

Patch Ultrasound

-Checkpoint Presentation



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Patch Ultrasound



Cart Ultrasound

from 1960s



Laptop Ultrasound

from 1990s



Phone Ultrasound

from 2010s



- Hand-free
- Multi-angles
- Remote control



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.

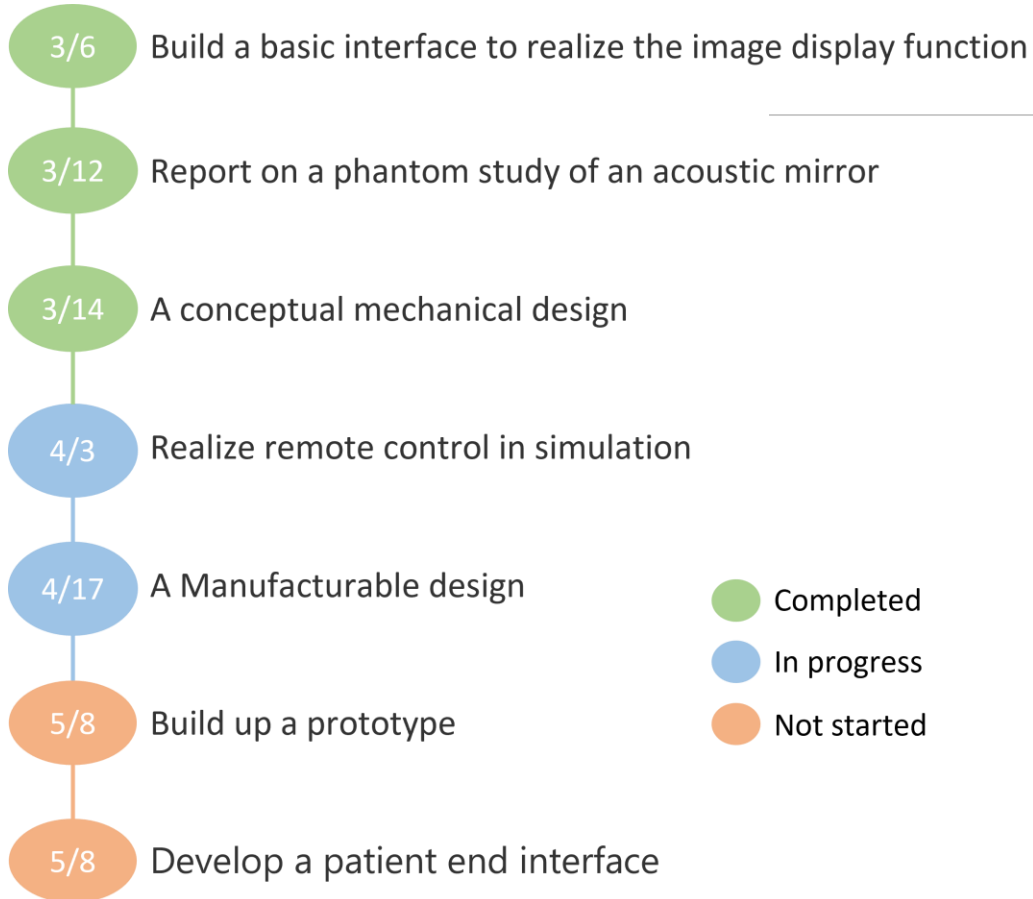
Patch Design

- 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.

Milestones



● Completed

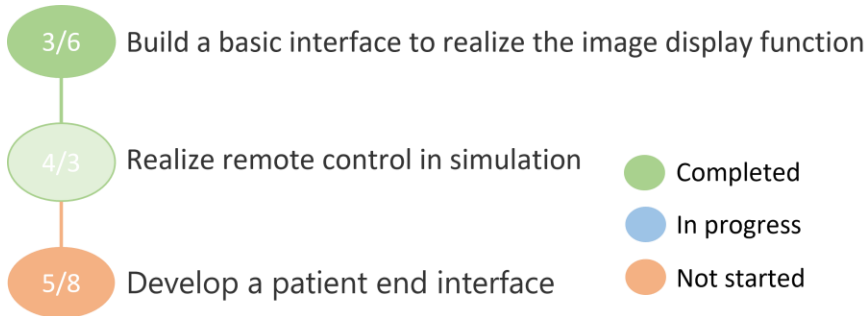
● In progress

● Not started

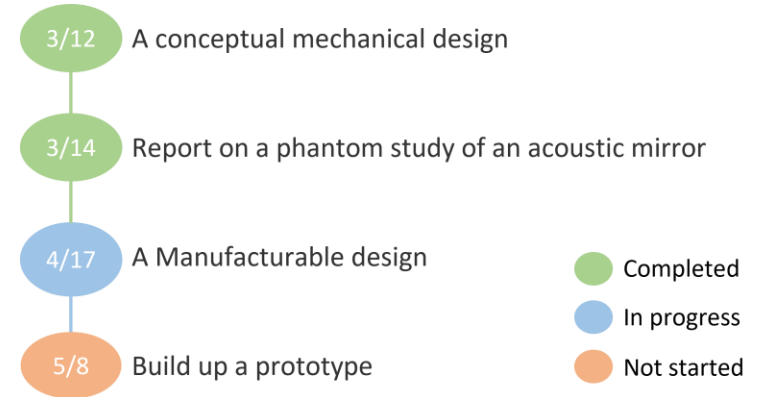


Milestones

User Interface (UI) Design



Patch Design





User Interface

- : Real-time image display
- : Remote control the ultrasound probe

} In a simulated system

Real-time Ultrasound Image
Time: 14:23:34 Thurs, Feb 24th

Patient's Information
Name: Sarah



Acoustic Mirror

- ⦿ A passive device used to reflect and concentrate sound waves
- ⦿ Parabolic and enormous
- ⦿ During World Wars, used as early-warning devices to detect enemy aircraft [1]

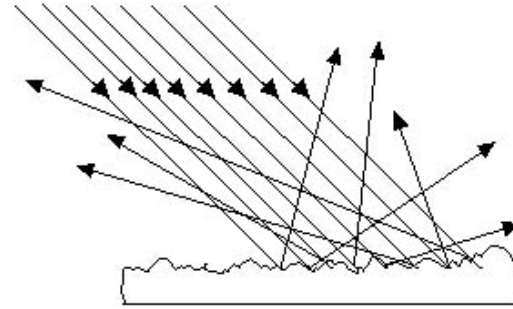


AD Editorial Team. "These Enormous Concrete Acoustic Mirrors Pepper the British Coastline" 17 Jul 2017. ArchDaily.

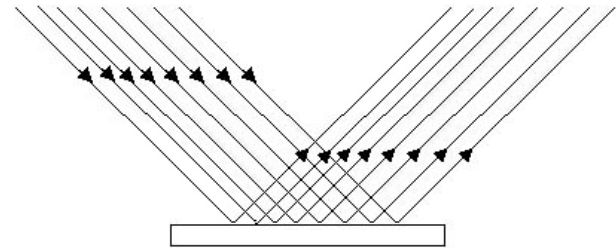
[1] ["The concrete blocks that once protected Britain"](#), January 7, 2019, BBC News website

“Acoustic Mirror” in patch ultrasound

- Reflect ultrasound waves
- Flat and small



Diffuse Reflection on rough surface [1]



Reflection on flat surface [1]

“Acoustic Mirror” in patch ultrasound

Acoustic Impedance (Z , in $\frac{kg}{m^2s}$ (Rayl))

- Physical property of the material
- Describes how much resistance an ultrasound beam encounters as it passes through a material

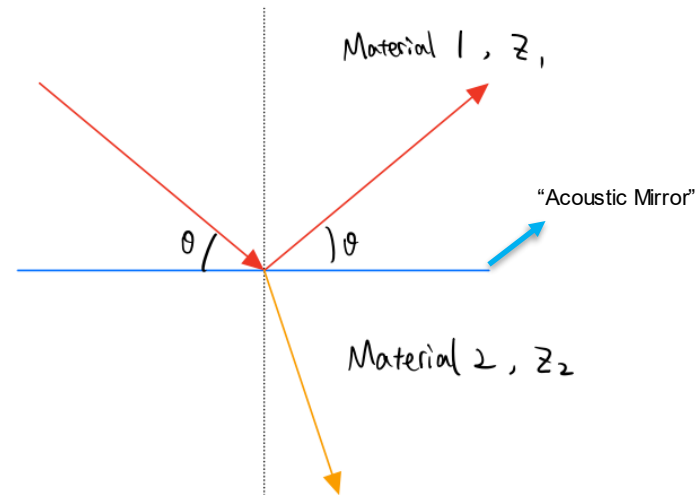
$$\text{Reflection Fraction} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

$$Z_{air} = 340 \text{ Rayl}$$

$$Z_{ultrasound\ gel} \approx Z_{water} = 1.5 \text{ MRayl}$$

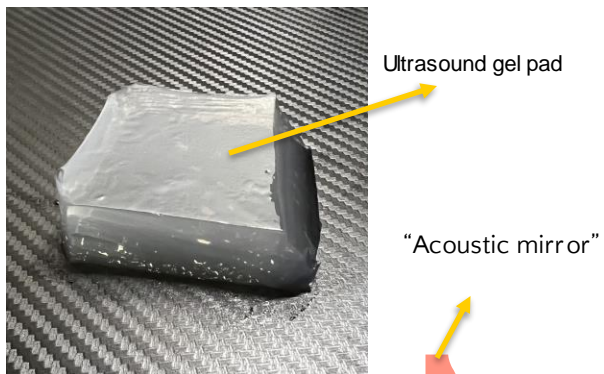
$$Z_{glass} = 13.0 \text{ MRayl}$$

$$Z_{stainless\ steel} = 45.5 \text{ MRayl}$$

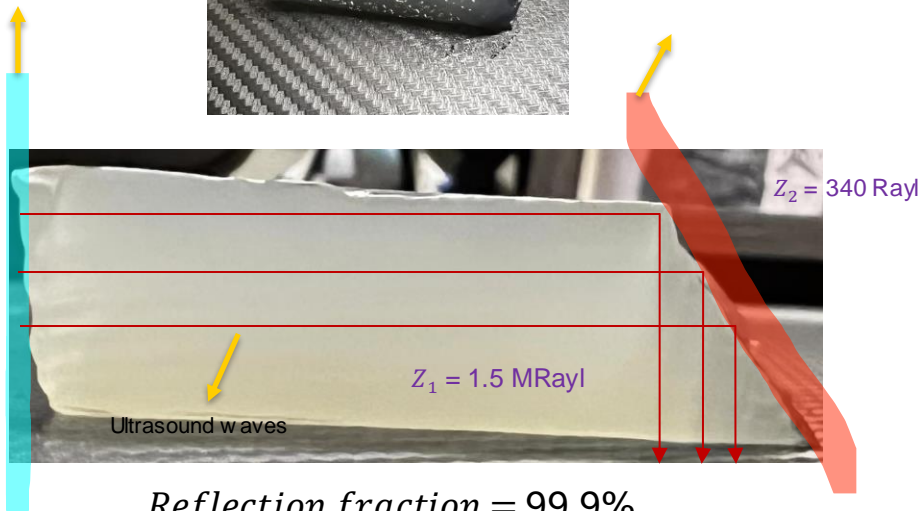




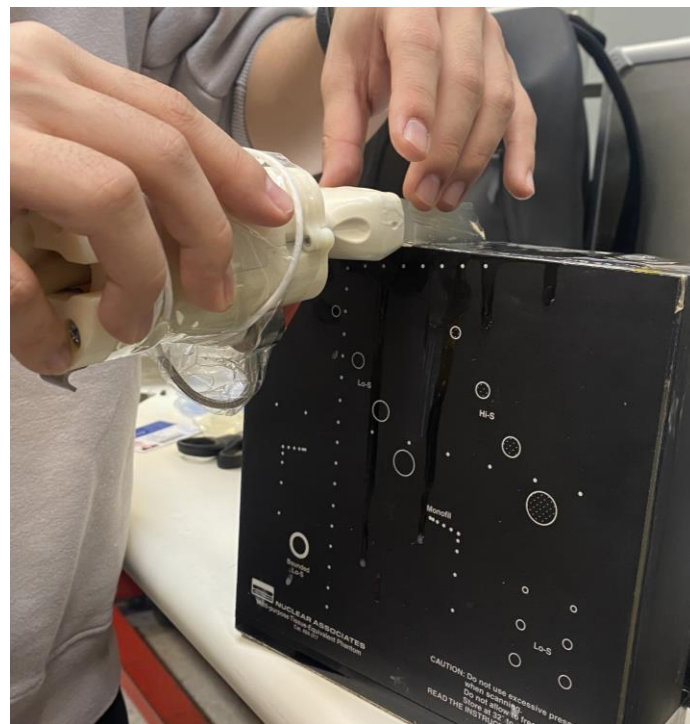
Phantom study on acoustic mirror



Entrance of ultrasound wave



Reflection fraction = 99.9%





Phantom study on acoustic mirror

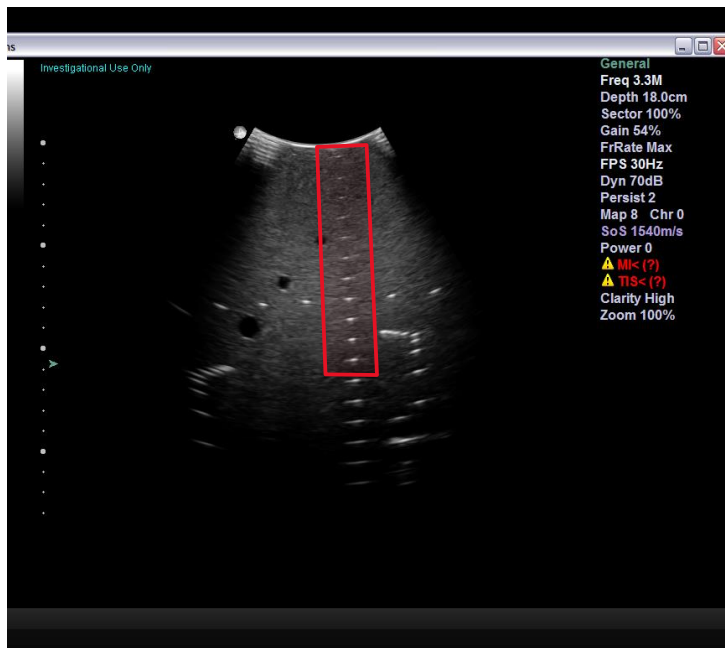


Image Without using “Acoustic Mirror”

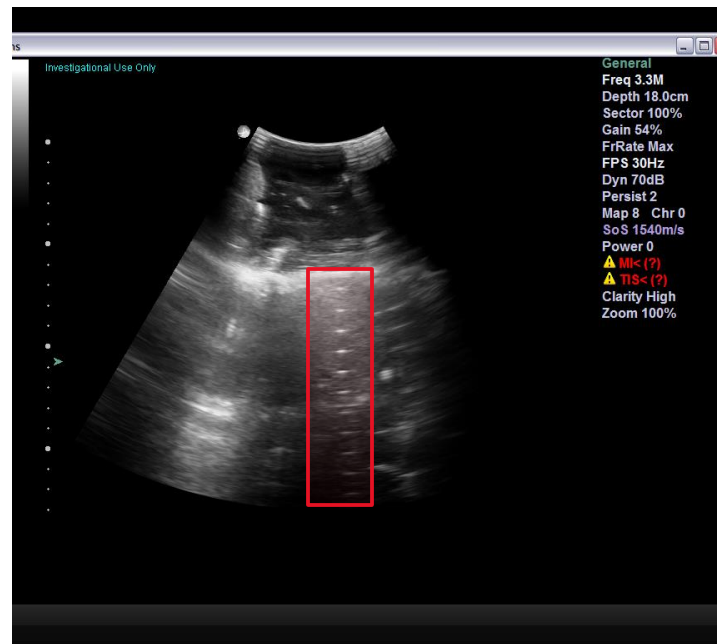


Image using “Acoustic Mirror”



Phantom study on acoustic mirror

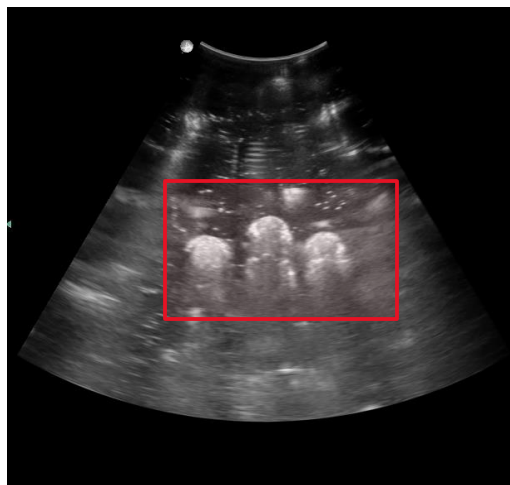


Image Without using "Acoustic Mirror"

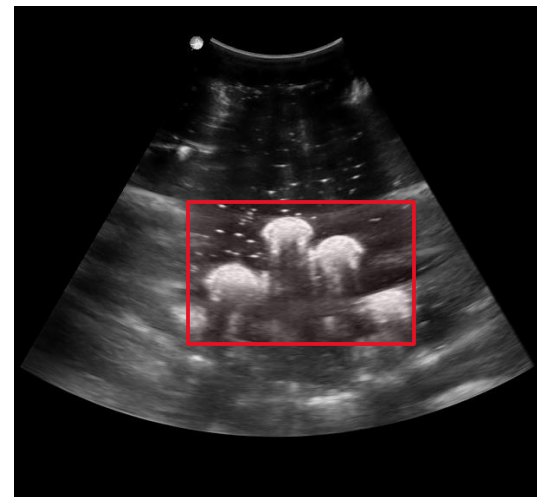


Image using "Acoustic Mirror"

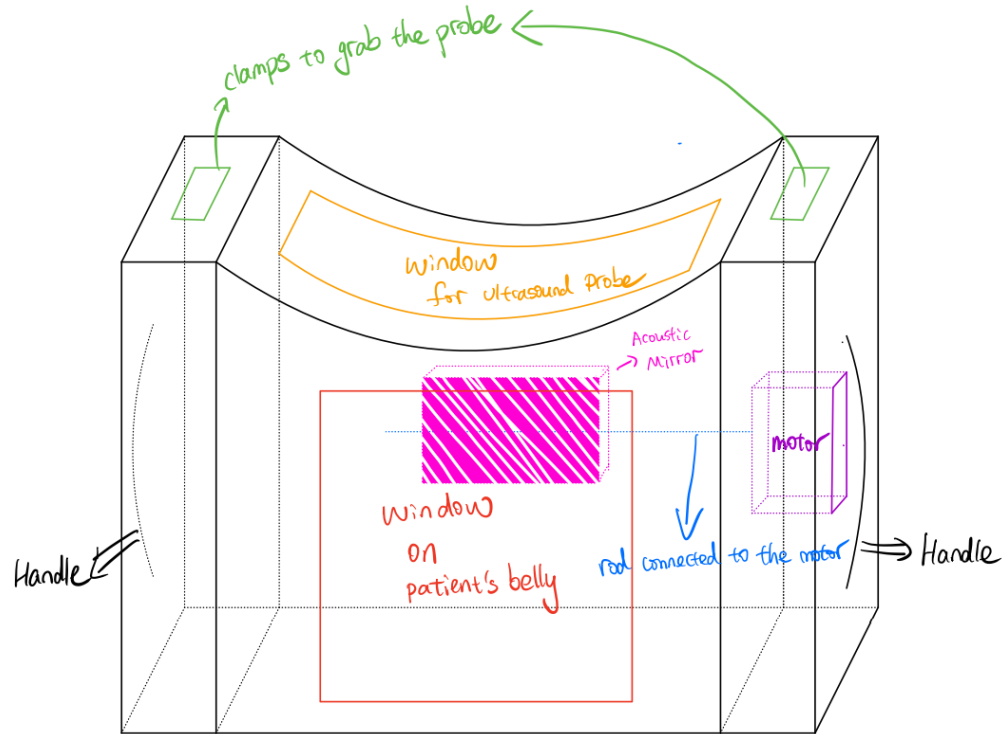


Phantom study on acoustic mirror





The Conceptual Design





Problems in conceptual design

- Reflection Fraction

$$\text{Reflection Fraction}_{(\text{glass mirror})} = \frac{13.0 \text{ MRayl} - 1.5 \text{ MRayl}}{13.0 \text{ MRayl} + 1.5 \text{ MRayl}} = 62.9\%$$



$$\text{Reflection Fraction}_{(\text{stainless steel})} = \frac{45.5 \text{ MRayl} - 1.5 \text{ MRayl}}{45.5 \text{ MRayl} + 1.5 \text{ MRayl}} = 87.6\%$$



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:

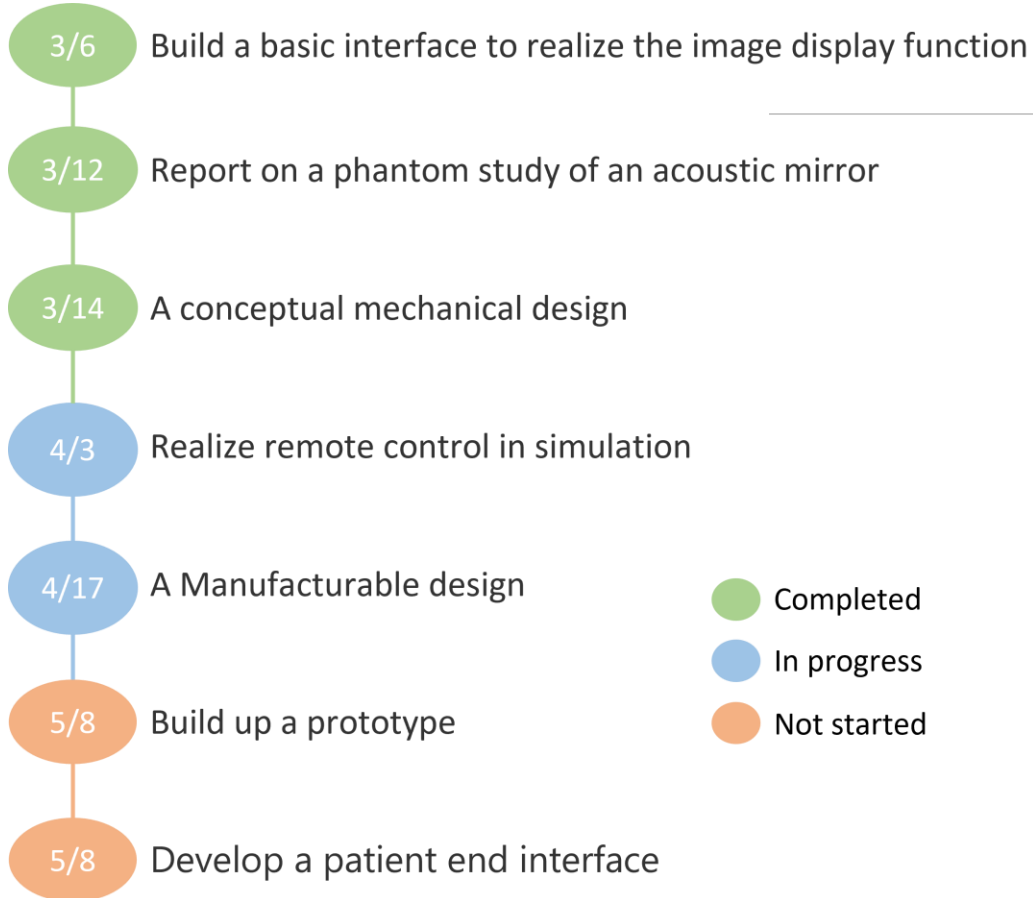
- Demo the UI on a real patch ultrasound prototype.
- Detailed manufacturable design (CAD).

Maximum:

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

Dependency	Solution	Alternative	Status	Due Dates	Effect on milestones if not met
Assembly parts (e.g., motors, mirrors, rods, etc.)	Purchasing from the internet	NA	Not started	4/24	<ol style="list-style-type: none"> 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	4/17	
The patch ultrasound simulator	Provided by Keshuai	No simulation	In progress	4/3	Hardware only
Acoustic Mirror	Purchase	Make a simple one	In progress	4/17	Create an innovative design without using an acoustic mirror
Ultrasound Machine and Probe	Dr. Boctor's lab has multiple devices	NA	Completed	NA	Run simulation instead
Arduino Uno	Purchase or provided by Dr. Boctor's lab	NA	In progress	4/17	Cannot control the rotation of the motor

Milestones



Thanks!

Any **questions** ?

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