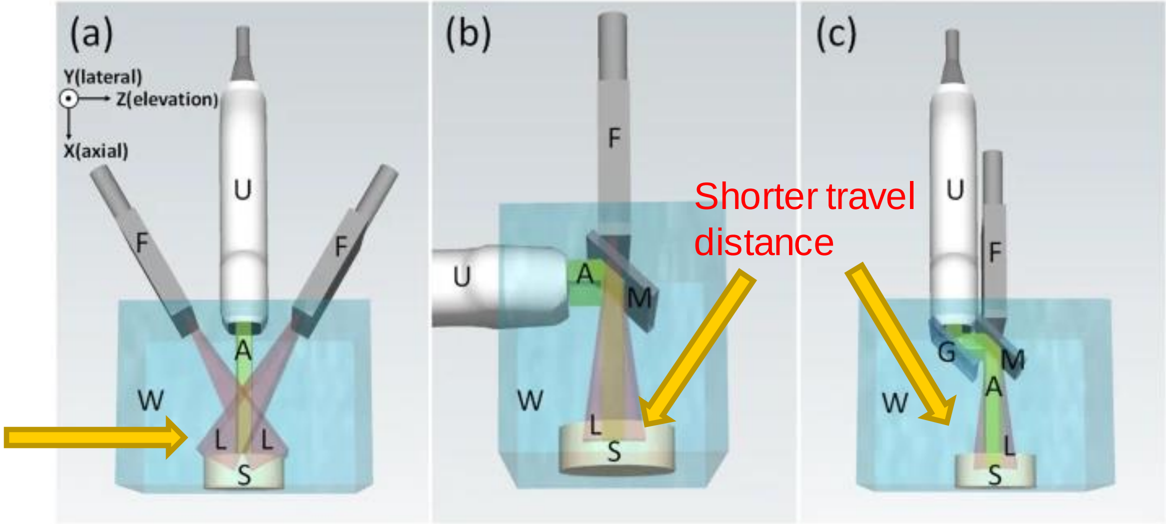



Fig: Schematic drawing of three different Photoacoustic (PA) imaging (PAI) systems.
(a) Conventional side-illumination PAI system.
(b) Single-reflector PAI system.
(c) Double-reflector PAI system.
U, ultrasound transducer array; F, fiber bundle; L, light beam; A, acoustic wave; W, water tank; S, sample; M, cold mirror; and G, glass. The laser beam is in red, and the acoustic wave is in green.

# Critical Review – Relevance to Our Project

**This Paper**

- Acoustic Mirror

Made by PMMA

$$Acoustic\ Impedance_{PMMA} = 3.33\ MRayl$$

**Our Project**

- Acoustic Mirror

Expected to be made by stainless steel

$$Acoustic\ Impedance_{ss} = 45.5\ MRayl$$

$$Acoustic\ Impedance_{water} = 1.48\ MRayl$$

# Critical Review – Pros and Cons

**Pros**

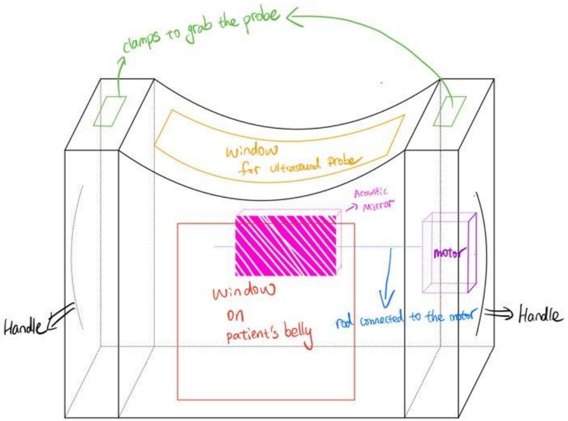
- Compact design
- Clear illustration on building up and testifying their design

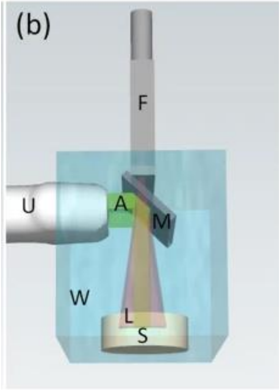
**Cons**

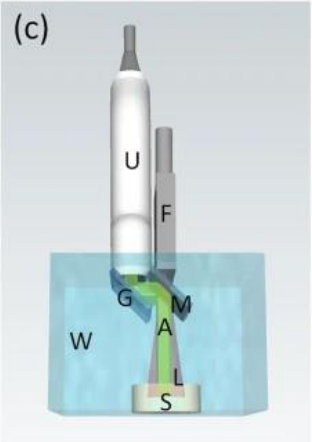
- The acoustic impedance of PMMA (3.33 MRayl) is close to the water (1.48 MRayl).
- Lack illustration on the results tested by different lights.

# Potential Upgrade on Our Project

- We could replace our single-reflector system with the double-reflector system to firmly attach the probe to the patch ultrasound.



# Paper Selection

TechRxiv
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## Human Teleoperation - A Haptically Enabled Mixed Reality System for Teleultrasound

The following approaches and results are acquired from the paper [2].

[2] Black, David; Yazdi, Yas Oloumi; Hadi Hosseinabadi, Amir Hossein; Salcudean, Septimiu (2021): Human Teleoperation – A Haptically Enabled Mixed Reality System for Teleultrasound. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.15175869.v1

# Summary of the Problem

- Diagnosis by sonographers: severely lacking or infrequent .
- Teleultrasound has immense potential to improve the quality of care of patients.
- Ultrasound teleguidance(verbally or with arrows or pointers): Inefficient, leading to high latency and low precision.
- Robotic teleultrasound systems(involves a robotic arm with ultrasound probe end effector which is teleoperated by a remote expert sonographer): Expensive and infeasible in every small town.

# Method - Human Teleoperation

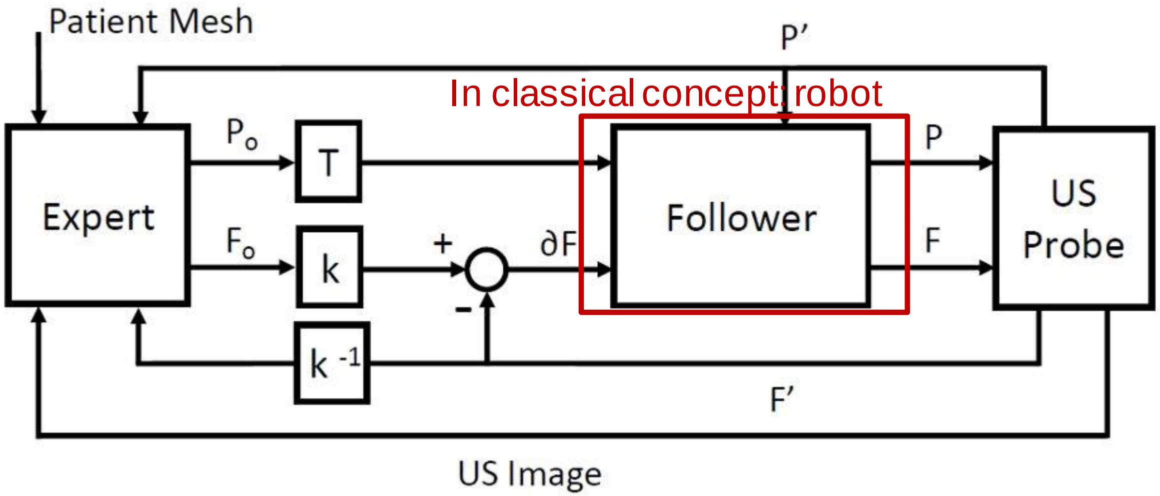


Fig. 1. Block Diagram of the Human Teleoperation System: The desired position, $P_o$, is transformed to the follower coordinate system using transform $T$. The forces are scaled down at the expert side by a factor of $k^{-1}$. Instead of a controller and actuators at the "slave" side, there is a human "follower".

# Method – System Overview

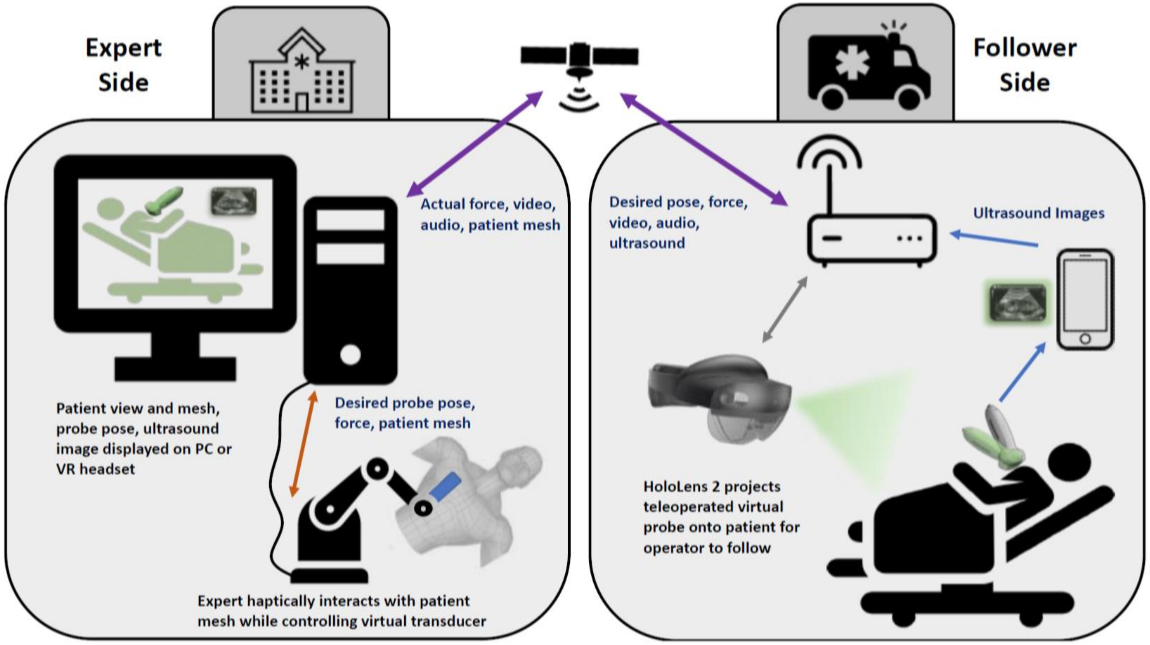


Fig. 2. System Level Diagram: The follower wears a Microsoft HoloLens 2 which projects a virtual transducer into the follower's scene. The expert controls this virtual probe using a haptic controller while observing the ultrasound images obtained by the follower. The expert and follower communicate via a (Mixed Reality WebRTC) video call interface and the probe pose, force, and patient mesh are sent by a WebSocket.

# Method

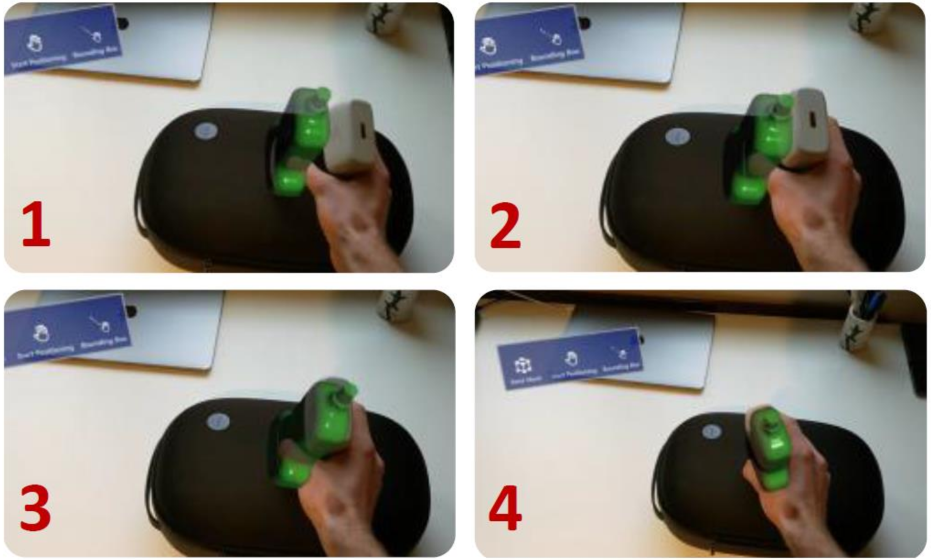


Fig. 3. Follower-Side Interface and Teleoperation: The follower sees the virtual transducer and a control menu. In frames 1-3 the follower starts in a random position and matches the virtual probe pose precisely within $< 0.5$ sec, before the probe pose changes and is immediately matched by the follower again in frame 4. The transducer is green to indicate the expert is happy with the applied force.

# Critical Review – Relevance to Our Project

**This Paper**

- Real-time Ultrasound Image Display: ClariusCast API

- Remote control

Human teleoperation: Through haptically-enabled mixed reality which bridges the gap between robotic and verbal methods of teleguidance.

**Our Project**

- Real-time Ultrasound Image Display: WebSocket

- Remote control: HTTP API to control the orientation, position, and movement speed.

# Critical Review – Pros and Cons

**Good points**

- Clear logic of technical methods: Begin with overall design objectives and system overview, and then the essential components of the system.

- Compare different aspects of testing and validation: Rigorous definition
  - Data latency
  - Teleoperation Latency and Precision
  - Precision
  - Latency

**Bad points**

• Not compared directly to robotic systems, which is also an important aspects of the conclusion.

Design objective includes bridging gap between teleguidance and robotic systems.

# Critical Review – Possible next steps

- Replace the follower side with the patch ultrasound.

- A range of additional research is possible for the human teleoperation concept, including applying it to other domains to see its efficacy there, and exploring the generalization of aspects of robotic control theory to human teleoperation. This includes for example studying stable and transparent force reflection in bilateral teleoperation under time delays imposed by the communication system and human response time.

# Thanks!

## Any questions ?


- Shuran Zhang szhan149@jhu.edu
- Yuanwu He yhe87@jhu.edu