Patch Ultrasound

-Project Plan

Team: Shuran Zhang, Yuanwu He
Mentors: Keshuai Xu, Prof. Emad Boctor, Baichuan Jiang, Dr. Peter Kazanzides

Background on Medical Ultrasound

- Needs experts to hold the probe

Cart Ultrasound

from 1960s

Laptop Ultrasound

from 1990s

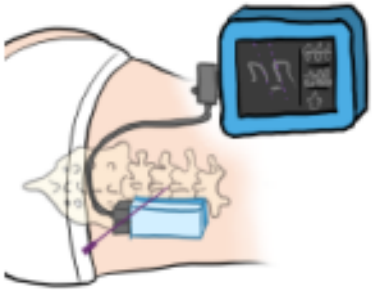
Phone Ultrasound

from 2010s

Patch Ultrasound

- Hand-free

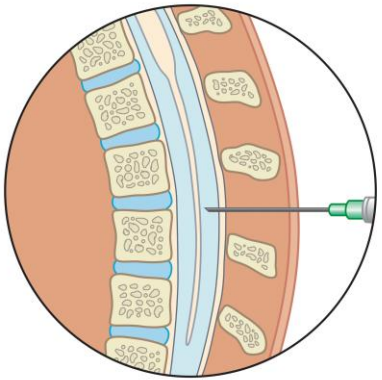
- Multi-angles
- Remote control



Background on Medical Ultrasound

- Fetal ultrasound measurement
- Lumbar puncture guidance

https://www.bing.com/images/searchview



https://www.bing.com/images/searchview

Fetal ultrasound measurement

- Crown-rump length (CRL)
- Biparietal diameter (BPD)
- Femur length (FL)
- Head circumference (HC)
- Abdominal circumference (AC)
- ...

Fetal ultrasound measurement

- Revisit the exam room multiple times.

https://www.fraserinstitute.org/blogs/more-money-wont-fix-newfoundland-and-labrador-health-care-system

https://www.bing.com/images/searchview

Fetal ultrasound measurement

- Exam the baby remotely and frequently.
- Avoid repetitive hospital visits.
- Promote the efficiency of exam rooms.
- Avoid risk of COVID-19.

Aims

We aim to develop components to realize a hand-free 4th generation ultrasound in OB/GYN applications.

Patch Design

- Enable hand-free scanning for fetal measurement.
- Enable multi-angle: Steering the image plane to standard planes.

User Interface (UI) Design

- Tele sonography: the experts control the ultrasound probe remotely.

Technical Approaches

User interface

- A web application with client and server architecture.
- Front end: JavaScript.
- Back end: Python.
- Communication: Web socket.

Patch Ultrasound Design

- Using a moving acoustic mirror to steer ultrasound images.
- The design of patch ultrasound will enable the holdable probe to be wearable.

Deliverables

Minimum:

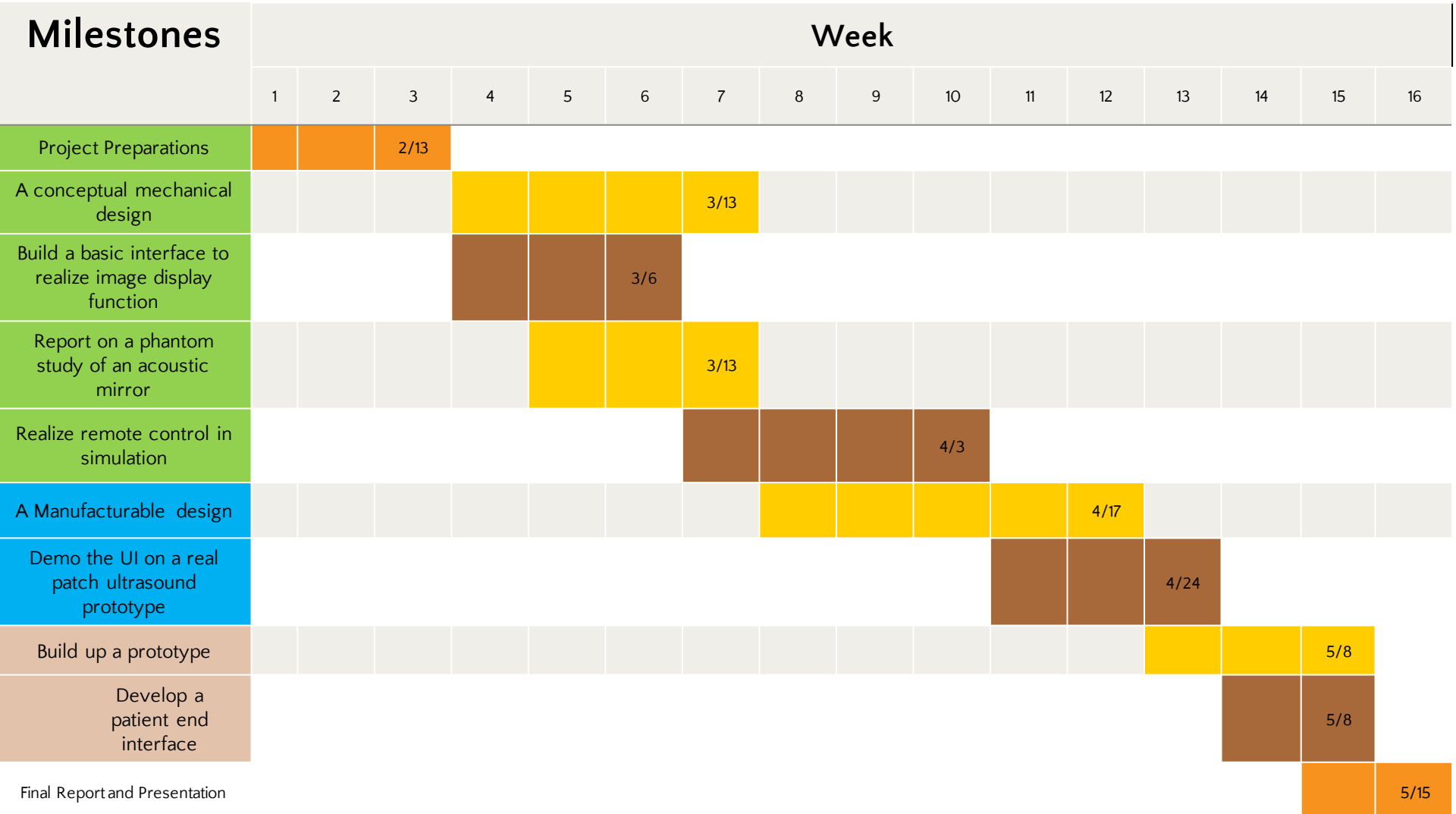
- A web page showing real-time ultrasound images with buttons to move the ultrasound probe in a simulated system.
- A conceptual mechanical design (mirror based) of the patch ultrasound.
- A report on a phantom study of an acoustic mirror.

Expected:

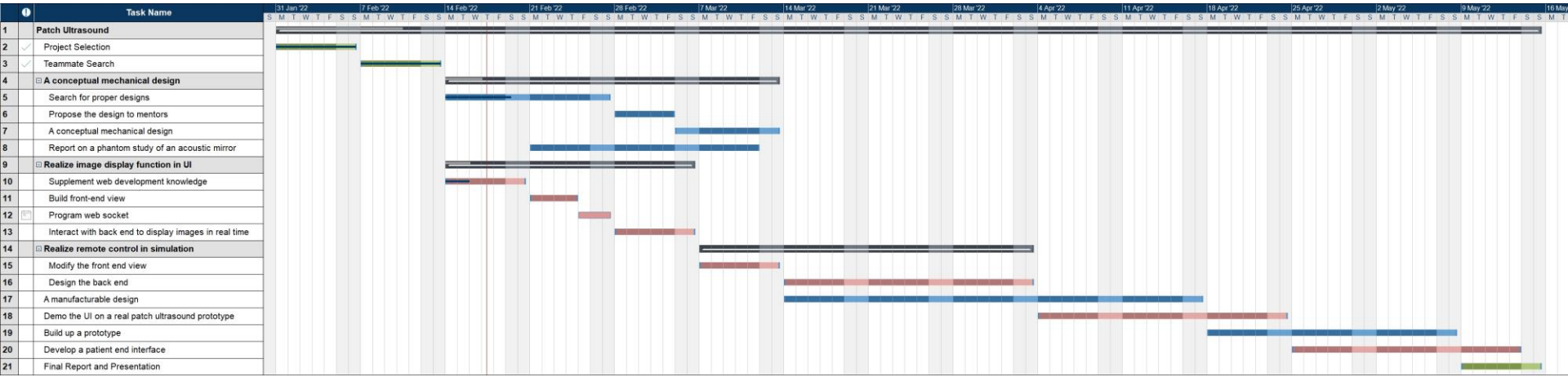
- Demo the UI on a real patch ultrasound prototype.
- Detailed manufacturable design (CAD).

Maximum:

- A patient end interface.
- A prototype to demonstrate the feasibility of mirror-based patch ultrasound.
- The communication between the prototype and the UI.


Milestones
Week
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Project Preparations
2/13
A conceptual mechanical design
3/13
Build a basic interface to realize image display function
3/6
Report on a phantom study of an acoustic mirror
3/13
Realize remote control in simulation
4/3
A Manufacturable design
4/17
Demo the UI on a real patch ultrasound prototype
4/24
Build up a prototype
5/8
Develop a patient end interface
5/8
Final Report and Presentation
5/15

Timeline: Gantt Chart



Dependency	Solution	Alternative	Status	Effect on milestones if not met
Assembly parts (e.g., motors, mirrors, rods, etc.)	Purchasing from the internet	NA	Not started	• The prototype could not be built. • Communication between the prototype and the UI could not be established.
3D printing	3D printer at Homewood campus	Purchasing from the internet	Not started	
The patch ultrasound simulator	Provided by Keshuai	No simulation	In progress	• Hardware only
Acoustic Mirror	Purchase	Make a simple one	Not started	• Create a new design without using acoustic mirror
Ultrasound Machine and Probe	Dr. Boctor's lab has multiple devices	NA	Completed	• Run simulation instead

Management Plans

- Setting up weekly project meeting with mentors on Fridays 12:30 p.m. – 2:30 p.m. : Keshuai Xu, Prof. Emad Boctor.
- Weekly team meeting for progress updates on Mondays and Wednesdays.
- Daily communication through Microsoft Teams.
- Code Management by GitHub.
- Other documentation uploaded to OneDrive.

Reading list

- [1] B. Jiang, K. Xu, R. H. Taylor, E. Graham, M. Unberath and E. M. Boctor, "Standard Plane Extraction From 3D Ultrasound With 6-DOF Deep Reinforcement Learning Agent," 2020 IEEE International Ultrasonics Symposium (IUS), 2020, pp. 1-4, doi: 10.1109/IUS46767.2020.9251555.
- [2] Gueziri, H.-E., Santaguida, C., Collins, D.L.: The state-of-the-art in ultrasound-guided spine interventions. Medical Image Analysis 65, 101769 (2020)
- [3] Hacihaliloglu, I., Rasoulian, A., Rohling, R.N., Abolmaesumi, P.: Statisticalshape model to 3D ultrasound registration for spine interventions using enhanced local phase features. In: International Conference on Medical Image Computing and Computer-Assisted Intervention, pp. 361–368 (2013). Springer
- [4] 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

Other Resources and Project Files

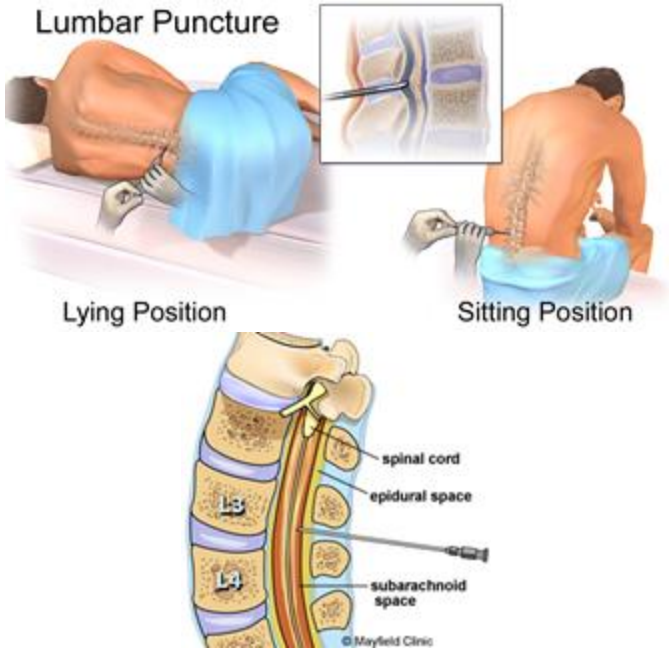
- [1] B. Jiang, K. Xu, A. Moghekar, P. Kazanzides, and E. M. Boctor, Auto InFocus, a new paradigm for ultrasound-guided spine intervention: a multi-platform validation study.

Thanks!

Any questions ?

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

Lumber Puncture Guidance

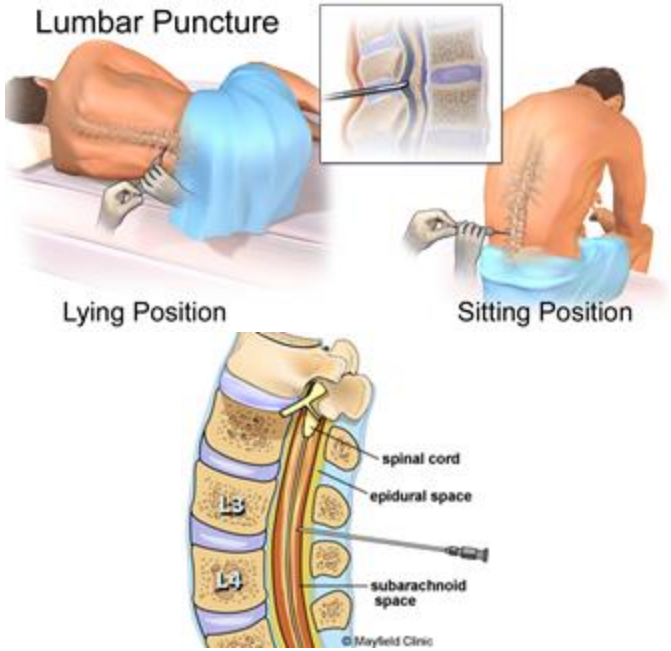


Lumbar Puncture

- Collect cerebrospinal fluid for diagnostic testing.
- Complex shapes of the self-shadowing vertebrae complicate the image interpretation and reduce the success rate.
- Loss of ability to use both hands for needle insertion.
- Current ultrasound guidance is done pre-op, not for real-time.

Slide: Haichong Zhang et al. Toward Dynamic Lumbar Punctures Guidance Based on Single Element Synthetic Tracked Aperture Ultrasound Imaging
Image: Mayfield Clinic

Lumber Puncture Guidance



Problem	Solution by Patch ultrasound
Complex shapes of the self-shadowing	Using images from multiple angles to build clear image
Loss of ability to use both hands for needle insertion	Hand-free patch ultrasound
Current ultrasound guidance is done pre-op	User interface to show real-time images.

Slide: Haichong Zhang et al. Toward Dynamic Lumbar Punctures Guidance Based on Single Element Synthetic Tracked Aperture Ultrasound Imaging
Image: Mayfield Clinic

Patch ultrasound prototype

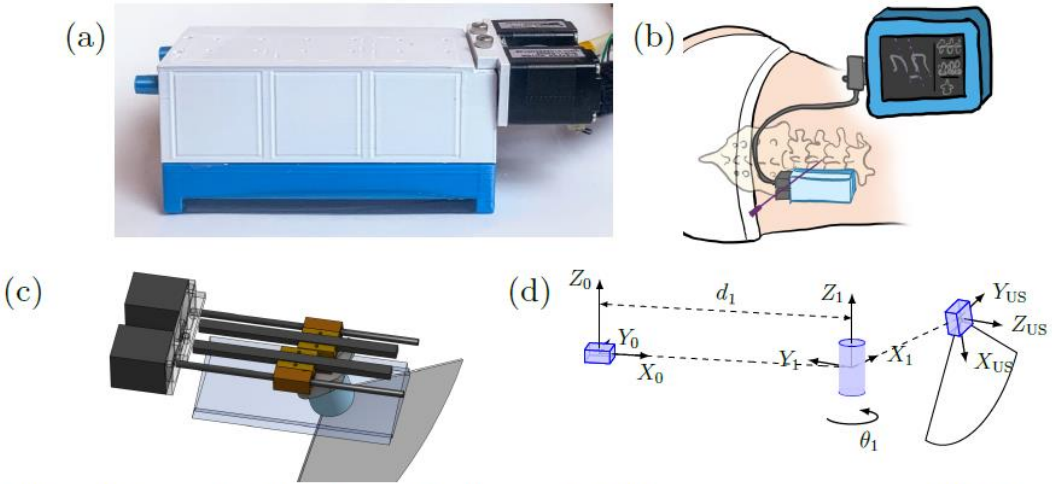
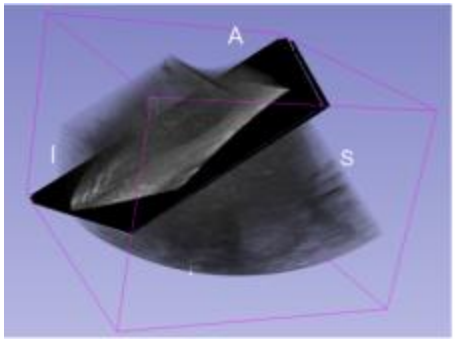


Fig. 4: Patch-based validation platform. **(a)** Prototype scanner. **(b)** Proposed placement of the scanner. **(c)** The parallel actuation mechanism. **(d)** Equivalent kinematics.

Standard plane



[1] B. Jiang, K. Xu, R. H. Taylor, E. Graham, M. Unberath and E. M. Boctor, "Standard Plane Extraction From 3D Ultrasound With 6-DOF Deep Reinforcement Learning Agent," 2020 IEEE International Ultrasonics Symposium (IUS), 2020, pp. 1-4, doi: 10.1109/IUS46767.2020.9251555.