http://www.strongmocha.com/images/apple/macbook%20pro/nonglare%20glare/MacBook%20Pro%20Glare%201_MG_9286.jpg

Age of Ultrasound

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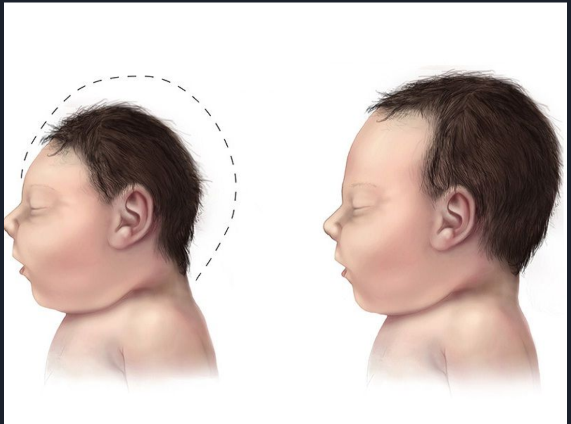
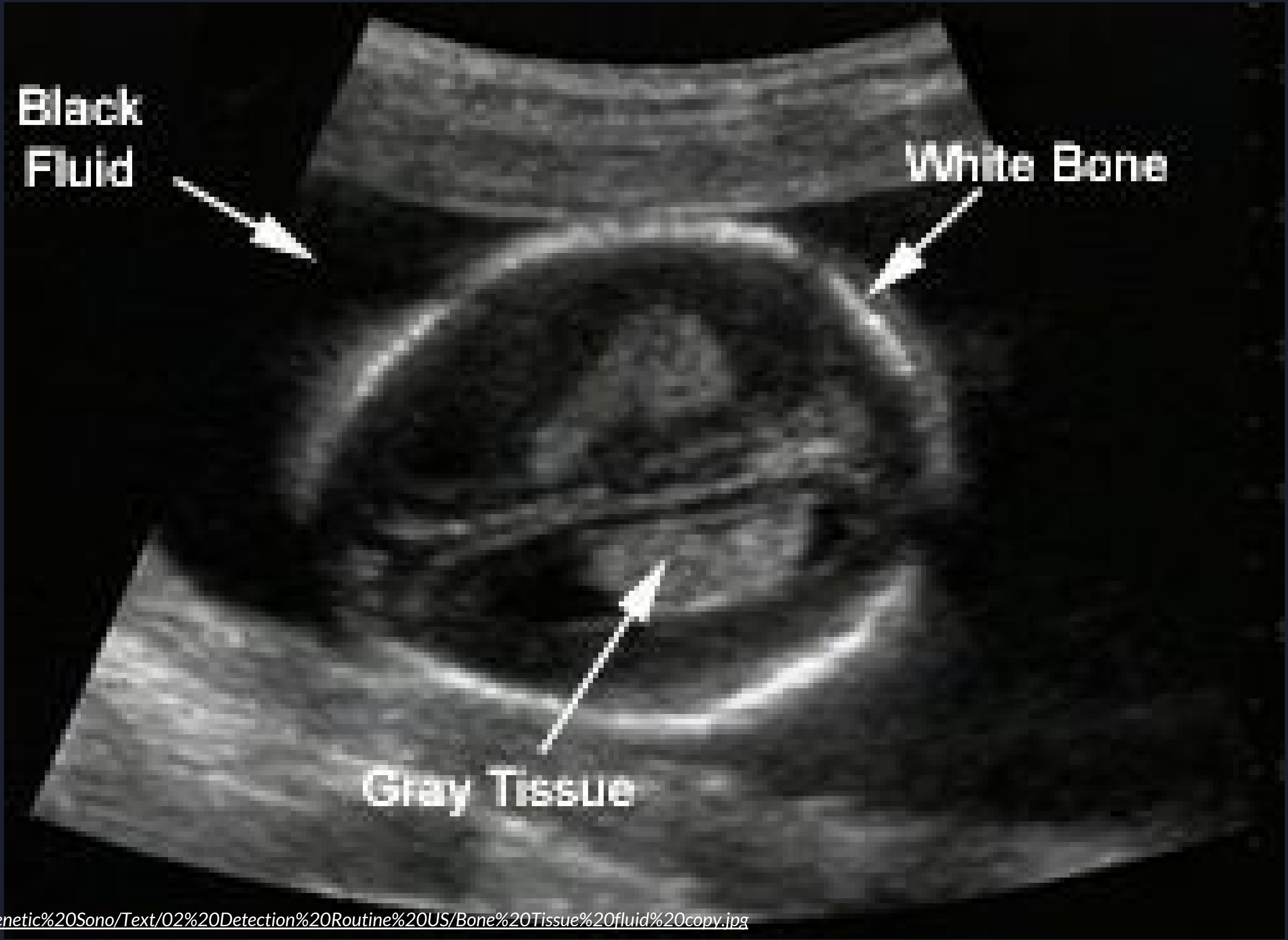
Lack of Ultrasound Specialists in Low Resource Clinics

- Necessary to transfer ultrasound image data to specialists in other locations
- Diagnosing fetal microcephaly in Zika infected mothers
    - Microcephaly is a birth defect where the head is smaller and undeveloped



http://image.techtimes.com/data/images/full/215552/microcephaly.jpg
http://www.fetalultrasound.com/online/text/1-024_files/image013.jpg



http://www.fetal.com/Genetic%20Sono/Text/02%20Detection%20Routine%20US/Bone%20Tissue%20fluid%20copy.jpg

Existing Method - Point and Shoot

- Smartphones (iPhone & Android) or flip phone cameras used
- Rough judgement to get best image
- Image sent through internet applications
  - Ex. WhatsApp, SMS, Email
  - Compression of the image file occurs

Problems with Current Method

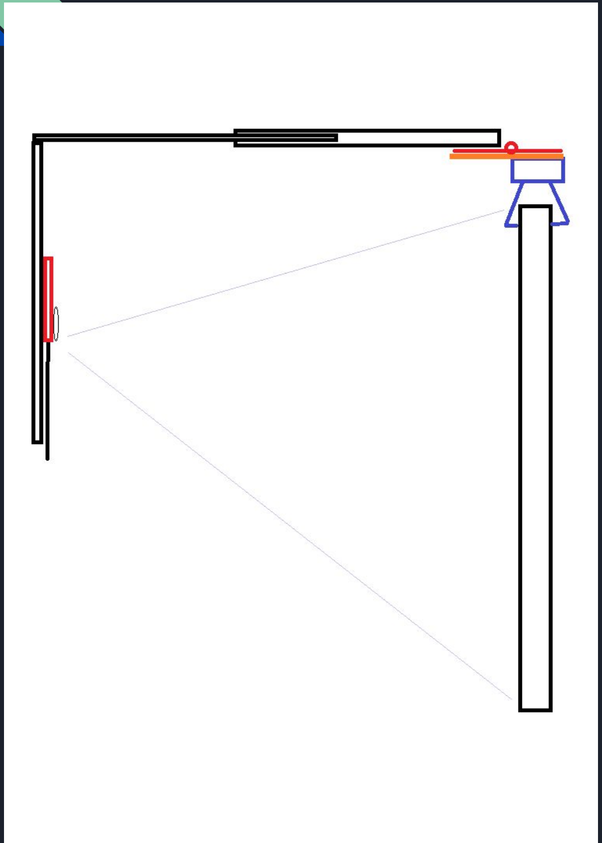
- Judgement to capture best photo varies
- Produces poor quality photos
    - Glare
    - Inadequate lighting
    - Clarity of image
        - Low contrast
        - Pixelated image
    - Photo captures surroundings of ultrasound

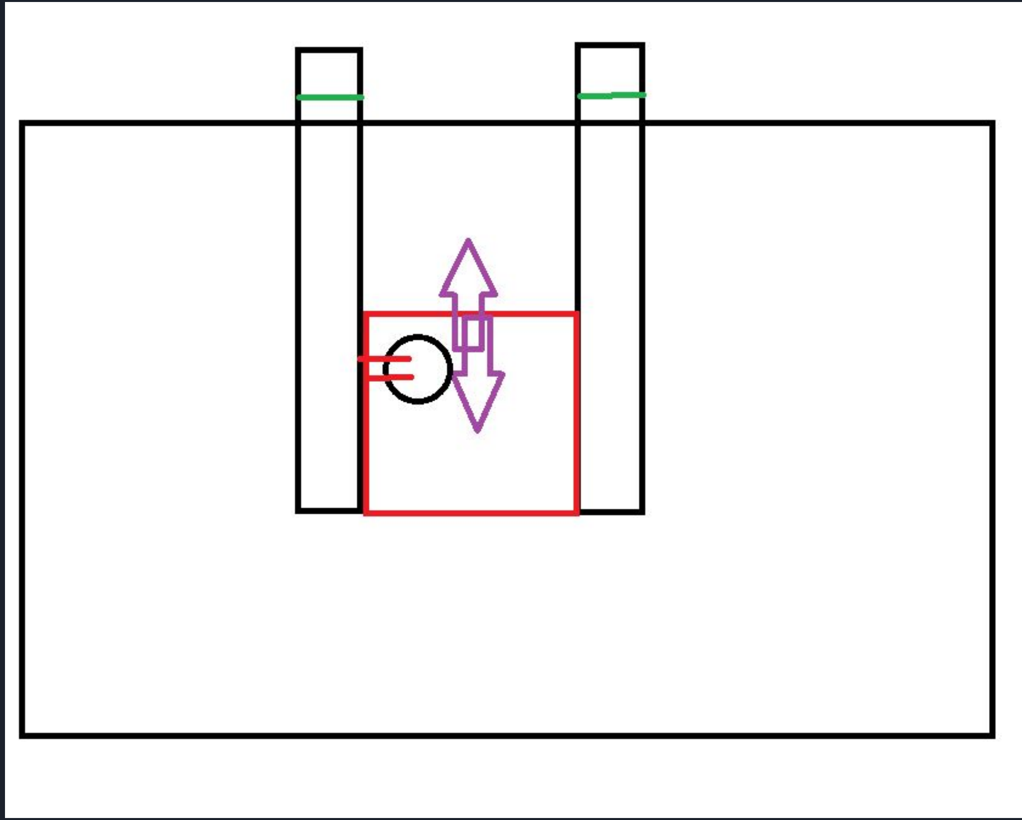
https://cdn4.explainthatstuff.com/taking-digital-photo.jpg

Problem Statement

Create a physical device that will improve the quality of images captured of ultrasound screens.

Preview of Selected Solution





Main Components

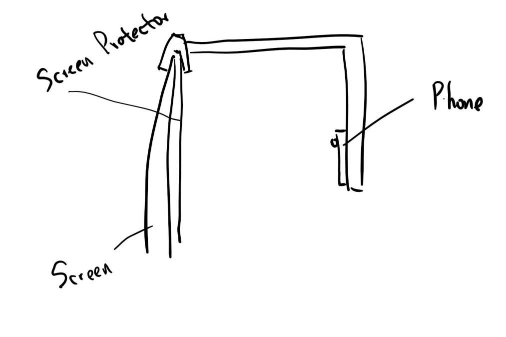
1. A stabilizing mechanism for the mobile phone
2. An anti-glare mechanism for the screen or the mobile phone
3. Variable design so that the solution can fit a variety of machines and phones

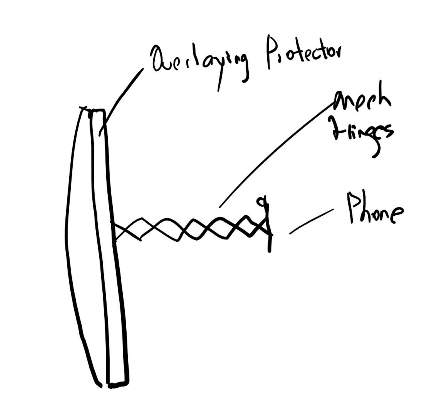
Design Constraints	Target Value
Percent of image that is the ultrasound	85% of the photo should be the ultrasound given there is elimination of glare and artifacting.
Sanitizable with alcohol	Can be washed without damaging components or functionality (no porous materials or cloth)
No magnetic components	The solution does not contain ferromagnetic materials

Quantitative Design Criteria

Design Objective	**Target Value**
Grayscale	>100 / 256 different shades must be present
Glare	> 85% of the ultrasound image must be free of glare
Ease of use	<2 minute setup time
Affordable	< $15 (bill of materials)
Durability	Survives 5 drop tests at 5ft
Easy to learn	≥4 on User Defined Scale

Concepts Going into Pugh Scoring

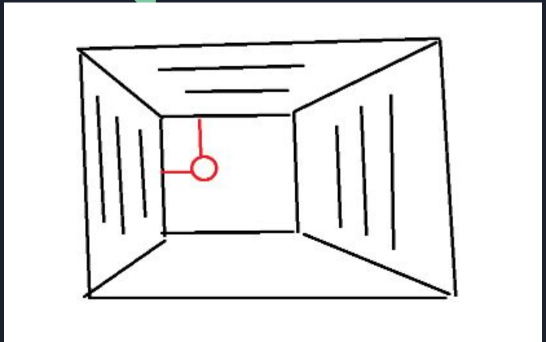


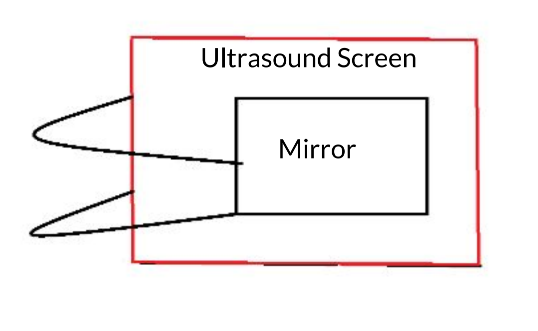


- **Flipped frame with screen protector**
    - <u>Folding Mechanism</u>: Flipped frame
    - <u>Anti Glare Mechanism</u>: Permanent screen protector for the ultrasound screen

- **Mechanical Hinges with Overlaying Protector**
    - <u>Folding Mechanism</u>: Adjustable monitor stand- multiple hinges for easy adjustment
    - <u>Anti Glare Mechanism</u>: Overlaying removable screen protector

Concepts Going into Pugh Scoring





- **Pyramid with Clip on Frame and Lens**
  - Folding Mechanism: Pyramid shaped clip-on frame that can adjust light coming into the frame
  - Anti Glare Mechanism: Polarized lens on phone camera
- **Mirror with Flexible Legs**
  - Folding Mechanism: Mirror attached to side of ultrasound machine by hinges and flexible stands
  - Anti Glare Mechanism: Overlaying removable screen protector

Pugh Matrix to Support Choice of Solutions

*FF=Flipped Frame

Design Criteria	Weighting	FF* and Overlaying Protector	Mech. Hinges with Overlaying Protector	FF* and Screen Protector	Clip-on Pyramid Frame and Lens	Mirror with Flexible Legs
Glare	20%	3	3	4	5	4
Grayscale	20%	2	2	3	4	5
Ease of Use	20%	3	3	4	2	1
Affordability	20%	5	5	3	2	4
Durability	15%	4	3	4	2	1
Easy To Learn	5%	5	4	5	3	3
Score	100%	3.45	3.25	3.65	3.05	3.10
Rank		2	3	1	5	4

Pugh Matrix to Support Choice of Solutions

*FF=Flipped Frame

Design Criteria	Weighting	FF* and Overlaying Protector	Mech. Hinges with Overlaying Protector	FF* and Screen Protector	Clip-on Pyramid Frame and Lens	Mirror with Flexible Legs
Glare	20%	3	3	4	5	4
Grayscale	20%	2	2	3	4	5
Ease of Use	20%	3	3	4	2	1
Affordability	20%	5	5	3	2	4
Durability	15%	4	3	4	2	1
Easy To Learn	5%	5	4	5	3	3
Score	100%	3.45	3.25	3.65	3.05	3.10
Rank		2	3	1	5	4

Specific Features and Material Choice of Top Solution from Pugh Scoring

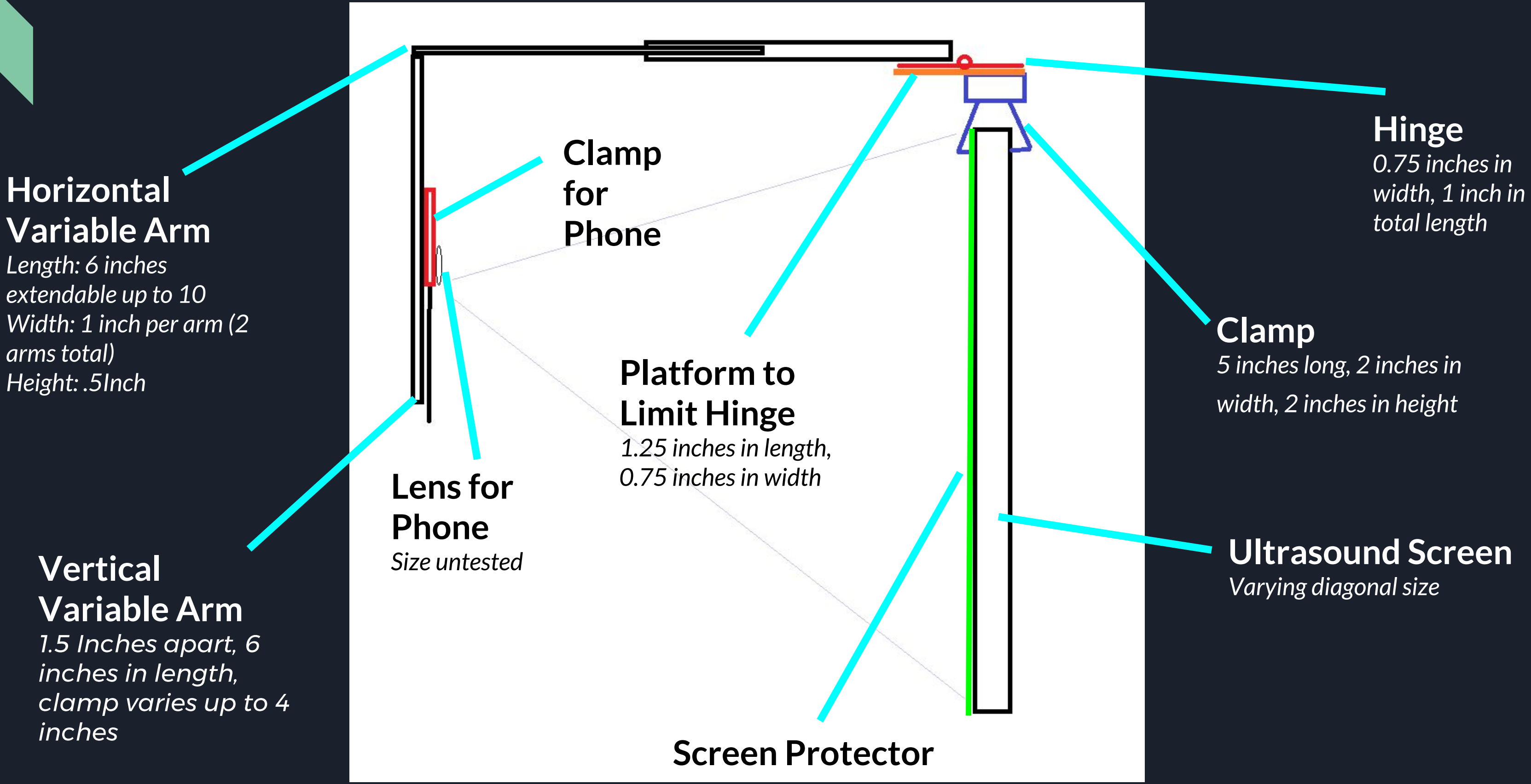
- Flipped frame
  - Plastic rods connected through hinges that fold on top of the machine
    - Adjustable via linear slide mechanism
- Screen Protector
  - Screen filter that adjusts for glare (matte finish)
  - Perforated to be able to fit any size screen

http://1ugn2l2m3z2y31d4y73c1m5w.wpengine.netdna-cdn.com/wp-content/uploads/2015/02/nexen-rail-brake.jpg

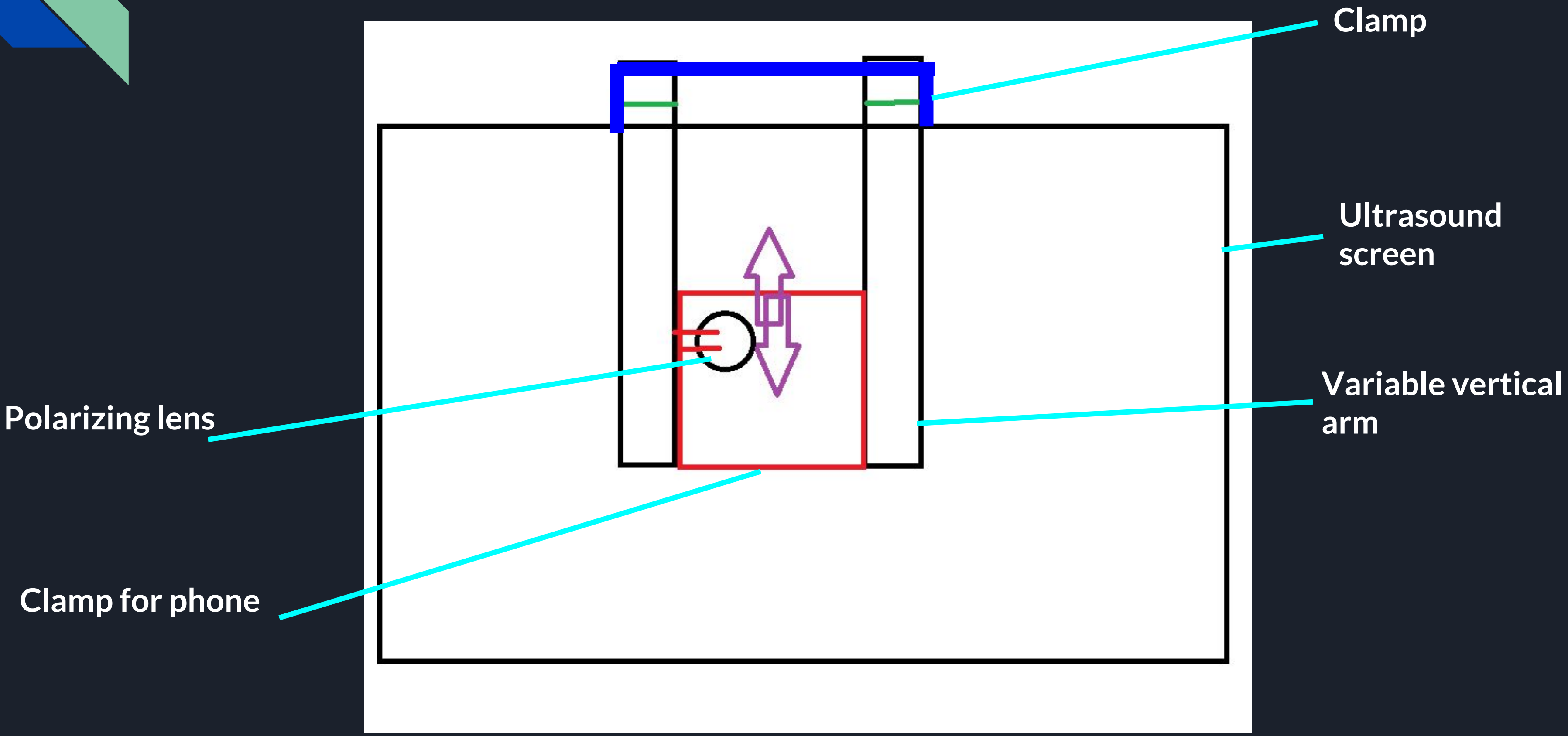
Impact of Matte Screen Protectors on Glossy Surfaces

https://www.photodon.com/c/LCD-Protective-Films.html

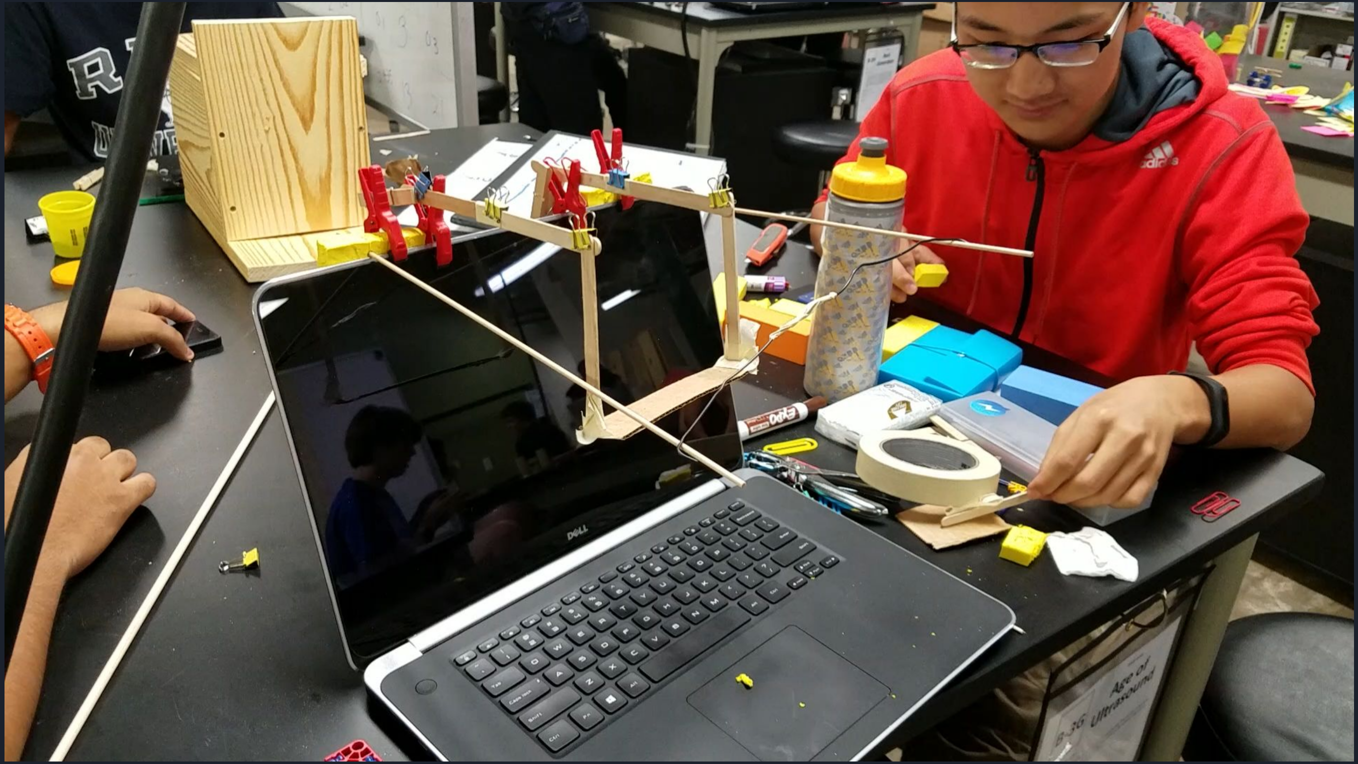
Side View of Flipped Frame with Screen Protector



Front View of Flipped Frame with Screen Protector



Low Fidelity Prototype of Selected Solution



Preview of Future Plans

- Test a scale prototype on mock ultrasound machines (LCD monitors and ultrasound machine screen)
  - Re-evaluate and improve prototypes
- Develop CAD model for flipped frame with screen protector design
- Develop a medium fidelity prototype of our solution
- Continue correspondence with on site specialists to get feedback

Acknowledgements

- Dr. Wettergreen
- TA: Keshav Rao
- Clients: Dr. Richardson & Dr. Sanz Cortes
- Writing Mentor: Lauren Poole

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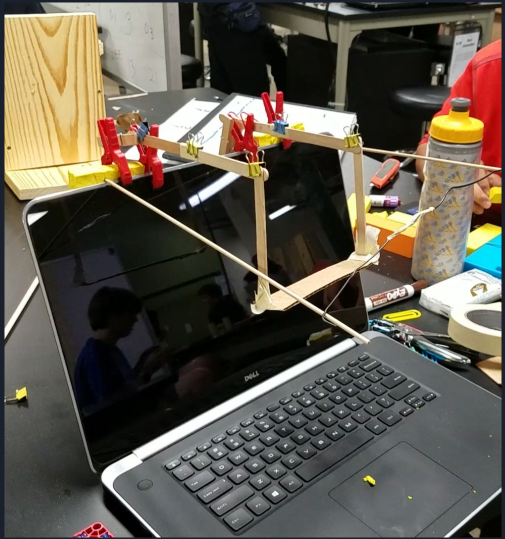
OEDK
Oshman Engineering Design Kitchen

Summary

- Goal
    - Develop a device to improve quality of ultrasound photos
- Final Solution
    - Flipped frame with a screen protector
- Current Developments
    - Testing and potential re-evaluation
    - Low fidelity prototype developed
- Impact
    - Improvement of diagnosis → public health impact



Appendix

2 Week Plan for Low Fidelity Prototyping

Task	Date Start	Date Completed
First round low fidelity prototypes	10/12	10/12/17
Second round low fidelity prototypes	10/16	10/17/2017
Evaluate and organize next steps	10/17	10/17/17
Determine deficiencies and oversights in prototyping	10/17	10/17
Create a flipped frame prototype	10/18	10/20
Replicate modules from final design drawings	10/18	10/20
Create a non-functional anti glare mechanism	10/19	10/20
Mock up lens and adjustable screen protector	10/19	10/20
Determine steps and materials needed for higher fidelity prototypes	10/19	10/20
Assign CAD roles and start mock up CAD models of prototype mechanisms and modules	10/20	--

Background Research

- Other machines used
  - VScan, Handhelds, Stationary
- Mobile Phone Penetration
  - 60% in target regions of Colombia, Costa Rica
- Typical camera quality
  - 3-9 Megapixels
- HIPAA Regulations
  - Confidential patient information is shown in all ultrasounds

http://www.ultrasolutions.com/sites/default/files/images/ge-voluson-i-large-01.png

Pairwise Comparison Chart

	Affordable	Durable	Easy to learn	Easy to use	Readable	Total
Affordable	---	1	1	1/2	0	2.5
Durable	0	---	1	0	0	1
Easy to learn	0	0	---	0	0	0
Easy to use	1/2	1	1	---	0	2.5
Readable	1	1	1	1	---	4

User Defined Scale: Easy to Learn

Ranking	Scale for Easy to Learn
5	Only requires a diagram to learn how to use
4	Requires step by step walkthrough
3	Requires multiple sets of instructions and diagrams to explain
2	Requires multiple people to understand how to setup
1	Instructions and multiple people still unable to setup device

User Defined Scale for Glare

Anti-Glare Scale	Value as a percentage of the ultrasound image that is free of glare
5	More than 95%
4	From 90% to 95%
3	From 85% to 90%
2	From 80% to 85%
1	Less than 80%

Scoring Scale for Durability

Score	Value
5	Survive a drop greater than 7 feet
4	Survives a drop from between 5 feet and 7 feet
3	Survives a drop from between 3 feet and 5 feet
2	Survives a drop from between 1 feet and 3 feet
1	Survives a drop from less than 1 feet or does not survive any drop

Scoring Scale for Easy to Use

Score	Value
5	<1 minute to use
4	1 to 1.5 minutes to use
3	1.5 to 2 minutes to use
2	2 to 2.5 minutes to use
1	>2.5 minutes to use

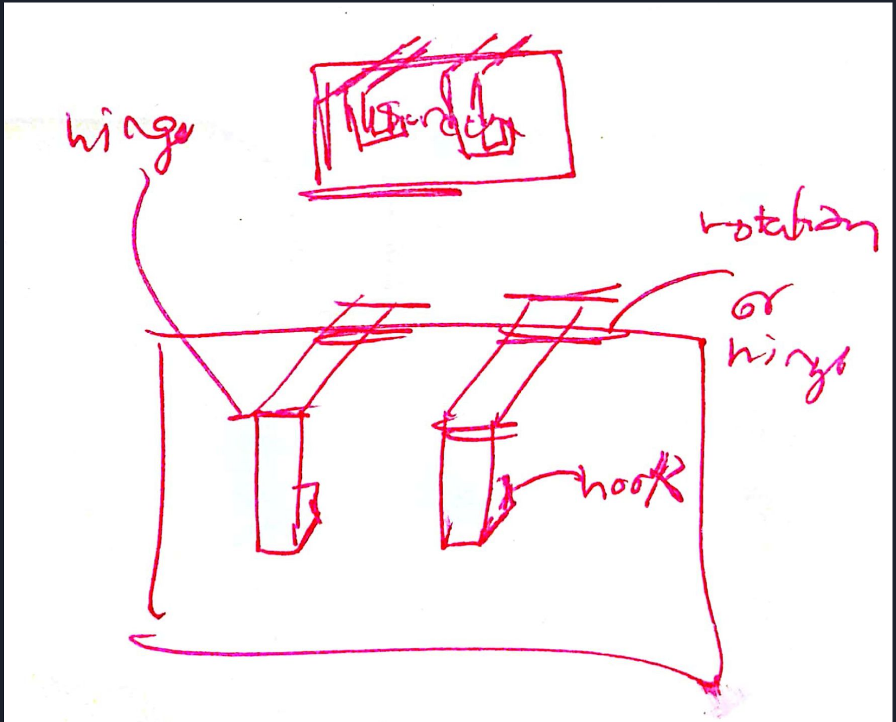
Scoring Scale for Grayscale

Score	Value on the 8-bit Grayscale from 0-256
5	200-256
4	150-200
3	100-150
2	50-100
1	0-50

Scoring Scale for Affordability

Score	Value
5	Manufacturing cost lower than 5$
4	Manufacturing cost from 5$ - 10$
3	Manufacturing cost from 10$ - 15$
2	Manufacturing cost from 15$ - 20$
1	Manufacturing cost higher than 20$

Sketch of flipped frame solution



Justification for Weightings

To weigh criteria, we looked at the Pairwise Comparison Chart and also how important each criteria was for the success of the solutions present. Initially weightage was 0.15 to durability, 0.20 to ease of use, 0.05 to easy to learn, 0.20 to affordable, and 0.4 to readability.
Readability had the most weight as it was crucial that the solution permitted the largest possible variety of grayscale so that the ultrasound image could be read.
Ease of use and affordability had half the value of readability and were weighted the same because the affordability of the solution was important so that it could reach all clinics in low resource areas but just as important was its implementation. The cost and time needed to use the solution were equally important to the solution being successful.
Durability was weighted 0.15 as it was important but not as important as affordability since the cost is a limiting factor for clinics. Easy to learn was weighted the least as the learning curve for the solution does not matter as much as the rest of the criteria. we realized that since our components were made of 2 sets of ideas, stabilizing and anti-glare, readability on its own would not be enough to asses the last solutions. To mitigate this issue we decided to split readability into two components solely for the purpose of the pugh scoring sets. Readability became 0.2 which assessed variety of grayscale present and anti-glare which became 0.2 to assess how well the solution reduces artifacting and glare.

References

- (Dr. Magda Sanz Cortes, Client Update, October 12th, 2017)
- (Dr. Magda Sanz Cortes, Client Update, September 30th, 2017)
- (Dr. Richardson, Client Update, September 16th, 2017